REPORT

Master Planning and CSO Facility Planning

BASELINE WATER QUALITY ASSESSMENT

August 1994

Massachusetts Water Resources Authority

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Acknowledgements:

Several people contributed their knowledge or expertise to this report. The authors would particularly like to acknowledge the assistance of Eric Adams, Agnes Ayuso, Merryl Alber, Kathy Baskin, Paul Barden, Grace Bigornia-Vitale, Dave Bingham, Dominique Brocard, Phil Carbone, Kathleen Colhane, Mike Connor, Maury Hall, Steve Halterman, Jeff Kennedy, Ken Keay, Paul Keohan, Paul Lavery, Mark Sullivan, and Lisa Wong.

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CHAPTER 1
INTRODUCTION

This document presents the results and conclusions of the data collection and analysis for the Baseline Water Quality Assessment performed in support of the System Master Plan (SMP) and Combined Sewer Overflow (CSO) Control Plan for Boston Harbor and its major tributaries. This Baseline Water Quality Assessment is the first part of the overall Water Quality Assessment that is described in more detail below.

1.1 OVERVIEW OF THE SYSTEM MASTER PLANNING PROGRAM

The System Master Planning (SMP) program is a three year effort undertaken by the Massachusetts Water Resources Authority (MWRA) to reassess the recommendations of the 1990 CSO Facilities Plan from a system-wide point of view, considering infiltration/inflow (I/I) reduction, flow management strategies, and wet weather primary and secondary treatment options, as well as CSO control. It is expected that through a combination of wet weather flows that are lower than previously predicted, system management, regulatory flexibility and other factors, considerable savings compared to the $1.3 billion cost from the 1990 CSO Facilities Plan can be realized. Such a systemwide approach will not only reduce CSO control costs but will also result in a more efficient and cost-effectively operated system and will provide the basis for the long-term capital program of the MWRA's Sewerage Division.

During 1992 and 1993, intensive flow and water quality monitoring was followed by development of a detailed system-wide hydraulic model in order to evaluate a wide range of I/I, transport, treatment and CSO alternatives (Metcalf & Eddy 1992, 1993a, 1993b, 1994a, 1994b, 1994d, MWRA 1993a). These studies led to predictions of annual CSO discharges that are considerably less than previously predicted, depending on assumptions regarding stormwater discharges at permitted CSO locations. Also during 1993, a plan for optimum flow management in the existing transport system was completed and is now being implemented (MWRA, 1993b). This System Optimization Plan (SOP) includes about 100 low cost, easily implemented projects that maximize in-system storage and resulting flow to the treatment plant under wet weather conditions.

The lower volume of combined sewage and less frequent overflows under future baseline conditions (*i.e.* flow management that excludes CSO control) was reported to EPA under the Federal District Court schedule in December, 1993. Subsequent Court milestones for completion of the SMP in 1994 include reporting of baseline CSO water quality impacts in March; definition of systemwide CSO control alternatives in June; draft recommendations for systemwide CSO controls in September; and final recommendations for CSO control in December.

Coincident with the SMP program and as a result of the new lower estimates wastewater flows, the MWRA's Program Management Division (PMD) has undertaken Design Package 29 (DP-29)

- a detailed reassessment of the 1988 Secondary Treatment Facilities Plan (STFP) recommendations regarding the required amount of secondary treatment capacity. Because flows to Deer Island are dependent, in certain circumstances, on CSO management during and after wet weather, the SMP and DP-29 are integrally linked and are being closely coordinated. Both efforts will use the same information regarding baseline wet and dry weather flows to Deer Island from both the North and South systems.

1.2 REGULATORY FRAMEWORK

The final SMP recommendations and, in particular, the CSO control program that will be part of the overall SMP recommendations, will be substantially influenced by various State and Federal policies and regulations that have been formulated or clarified since the 1990 CSO Facilities Plan. These policies and regulations have defined the general approach and specific tasks included in the overall water quality assessment. A brief overview of key regulatory issues is provided below.

1.2.1 U.S. EPA CSO Policy

The water quality assessment has been formulated to conform, as much as possible, to the guidelines of the U.S. EPA CSO Policy. EPA's guidance documents, which will explain and define the intent of the policy, have not yet been issued.

In general, the water quality assessment uses the "demonstration approach" described in the Policy. Under this approach, the CSO control plan must be demonstrated to meet Massachusetts water quality standards. This will entail evaluation of sewer separation and CSO relocation and, if those are unaffordable or infeasible, other CSO control options, along with a partial use designation, as discussed below. For some of the smaller water bodies the "presumptive" approach may be considered - if justified by baseline CSO volume or frequency characteristics.

The need to maximize flow to POTWs under wet weather conditions will be an objective of the alternative evaluation, and, therefore, a "CSO-related bypass" as defined in the Policy may be considered. As defined in the CSO Policy, a CSO-related bypass for the Deer Island discharge would allow flows to the plant, above a specified rate, for treatment through the primary treatment batteries. Flow would then bypass the smaller capacity secondary treatment units during brief pre-specified periods of high wet weather flow. During these brief wet weather periods, plant effluent quality would be allowed to exceed secondary treatment limits for BOD and suspended solids. For a CSO-related bypass to be granted by EPA, several conditions need to be demonstrated including that the secondary capacity is designed to treat a reasonable amount of wet weather flow above average dry weather flow, that other treatment options have been evaluated and employed, as appropriate, and that the exceedance of BOD and suspended solids limits will not cause a violation of water quality standards (WQS). The water quality studies for the new outfall and engineering analyses (treatment plant) needed to justify a CSO-related bypass, if appropriate, will be accomplished under the DP-29, Secondary Treatment Concept Reassessment effort.

The need for states to review and possibly revise their water quality standards for CSO-impacted waters in light of long-term CSO control planning results is a key element of the EPA Policy. It is consistent with Massachusetts requirements that water quality standards be changed for any water receiving CSO discharges, as discussed below.

In the water quality assessment, the EPA's "sensitive area" provisions of the Policy will be applied to waters with "critical use" designations in Massachusetts.

1.2.2 Massachusetts CSO Policy and WQS

Massachusetts requires that CSOs be eliminated through sewer separation unless it can be shown that the cost of separation would cause substantial and widespread economic and social impact. This alternative will be evaluated in the SMP for each receiving water. Where separation is not feasible, outfall relocation will be investigated. Where neither is economically or technically feasible, a "partial use" designation may be given for the impacted segment.

A partial use determination may also be justified if water quality standards are violated as a result of natural or human-caused, irreversible conditions in the watershed that are unrelated to CSOs. The SMP water quality assessment is structured to provide a preliminary evaluation of non-CSO watershed conditions that may affect the long-term ability to meet water quality standards in certain water bodies. This is discussed in more detail in Section 1.3.2 below (under Task 3). Minimum water quality criteria for all waters in Massachusetts are presented in Table 1-1. Massachusetts State Water Quality Standards for Class SB and Class B waters are summarized in Table 1-2.

1.2.3 EOEA/MassDEP Watershed Planning Approach

Both nationally and in Massachusetts, the need to plan and manage water quality on a watershed basis has been realized. It is understood that decision-making should be made with consideration of the relative impact of all pollution sources in a watershed and that water quality management funds should be targeted for control of sources where the water quality benefits would be greatest.

The water quality assessment for the SMP has been structured using a watershed approach. The watershed approach entails estimation using the best information available of pollution sources in the watershed in addition to CSOs, including stormwater from separate sewer areas and non-point sources that are included in the upstream inflow to the study area water bodies. The watershed approach also includes consideration of a range of beneficial use goals for each CSO-impacted water body.

TABLE 1-1. MINIMUM WATER QUALITY CRITERIA FOR ALL WATERS OF THE COMMONWEALTH

Parameter	Criteria
1. Aesthetics	All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.
2. Bottom Pollutants	All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.
3. Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
4. Radioactivity	All surface waters shall be free from radioactive substances in concentrations or combinations that would be harmful to human, animal or aquatic life or the most sensitive designated use; result in radionuclides in aquatic life exceeding the recommended limits for consumption by humans; or exceed Massachusetts Drinking Water Regulations as set forth in 310 CMR 22.09.
5. Toxic Pollutants	All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life, or wildlife. Where the Division determines that a specific pollutant not otherwise listed in these regulations could reasonably be expected to adversely effect existing or designated uses, the Division shall use the recommended limit published by EPA pursuant to Section 304(a) of the Federal Act as the allowable receiving water concentration for the affected waters unless a site specific limit is established. Site-specific limits, human health risk levels and permit limits will be established in accordance with the following: a. <u>Site-Specific Limits</u> - Where recommended limits for a specific pollutant are not available or where they are invalid due to site-specific physical, chemical or biological considerations, the Division shall use a site-specific limit as the allowable receiving water concentration for the affected waters. In all cases, at a minimum, site-specific limits shall not exceed safe exposure levels determined by toxicity testing using methods approved by the Director. b. <u>Human Health Risk Levels</u> - The human health-based regulation of toxic pollutants shall be in accordance with guidance issued by the Department of Environmental Protection's Office of Research and Standards. The

TABLE 1-1. (Continued) MINIMUM WATER QUALITY CRITERIA FOR ALL WATERS OF THE COMMONWEALTH

Parameter	Criteria
5. Toxic Pollutants (cont.)	Division's goal shall be to prevent all adverse health effects which may result from the ingestion, inhalation or dermal contact with contaminated waters during their reasonable use as designated in these regulations. When this goal is not attainable, the guidance will specify acceptable excess lifetime cancer risk levels for carcinogens and methodology to be used for their application. The Division may also consider factors of practicability and feasibility when deriving effluent limitations from the human health-based criteria.
	c. <u>Accumulation of Pollutants</u> - Where appropriate the Division shall use an additional margin of safety when establishing water quality based effluent limits to assure that pollutants do not persist in the environment or accumulate in organisms to levels that: (a) are toxic to humans or aquatic life; or (b) result in unacceptable concentrations in edible portions of marketable fish or shellfish or for the recreational use of fish, shellfish, other aquatic life or wildlife for human consumption.
	d. <u>Public Notice</u> - Where recommended limits or site-specific limits are used to establish water quality based effluent limitations they shall be documented and subject to full intergovernmental coordination and public participation as set forth in 314 CMR 2.00 "Permit Procedures".

TABLE 1-2. MASSACHUSETTS WATER QUALITY STANDARDS FOR CLASS SB AND CLASS B WATERS

CLASS SB	CLASS B
Class SB - These waters are designated as a habitat for fish, other aquatic life and wildlife and for primary and secondary contact recreation. In approved areas they shall be suitable for shellfish harvesting with depuration (Restricted Shellfish Areas). These waters shall have consistently good aesthetic value.	Class B - These waters are designated as a habitat for fish, other aquatic life, and wildlife, and for primary and secondary contact recreation. Where designated they shall be suitable as a source of public water supply with appropriate treatment. They shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.
Dissolved Oxygen - (a) Shall not be less than 5.0 mg/l unless background conditions are lower; (b) natural seasonal and daily variations above this level shall be maintained; levels shall not be lowered below 60 percent of saturation due to a discharge; and (c) site-specific criteria may apply where background conditions are lower than specified levels or to the bottom stratified layer where the Director determines that designated uses are not impaired.	Dissolved Oxygen (a) Shall not be less than 6.0 mg/l in cold water fisheries nor less than 5.0 mg/l in warm water fisheries unless background conditions are lower; (b) natural seasonal and daily variations above these levels shall be maintained; levels shall not be lowered below 75 percent of saturation in cold water fisheries nor 60 percent of saturation in warm water fisheries due to a discharge; and (c) site-specific criteria may apply where background levels are lower than specified levels, to the hypolimnion of stratified lakes or where the Director determines that designated uses are not impaired.
Temperature - (a) Shall not exceed 85°F (29.4°C) nor a maximum daily mean of 80°F (26.7°C), and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C) during the summer months (July through September) nor 4°F (2.2°C) during the winter months (October through June); (b) natural seasonal and daily variations shall be maintained; there shall be no changes from background that would impair any uses assigned to this class including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms; and (c) any determinations concerning thermal discharge limitations in accordance with Section 316(a) of the Federal Act will be considered site-specific limitations in compliance with these regulations.	Temperature - (a) Shall not exceed 68°F (20°C) in cold water fisheries nor 83°F (28.3°C) in warm water fisheries, and the rise in temperature due to a discharge shall not exceed 3°F (1.7°C) in rivers and streams designated as cold water fisheries not 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°C) in the epilimnion (based on the monthly average of maximum daily temperature); and (b) natural seasonal and daily variations shall be maintained. There shall be no changes from background conditions that would impair any use assigned to this Class, including site-specific limits necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

TABLE 1-2. (Continued) MASS WATER QUALITY STANDARDS FOR CLASS SB AND CLASS B WATERS

CLASS SB	CLASS B
pH - Shall be in the range of 6.5 - 8.5 standard units and not more than 0.2 units outside of the normally occurring range. There shall be no change from background conditions that would impair any use assigned to this class.	pH - Shall be in the range of 6.5 - 8.3 standard units and not more than 0.5 units outside of the background range. There shall be no change from background conditions that would impair any use assigned to this Class.
Fecal Coliform Bacteria - (a) Waters approved for restricted shellfishing shall not exceed a fecal coliform median or geometric mean MPN of 88 per 100 ml, nor shall more than 10 percent of the samples exceed an MPN of 260 per 100 ml (more stringent regulations may apply, see Section 4.06 (1) (d) (4) of these regulations); and (b) waters not designated for shellfishing shall not exceed a geometric mean of 200 organisms in any representative set of samples, nor shall more than 10 percent of the samples exceed 400 organisms per 100 ml. This criterion may be applied on a seasonal basis at the discretion of the Division.	Fecal Coliform Bacteria - Shall not exceed a geometric mean of 200 organisms per 100 ml in any representative set of samples nor shall more than 10 percent of the samples exceed 400 organisms per 100 ml. This criterion may be applied on a seasonal basis at the discretion of the Division.
Solids - These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.	Same as for Class SB
Color and Turbidity - These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.	Same as for Class SB
Oil and Grease - These waters shall be free from oil, grease, and petrochemicals that produce a visible film on the surface of the water, impart on oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life.	Same as for Class SB

TABLE 1-2. (Continued) MASS WATER QUALITY STANDARDS FOR CLASS SB AND CLASS B WATERS

CLASS SB	CLASS B
Taste and Odor - None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.	Same as for Class SB

As described below, engineering alternatives will be defined for the range of water quality use goals so that a realistic evaluation of benefits and costs can be employed in determination of the best CSO control program.

1.3 SMP WATER QUALITY ASSESSMENT

1.3.1 Purposes of the Water Quality Assessment

As a key element of the SMP, the water quality assessment will be used to identify priority areas for water quality control. Through the SMP, the MWRA's capital and operating investments will be allocated to priority areas where feasible and CSO controls will achieve significant improvements in quality and beneficial uses of receiving waters.

The overall Water Quality Assessment has been formulated to support the SMP development program by:

1. Defining "baseline" water quality conditions which reflect future planned conditions that will exist in 1997, before CSO controls are implemented;

2. Assessing the water quality benefits of various CSO control alternatives with respect to the baseline (future planned) conditions;

3. Providing technical analysis and documentation in support of necessary modifications to state water quality standards (WQS) through the Massachusetts Department of Environmental Protection's (MassDEP) "partial use" application process and in support of other state and/or Federal requirements for approval of the revised CSO Concept Plan to be submitted in December 1994;

4. Providing scientific water quality analyses in response to public concerns and issues.

"Future Planned" baseline conditions are defined in Section 2.2.1 below and described in Metcalf & Eddy (1994d).

With respect to objective #3 above, it is important to note that the System Master Plan program completed during this year (1994) will be followed by a comprehensive revision of the CSO Facilities Plan in accordance with the recommendations put forth in the SMP in December, 1994. The subsequent Facilities Planning revision effort is currently planned to take about one and one-half years and will include a detailed revision and updating of the Environmental Impact Report (EIR) that accompanied the 1990 Facilities Plan. It is that revised EIR and Facilities Planning document that will provide the formal and complete supporting environmental information and engineering justification for actual applications for partial use or other State and Federal approvals. The Water Quality Assessment supporting the SMP is intended to be a preliminary document, comparable in level of detail and scope to the SMP itself. Its goal is to provide, at this stage, sufficient justification and assurance to regulatory agencies and other reviewers that the CSO recommendations proposed in the SMP will meet policy and regulatory requirements when Facilities Planning is ultimately completed.

The water quality assessment will be conducted in conjunction with SMP development and will be included in the Draft and Final Reports in September and December of 1994.

1.3.2 Overview of the Water Quality Assessment

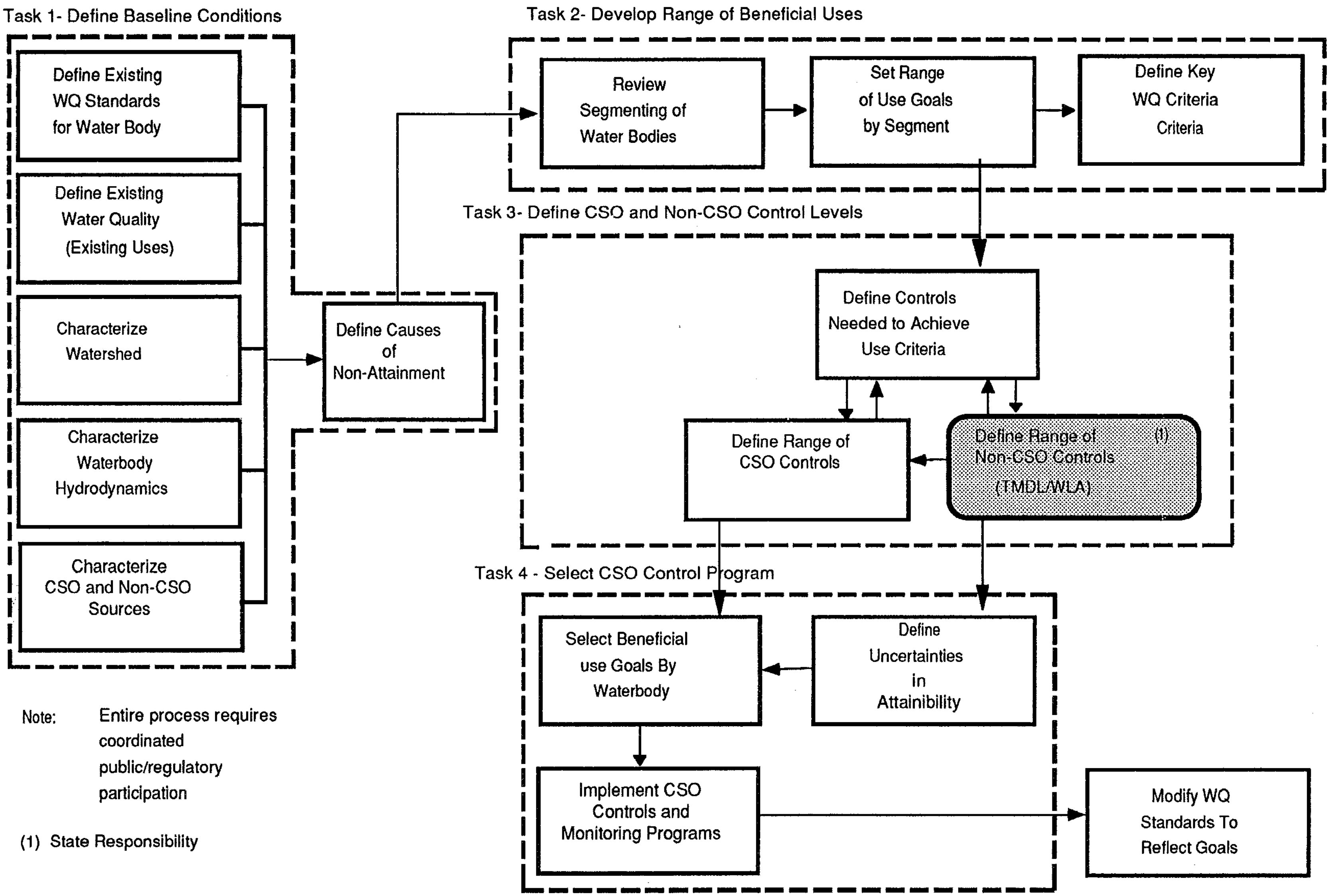
Figure 1-1 is a diagram of a watershed approach to CSO control planning. It differs from traditional approaches in that it is water quality based. The following is a description of each of the steps.

Task 1 - Define Baseline Conditions

The development of baseline conditions involves definition of applicable water quality standards and existing water quality for each receiving water, characterizing the watershed and the waterbody hydrodynamics, characterizing CSO and non-CSO sources of pollution, and defining characteristics and causes of non-attainment based on this information. These elements are discussed in more detail in Section 1.4 of this document.

Task 2 - Define Range of Beneficial Uses

This task involves evaluating baseline water quality as defined in Task 1 and setting a range of beneficial use goals for which plans for CSO controls and control of non-CSO sources will be developed. The achievement of existing beneficial uses designated in current WQS is one of the goal levels, whether or not those uses are presently attained. Where water quality is degraded and uses are not attained, a lower level or levels of use may be defined in order to develop and



Note: Entire process requires coordinated public/regulatory participation

(1) State Responsibility

FIGURE 1-1. A WATERSHED APPROACH TO CSO CONTROL PLANNING evaluate control options and associated costs for attainment. For example, a "B-Partial" designation with allowance for a specified number of excursions from water quality criteria per year due to CSO and stormwater discharges may be considered for the Charles River. In some cases, a use or designation higher than that currently set may be warranted. For example, the Magazine Beach area of the Charles River may be considered for designation as an outstanding resource water or critical use area.

The key water quality criteria that indicate attainment of a specific use are defined in this task. For example, fecal coliform bacteria, dissolved oxygen, and floatables may be defined as the key indicator criteria for attainment of swimming use, even though other criteria such a turbidity and taste/odor are also included in the WQS.

Task 3 - Define Necessary CSO and Non-CSO Control Levels

For each level of beneficial use defined in Task 2, a program for control of CSOs and non-CSO sources to achieve that use level must be developed. The CSO and non-CSO controls must be directed at control of the critical water quality criteria defined in Task 2. The control programs will consider a complete array of potential control options including non-structural and structural best management practices (BMPs), institutional and regulatory options for land management, source controls, and pollution prevention.

Because water quality is driven by all sources in the associated watershed, control programs that have the greatest impact on water quality, including both CSO and non-CSO sources, must be developed for those sources. In most cases, the CSO control program is by far the most straightforward for developing a range of beneficial use options. This is because CSOs, in comparison to diffuse, non-point sources and stormwater, have known locations, are relatively few in number, drain a relatively small percentage of a watershed, have been studied to a greater degree and, in general, have better developed, more proven control technologies.

In many cases, however, a substantially higher percentage of the pollutant load for critical criteria comes from non-CSO sources. This is, in fact, the case for most of the receiving waters in the MWRA CSO study area, and, consequently, a problem exists with respect to the MWRA's current SMP program. While CSO control programs for attainment of various levels of beneficial use can be developed, the SMP, and this associated water quality assessment, do not have the scope, schedule, or resources to develop parallel control plans for non-CSO sources. During the course of collecting and analyzing data, developing baseline water quality conditions, and developing models for stormwater and upstream inputs to the study area waters we attempted to characterize, in general terms, the nature and relative magnitude of other pollution sources in the watershed. From this characterization, serious questions regarding the feasibility of ultimate attainment of Class B or SB uses during both wet and dry periods have been uncovered. In several of the receiving waters, it is possible that 1) human-caused conditions or sources of pollution prevent attainment of uses, and/or 2) natural background conditions prevent attainment of uses. These are two of the three conditions that justify designation of a partial use or downgrading of a use in Massachusetts. The third justification for partial use or downgrading is that of the cost of control that would cause "substantial and widespread adverse economic and social impact". In light of the potential cost for control of stormwater, non-point sources, and other non-CSO sources, in addition to the cost of CSO control, it is important that a complete watershed-wide evaluation including permissible Total Maximum Daily Loads, costs of control of both CSO and non-CSO sources, and verification of the potential for attainment of designated uses, be performed before substantial money is committed for high levels of CSO control.

This component of Task 3 is shown in Figure 1-1 as the shaded box. The MWRA is actively seeking to support and cooperate with the State to complete the non-CSO portion of watershed-based plans for critical waters. We believe that such a comprehensive evaluation is required to rationally evaluate justification for a partial use designation or other downgrading of standards. The analyses and information provided with this water quality assessment, when complete, will be a part, but not all, of the puzzle.

Task 4 - Determine CSO Control Program

This task involves evaluating, for each receiving water as well as for systemwide scenarios, the CSO control options developed for each level of beneficial use (Task 3). CSO control - beneficial use options will be considered relative to a range of criteria including technical, economic, environmental, regulatory, financial and institutional factors. The time period necessary for implementation of each option and attainment of benefits will also be considered.

It is important, at this point, to evaluate non-CSO improvements (*i.e.* non-point source, stormwater) that must be completed to attain the beneficial use targeted for each level. This is a large and complex effort in that there are, at present, no watershed management plans that predict or require specific levels of improvement for non-CSO sources. Such plans would consider technology options; implementation requirements, timeframes and responsibilities; funding options and other issues. In the course of the SMP, it will be possible only to speculate, in general, as to possible levels of improvement throughout a watershed. For example, for a certain watershed, the impact on beneficial uses of levels of reduction of 20, 40, or 60 percent of coliform bacteria from non-CSO sources over a 20 year period will be estimated. The realism of various levels of reduction of pollutants from non-CSO sources must be considered in evaluating CSO control levels.

Public Participation

Because a "downgrade" of WQS to B-Partial or SB-Partial may be the result of the SMP for water bodies where CSOs remain active, the public participation process takes on added importance. Input and concerns of communities, environmental groups, and other interested groups will be sought throughout all four tasks described above. Actual current uses of the waters, public priorities for water quality improvement, feasibility of improvements for non-CSO sources, preferences for CSO control alternatives and costs, and other input will be important to selection of the appropriate CSO control level.

The next section describes Task 1 - Define Baseline Conditions, which is the primary subject of this document.

1.4 OVERVIEW OF THE BASELINE WATER QUALITY ASSESSMENT

The remaining chapters of this report discuss the results of the baseline water quality assessment. For each of fourteen CSO receiving water segments or sub-watersheds, the following analyses have been performed:

> Define Existing Water Quality Standards - The designated use classification, associated beneficial uses, and numeric and narrative water quality criteria necessary for achievement of each use are clearly defined for each segment of fresh and marine waters impacted by CSOs. Critical use waters (Outstanding Resource Waters [ORWs] and High Quality Waters), Areas of Critical Environmental Concern (ACECs), and other special designations are included.
>
> Define Existing Water Quality - Available and relevant water quality data are collected, analyzed and summarized for each segment. Quality data for wet and dry conditions for the specific criteria associated with each beneficial use are necessary to completely determine attainment or non-attainment of designated uses. Areas where shellfishing is restricted or prohibited, where fish consumption is limited, or where other water or sediment quality problems exist are defined to the extent possible. Criteria for which inadequate information is available are identified. Where possible, information is summarized on a matrix for each segment, indicating attainment, non-attainment or uncertainty, as the data dictate, for wet and dry conditions.
>
> Characterize Watersheds - A preliminary, qualitative assessment of the hydrology, geography, land uses, and other pertinent characteristics is done to generally describe the types of natural and human-caused pollution sources in each watershed. In some cases, relevant previous studies are available. In the cases of the Charles, Neponset and Mystic Rivers, watershed characteristics can be referenced to water quality data available at the boundaries of the study area in an effort to comment on the overall water quality impacts of land uses. For the urban areas within the study area, stormwater flows and loads are quantified with a relatively greater level of confidence using a rainfall - runoff model.
>
> Characterize Waterbody Hydrodynamics - The temporal and areal impacts of CSOs vary between waterbodies depending upon a number of factors, including the depth, flow rate and velocity, water density (*i.e.* salt vs. fresh waters), tides, prevailing wind conditions, impoundments (*e.g.* Charles and Mystic Rivers) and other mixing characteristics. In some waterbodies, CSO discharges may stay close to the shore and impact only the surface layer for an extended period, while in other waterbodies discharges may be diffused quickly throughout the water depth and be flushed out of the segment quickly. This report attempts to describe distinguishing hydrodynamic differences between waterbodies that may influence:

1. The impacts of CSOs with respect to resource areas such as beaches, shellfish beds and near shore areas (where floatables may accumulate), etc. or,

2. The type and location of potential CSO control alternatives.

Characterize CSO Sources - The volume, frequency and location of CSOs are determined using comprehensive hydraulic models that are well-calibrated and verified. The CSO flows and loads are computed for various size storms and for an entire year. Predictions of future planned conditions assume that various other programs will be complete, including Deer Island facilities, SOPs, and various interceptor improvement projects.

Receiving Water Modeling - Flows and loads from the upstream watershed sources, from stormwater within the study area, and from CSOs are input into water quality models for the Charles River and Boston Harbor to estimate wet weather impacts on receiving waters for key CSO-related pollutants. The models, developed and run by MIT, predict pollutant concentrations over time and space for each segment. These concentrations are compared to State water quality standards to estimate the impact of the various pollution sources on attainment of beneficial uses. The models are also used to distinguish the relative contribution from CSO and non-CSO sources.

Define Causes of Non-Attainment - Information developed under the above activities will be used to summarize the causes of non-attainment of water quality in each basin. Specific impacts of CSO discharges will be discussed. Only general indications of non-CSO impacts can be made at this time because less detailed information is available about non-CSO sources in the watersheds.

The information in this report has been summarized in Chapter 4 of the SMP Baseline Assessment Report (Metcalf & Eddy, 1994d) which also describes future planned baseline conditions in the sewer system.

CHAPTER 2
BACKGROUND INFORMATION AND METHODOLOGIES

2.1 WATER QUALITY INVESTIGATIONS

An extensive flow monitoring program was conducted during 1992 in order to accurately characterize existing conditions in the community CSO systems and the MWRA interceptor system. The actual volumes of CSO discharge for various storm conditions were measured and this information was then used for the calibration and verification of the CSO Community System Model. Extensive information on this monitoring program can be found in the Interim CSO Report, February, 1993 (MWRA, 1993a) and in Metcalf & Eddy, Inc. (1993a).

In 1993, targeted flow monitoring was conducted to better understand selected parts of the CSO community systems. Much of this monitoring was done in the Stony Brook system although smaller, upstream areas in other systems were also monitored. Data on these efforts can be found in the draft 1993 Flows and Quality Monitoring Program and Results (Metcalf & Eddy 1994a).

Monitoring was done during both 1992 and 1993 to obtain a systemwide understanding of the pollutant loads discharged during CSO events. In 1992, CSO quality monitoring was done at ten representative CSO locations. Locations were chosen based on several factors including:

- Geographic Location - sites represented a broad geographic spread
- Accessibility - sites were readily accessible, outside of high traffic areas
- Discharge Volume - sites were significant in terms of volume
- Stormwater - some stormwater sites were sampled

These 1992 sampling locations are described in Table 2-1.

Automatic samplers were placed at the CSO locations to provide up to eight discrete samples per sampling location per storm event. These samples, as well as grab samples, were collected for two storms during the metering period, on November 3, 1992 and November 22-23, 1992. Fecal coliform bacteria tests were run on individual grab samples. All individual discrete samples from the automatic samplers were analyzed for total suspended solids (TSS), while selected discrete samples were analyzed for five-day biochemical oxygen demand (BOD_5) and conductivity. Conductivity was analyzed to check for possible seawater intrusion at CSO sampling sites. One flow-weighted composite sample for each station was analyzed for selected nutrients and metals. The results from these storm events are presented in Metcalf & Eddy (1993a) and in the Interim CSO Report (MWRA, 1993a).

During the November, 1992 storm events, additional sampling was done within the receiving waters. Four locations were sampled between the Charles River Dam and Watertown Dam on the Charles and sampling was also done at the Amelia Earhart Dam on the Mystic River.

TABLE 2-1. 1992 MWRA CSO WATER QUALITY MONITORING LOCATIONS

CSO Number	Community	Receiving Water
SOM003	Somerville	Alewife Brook
SOM009	Somerville	Prison Point CSO Facility, Upper Inner Harbor
Somerville Marginal CSO Facility Influent	Somerville (MWRA)	Mystic River, Mystic River/Chelsea Creek Confluence
BOS003	Boston	Lower Inner Harbor
BOS012	Boston	Upper Inner Harbor
Union Park Pump Station Discharge	Boston	Fort Point Channel
BOS080	Boston	Reserved Channel
BOS086	Boston	Northern Dorchester Bay
MWR023	Boston (MWRA)	Lower Charles River
MWRA Fox Point CSO Facility Influent	Boston (MWRA)	Southern Dorchester Bay

Source: Metcalf & Eddy, 1992

During one storm event, sampling was done in Boston Harbor at some of the locations regularly used by the MWRA's Harbor Studies monitoring staff.

The intent of water quality monitoring conducted during 1993 was somewhat different than the 1992 monitoring. Monitoring was focused specifically on the Stony Brook portion of the Boston Water and Sewer Commission (BWSC) system. This area was targeted in order to fully understand and characterize the quality of discharges from the Stony Brook system. This monitoring program was conducted in three stages: 1) field screening, 2) dry weather monitoring, and 3) wet weather monitoring. The field screening program was designed to refine the selection of sites for the dry and wet weather monitoring. Following field screening, eight sampling locations were chosen in order to characterize CSO, stormwater, brook/base flow and interceptor flow. These locations are described in Table 2-2. Grab samples were collected at each sampling location once during dry weather, and up to four times each during two wet weather events. The storms occurred on November 28, 1993 and December 4-5, 1993. Concurrent receiving water sampling was conducted in the Charles River during the December 4-5, 1993 storm events.

TABLE 2-2. 1993 MWRA DRY AND WET WEATHER QUALITY MONITORING LOCATIONS

Structure Designation	BWSC Sheet No.	Description(1)	Receiving Water
1. MH-4	21I	Immediately downstream of BWSC Gatehouse No. 1, on the Stony Brook Conduit, Back Bay. Flow comprised of mixed stormwater and CSO during wet weather.	Charles River
2. MH-5	21I	Immediately downstream of BWSC Gatehouse No. 2, on the Old Stony Brook Conduit, Back Bay. Flow comprised of mixed stormwater and CSO during wet weather.	Inner Harbor via MWRA Prison Point CSO Treatment Facility
3. MH-100	17H	Off Marbury Terr, near Amory St. on the Stony Brook Conduit, Roxbury. Flow comprised of mixed stormwater and CSO during wet weather.	Charles River/Fens Pond
4. MH-107	17H	Off Marbury Terr. near Amory St. on the Stony Brook Valley Sewer, Roxbury. Flow comprised of mixed combined sewer and sanitary.	Boston Harbor via MWRA Deer Island WWTP
5. MH-96	15G	St. Joseph St. on Goldsmith Brook Conduit, Jamaica Plain. Flow comprised of stormwater during wet weather.	Charles River/Fens Pond
6. MH-39	14G	Brookley St. and Stonley St. on the Stony Brook Conduit, downstream of Bussey Brook Conduit, Roslindale. Flow comprised of mixed stormwater and CSO during wet weather.	Charles River/Fens Pond
7. MH-306	11F	Lawnsdale Rd. and Stellman Rd. on the Stony Brook Conduit, Roslindale. Flow comprised of stormwater during wet weather.	Charles River/Fens Pond
8. MH-114	11G	Florian St. and Catherine St., on the Stony Brook Conduit, downstream of Canterbury Brook Conduit, Roslindale. Flow comprised of stormwater during wet weather.	Charles River/Fens Pond

1) "Flow comprised" statement based on data from BWSC 100-scale mapping.

Source: Metcalf & Eddy, 1994a.

The MWRA also has a CSO Receiving Water Monitoring Program which was developed to satisfy the CSO receiving water monitoring requirements in the Authority's NPDES permit. The conditions of the permit require MWRA to: (a) "assess compliance or noncompliance with water quality standards during wet weather and dry weather and minimum dilution conditions (for receiving waters); and (b) provide an assessment of individual overflow impacts on the receiving waters." The current CSO Receiving Water Monitoring program study area encompasses five geographic subareas (although these areas have been further subdivided for the purposes of this report). These areas are: 1) the Inner Harbor, 2) the Neponset River and Dorchester Bay, 3) the Alewife Brook and Mystic River, 4) the Charles River, and 5) Constitution Beach. Monitoring takes place year-round, but is most intensive in between April and October. Sampling is focused on one geographical area at a time. Each area was monitored for approximately three consecutive weeks, six days a week. Attempts are made to collect samples from all stations within an area each day. The sampling locations and methods are fully described in Rex (1993). The parameters measured include bacteria, dissolved oxygen, temperature, and salinity. Some pH measurements have also been made. Information from these long-term monitoring program is used throughout this report in the assessment of existing water quality.

Additional special studies on water quality have been conducted or sponsored by the MWRA and other organizations, and this material has also been cited in this document. Please refer to the references for additional information on specific data sources.

2.2 METHODOLOGY FOR DEVELOPMENT OF CSO FLOWS, FREQUENCY AND LOADS

2.2.1 Definition of Baseline Conditions

Throughout this report, CSO flows from *existing conditions* as well as *future planned conditions* are considered. These conditions are described below.

Existing Conditions

Existing conditions refers to the conditions of the system in 1992, when the extensive CSO monitoring program was conducted. Compared to 1988, when treatment plant and other improvements were initiated by the MWRA, existing conditions include a number of system improvements which have reduced the frequency and volume of CSOs. During 1990 and 1991, the MWRA completed several projects to improve the operation and reliability of the existing Deer Island Treatment Plant, which must remain in operation until the new treatment facilities are on-line. Under the Fast-Track Improvements Program, the power supply was upgraded and augmented through repairs to the electrical distribution system, placement of a new cross-harbor cable and installation of new generators. Five new sewage pumps, along with four new electric pump motors, were installed in the North Main Pump Station to significantly increase overall pumping capacity. In addition, rehabilitation of the primary sedimentation tanks resulted in less off-line time for maintenance and repairs. Increased pumping capacity at Deer Island has reduced the amount of time that flows are choked back at the headworks facilities and has increased the peak flow conveyance capacity of the collection system. As a result, while the total daily flows have remained relatively constant over the past five years, maximum hour flows have seen a marked increase (MWRA, 1993a).

Future Planned Conditions

The system conditions characterized as *future planned conditions* include a number of system improvements and modifications which are part of previous planning such as the Boston Harbor Project and early results of CSO planning efforts. Compared to existing conditions, future planned conditions include the following elements, which are further described below:

- Increased pumping capacities at Deer Island and other facilities
- CSO System Optimization Plans (SOPs)
- CSO Intermediate Projects
- Central Artery modifications
- Interceptor projects for which planning is complete
- Infiltration/Inflow (I/I) rehabilitation projects

Increased Pumping Capacities. These increases result from upgrades of the North Main Pump Station, Charlestown Pump Station and East Boston Pump Station. The North Main Pump Station draws the flows through the North Metropolitan Relief Tunnel and the Boston Main Drainage Tunnel. Under existing conditions, the distribution of flows between these tunnels during periods of high flows can be controlled by the operators at the North Main Pump Station through throttling orders sent to the Chelsea Creek, Ward Street and Columbus Park Headworks. For future planned conditions, the capacity of the North Main Pump Station will equal the joint capacity of the two tunnels, so that the throttling should be limited to instances when flows reaching the headworks exceed tunnel capacities.

System Optimization Plans. These are relatively inexpensive measures which can be implemented in the short term to decrease the frequency and volume of CSOs (MWRA, 1993b). These measures primarily include the raising of regulator weirs and the enlargement of regulator connections to interceptors. The SOPs, which include approximately 150 site specific projects, are expected to reduce untreated CSO volumes by about 25% for the 3-month storm and 12% for the 1-year storm.

Intermediate Projects. These are projects of larger magnitude than the SOPs which have been identified as being beneficial to the performance of the system relative to CSOs. These projects will be designed and built prior to the implementation of system master plan strategies. The intermediate projects included in the future planned conditions are:

- Minor modification at Alewife Brook Pump Station (MWRA system)

- Increased intercept capacity at CHE002, CHE003 and CHE004 (Chelsea system)
- Storm drain separation at MWR207, Regulator 002 (East Boston system)

Central Artery Modification. As part of the Third Harbor Tunnel and Central Artery depression projects, numerous BWSC sewer system modifications were designed and are included in the future planned conditions.

Interceptor Projects. These projects include:

- Braintree-Weymouth interceptor, per Facilities Plan (Metcalf & Eddy, 1993c)
- Framingham Extension Relief Sewer, per design plans (Anderson-Nichols 1992-1993)
- Wellesley Extension Sewer Replacement
- New Neponset Valley Relief Sewer, including Walpole Extension Relief Sewer, Stoughton Extension Relief Sewer, New Neponset Valley Relief Sewer, pumping station and force main
- Upper Neponset Valley Sewer, existing conditions
- Cummingsville branch, existing conditions
- North Metropolitan Trunk Sewer; pipe lining will result in reduced cross section but smoother pipe - 1992 conditions used

I/I Reduction. The MWRA Local Financial Assistance Program has initiated I/I reduction projects which are proposed for construction in the near future. These projects are included in the future planned conditions baseline. Infiltration reduction projects in Newton, Winchester, Melrose, Randolph, Weymouth, Braintree and Stoughton are expected to reduce flows by a total of 3 MGD. Inflow reduction projects in Norwood, Everett, Medford, Belmont and Boston are expected to reduce inflow by 11.3 MG for the 1-year, 6-hour storm.

2.2.2 CSO Flows and Frequencies

The estimation of the CSO flows and frequencies was performed using the EPA Stormwater Management Model (SWMM). The SWMM model was calibrated and verified using field monitoring data. The RUNOFF block of SWMM was used to simulate stormwater runoff into the combined sewer system. The EXTRAN block of SWMM was used to simulate dry weather flow inputs (sanitary and infiltration) to the sewer system and to hydraulically route flow within, and that overflowing from, the system.

An extensive field monitoring program was conducted from April through November, 1992. The field program involved CSO regulator and outfall inspections, rainfall gauging, CSO and sewer system flow metering and CSO quality sampling. Over sixty storms with a good range of variability occurred during the monitoring program. Two of the storms were sampled for quality as discussed above. The sampling program and results are summarized in Chapters 5 and 6 of the Interim CSO Report (MWRA, 1993a).

The field data collected during the 1992 program was used to calibrate and verify the SWMM model used for the Interim CSO Report. Chapter 8 of the Interim CSO report summarizes the use of the field data for the calibration and verification of the CSO model (MWRA, 1993a).

The calibrated/verified model was used to predict CSO flows for a range of design storm events and the results were presented in Chapter 8 of the Interim CSO Report. The predictions presented in the Interim CSO Report showed that the CSO volumes are less than those predicted during the 1990 MWRA CSO Facilities Plan (MWRA, 1990).

Since the February, 1993 Interim CSO Report, upgrades and refinements to the CSO model have been performed as additional information has become available, and studies have been conducted in support of implementation of System Optimization Plans (SOPs), evaluation of intermediate projects and during the development of the MWRA interceptor system model. Also, a second year of field monitoring (October through December, 1993) was performed at specific locations in the CSO system to better define the characteristics of these systems. The CSO systems which were monitored during the second year program included the Stony Brook system, Commercial and Fox Point CSO Treatment Facilities, and the West Side Interceptor.

The model predictions for existing and future planned conditions are described in the SMP Baseline Assessment (Metcalf & Eddy, 1994d). A final calibration/verification report for all system models is being prepared.

2.2.3 CSO Pollutant Concentrations and Loads

CSO pollutant concentrations were estimated by statistical analysis of available CSO quality data. These concentrations were multiplied by CSO volumes to determine pollutant loadings to the receiving waters. Sensitivity analyses were performed to determine whether there were statistically significant differences among the 1992 and 1993 sampling stations, type of discharge being sampled (combined sewage, stormwater or sanitary sewage) and other sampling programs conducted within the study area (Metcalf & Eddy, 1994a). It was concluded that a system-wide arithmetic mean concentration of pollutants is the best representative condition for untreated CSOs (Metcalf & Eddy, 1994a). For effluent from CSO treatment facilities, the mean concentration for each facility was used. Mean concentrations are given in Table 2-3.

2.2.4 Averaging - CSO

In calculating pollutant concentrations, we used the arithmetic mean of the available data. Most pollutant concentrations are log-normally distributed, and therefore the geometric mean is the best indicator of central tendency, and the appropriate average to use to compare data sets or determine spatial or temporal trends. However, the arithmetic average is more appropriate for estimating the total loads, since "spikes" that drive up the arithmetic mean also can contribute large amounts of the pollutant, even if they are infrequent. The difference between the arithmetic and geometric mean is greatest for fecal coliform counts: for example, in the CSO treatment facility data the arithmetic mean is one to three orders of magnitude greater than the geometric mean.

While using the arithmetic mean concentration may give a reasonably good estimate of the annual load, its use is more problematic when looking at the loads contributed by individual storms. Most storms will contribute much less of the pollutant than our "average load", while a few will contribute more. Another approach would have been to use a percentile, say the value for which the measured concentration is less than that value 80% of the time, and indicate that the loading from actual storms will be worse for CSO pollutant concentrations on occasion. We decided to use the arithmetic mean concentration; however, this caveat should be kept in mind when interpreting design storm loads.

We considered only those pollutants for which CSOs could contribute at concentrations which could cause violations of water quality criteria (fecal coliform bacteria, TSS, BOD, Cu, Zn) or could cause eutrophication (BOD, NO_3+NO_2, TKN, total P).

The pollutant concentrations were determined as described in the draft 1993 Flow and Quality Monitoring Program and Results (Metcalf & Eddy, 1994a). Pollutant concentrations presented in Table 2-3 were applied to the CSO volumes to determine the total load to each receiving water segment.

2.2.5 CSO Frequency, Flow and Load Scenarios

The CSO flows and loads to the receiving waters are presented in this report for the three-month and one-year design storms and for a typical year under future-planned system conditions.

The future-planned conditions represent the 1997 planned MWRA wastewater system conditions. This includes completion of the upgrade to the North Main Pump Station and Winthrop Terminal at Deer Island, the completion and activation of the cross-harbor tunnel from the Nut Island Headworks to Deer Island and the outfall tunnel from Deer Island to Massachusetts Bay (see Section 2.2.1).

Differences between existing (*c.* 1991-93) and future-planned (*c.* 1997) CSO flows are presented in Table 2-4 and discussed for each receiving water segment in Chapters 3 through 16 of this report.

2.2.6 Typical Year (Annual) CSO Flows and Loads

The typical year (annual) statistics reflect the use of a typical rainfall year for use in the simulations to estimate the long term average of wet weather conditions which are the cause of CSOs.

TABLE 2-3. MEAN COMBINED SEWAGE POLLUTANT CONCENTRATIONS

		CSO	
Parameter	Unit	Untreated	Treated(a)
TSS	mg/l	140	112
BOD_5	mg/l	78	70
Fecal Coliform	#/100 ml	538,000	(b)
Ammonia	mg/l	3.1	3.1
Nitrate + Nitrite	mg/l	3.4	3.4
TKN	mg/l	5.9	5.9
Total Phosphorus	mg/l	3.1	3.1
Copper	mg/l	0.063	0.063
Zinc	mg/l	0.21	0.21

(a) The treated values for TSS and BOD_5 are applicable for the Cottage Farm and Prison Point CSO Treatment Facilities, only, where a 20 percent removal of TSS and 10 percent removal of BOD_5 is achieved. The other four CSO Treatment Facilities provide screening and disinfection, only.

(b) We used the arithmetic mean fecal coliform count in disinfected effluent from each of the six MWRA CSO treatment facilities, measured for activations between 1990 and 1993. The values for each facility are as follows:

Cottage Farm	26,989/100 ml
Somerville Marginal	167/100 ml
Prison Point	18,345/100 ml
Constitution Beach	3,400/100 ml
Fox Point & Commercial Point	1,600/100 ml (average of the means at the two facilities)

The 1992 calendar year was used as a starting point because rainfall data were available at intervals short enough to allow accurate CSO volume estimation (MWRA, 1994d). Since 1992 was slightly drier than average, with fewer large storms but more small storms, the rainfall record was "typicalized" using the rainfall records from Logan Airport between 1949 and 1987. Some larger storms were added and small ones deleted to bring the monthly and annual statistics for rainfall, number of storms, and storm duration and intensity closer to the long term average.

The best fit year of typical annual rainfall record for the period 1949 through 1987 was identified as 1992. The 1992 rainfall record was refined to delete eight smaller storms (0.25 to 0.76 inches) of which there were too many versus the long-term record. Three larger historical

TABLE 2-4. COMPARISON OF CSO VOLUMES FOR EXISTING AND FUTURE PLANNED CONDITIONS

	3-Month Design Storm			1-Year Design Storm			Typical Year		
	Existing Conditions	Future Conditions	Percent Change	Existing Conditions	Future Conditions	Percent Change	Existing Conditions	Future Conditions	Percent Change
Upper Charles River	0.03	0.02	-33	1.70	2.43	43	46.06	20.04	-56
Lower Charles River	18.19	13.12	-28	61.29	50.85	-17	342.98	213.88	-38
Back Bay Fens	0.00	0.00	0	4.41	3.19	-28	5.25	4.91	-6
Alewife Brook	1.20	0.94	-22	7.34	5.16	-30	26.81	18.30	-32
Upper Mystic River	0.93	0.90	-4	4.58	4.45	-3	7.67	6.76	-12
Mystic River/Chelsea Creek Confluence	8.24	4.40	-47	18.65	10.30	-45	185.96	117.31	-37
Upper Inner Harbor	27.07	14.84	-45	61.44	40.65	-34	307.56	222.13	-28
Fort Point Channel	12.28	8.96	-27	33.40	28.34	-15	298.81	167.68	-44
Lower Inner Harbor	1.32	0.82	-38	6.19	4.70	-24	36.89	12.87	-65
Reserved Channel	4.42	3.58	-19	9.79	8.80	-10	89.09	66.53	-25
Constitution Beach	0.16	0.02	-87	1.03	0.36	-65	4.00	1.35	-66
Northern Dorchester Bay	0.56	0.23	-59	8.61	1.96	-77	14.23	9.03	-37
Southern Dorchester Bay	7.16	6.70	-6	17.62	17.62	0	186.04	168.32	-10
Neponset River	0.09	0.20	135	1.96	1.98	1	6.98	5.79	-17

Note: Volume in million gallons
Source: Metcalf & Eddy, 1994d.

storms (1.18, 1.89, and 2.79 inches) were added to compensate for a lack of larger storms in the 1992 rainfall record. The typical year rainfall contains a total rainfall depth of 43.1 inches occurring in 109 storms. These values are extremely close to the average of the long-term rainfall record. A presentation of the methodology for selecting the typical year rainfall and modeling techniques are presented in the Technical Memorandum for CSO Flows and Loads Analysis - Methodology (Metcalf & Eddy, 1993b).

Once the typical year annual CSO flows to each receiving water segment were determined, the pollutant concentrations listed earlier were multiplied by the volumes to estimate the total annual loads.

2.2.7 Design Storm Flows and Loads

The design storms chosen for evaluation under this report are the three-month and one-year, 24-hour duration design storms. The methodology for selecting the historical storms which best represent the approximate recurrence interval of each is described in the Technical Memorandum for CSO Flows and Loads Analysis - Methodology (Metcalf & Eddy, 1993b). The design storm rainfall characteristics used are presented in Table 2-5.

TABLE 2-5. CHARACTERISTICS OF SELECTED DESIGN STORM EVENTS

Design Storm	Date	Duration (Hrs.)	Depth (In.)	Maximum Intensity (In/Hr.)	Average Intensity (In/Hr.)
3-Month	7/20/82	21	1.84	0.40	0.09
1-Year	9/20/61	22	2.79	0.65	0.13

Design storm CSO volumes were multiplied by the pollutant concentrations listed earlier to estimate the total design storm pollutant loads for each receiving water segment.

2.3 METHODOLOGY FOR DEVELOPMENT OF STORMWATER FLOWS AND LOADS

2.3.1 Stormwater Flows

The estimation of the stormwater flows was performed using the EPA Stormwater Management Model (SWMM) RUNOFF block. The stormwater discharges were modeled as direct, nonconduit point discharges. The model development for this Program and the pollutant concentrations used are described in the Technical Memorandum Estimation of Stormwater Flows and Loads. (Metcalf & Eddy, 1994b).

Stormwater flows are assumed to be the same under existing and future-planned conditions. The flows and loads for the three-month and one-year, 24-hour duration design storms and typical year (annual) were also simulated using the same rainfall records as identified earlier for the estimation of CSO flows and loads. Runoff from separate stormwater areas that discharges into combined sewers downstream of the regulators was included with stormwater flow, not with CSO flow, although it enters the receiving water through a CSO outfall.

2.3.2 Stormwater Pollutant Concentrations and Loads

Stormwater pollutant concentrations were estimated by statistical analysis of available stormwater quality data collected from the study area (Metcalf & Eddy, 1994b). These concentrations were multiplied by stormwater volumes estimated using SWMM (see Section 2.3.1 above) to determine stormwater pollutant loadings to the receiving waters. Because Logan Airport stormwater was found to have rather different concentrations for some pollutants (Metcalf & Eddy, 1994b), runoff volumes from airport catchments were multiplied by these "airport stormwater" concentrations to calculate pollutant loadings.

With the exception of nitrate + nitrite, concentrations of fecal coliform, BOD_5, TSS, nutrients, and metals are lower in stormwater than in combined sewage (Metcalf & Eddy, 1994a, 1994b).

2.3.3 Averaging - Stormwater

As for combined sewage, the concentration of each pollutant was estimated to be equal to the arithmetic mean of the available data. The caveat noted above for CSO pollutant concentrations also applies to stormwater pollutant concentrations. The arithmetic mean concentration yields a load that is an overestimate for the "typical" storm, but is the best estimate of the load for a series of storms combined. The paucity of water quality data, and its variability, is even more pronounced for stormwater than for combined sewage.

In particular, it should be kept in mind that "clean" stormwater at some particular locations (see, for example, BWSC 1993) appears to potentially have a fecal coliform count about one to three orders of magnitude less than the system-wide average for stormwater (Metcalf & Eddy, 1994b). However, for most parameters, the average concentrations in Table 2-6 are consistent with those measured in nationwide studies of urban stormwater, (such as for the U.S. EPA's NURP or U.S.G.S. sampling program as cited in Metcalf & Eddy, 1994a and U.S. EPA 1993). Exceptions to this include the overall concentration of total suspended solids, which lower in the Boston area, and of nitrate and nitrite, which was higher.

TABLE 2-6. MEAN STORMWATER POLLUTANT CONCENTRATIONS

Parameter	Unit	Study Area Excluding Logan Airport	Logan Airport Non-Deicing	Logan Airport Deicing
TSS	mg/l	38	21	54
BOD_5	mg/l	20	42	200
Fecal Coliform	#/100 ml	30,255	--	--
Ammonia	mg/l	1.1	0.76	2.3
Nitrate + Nitrite	mg/l	3.7	0.54	0.49
TKN	mg/l	2.6	2.3	53
Total Phosphorus	mg/l	0.43	0.15	--
Copper	mg/l	0.048	0.070	0.081
Zinc	mg/l	0.17	0.13	0.19

-- Not Measured
Source: Metcalf & Eddy, 1994d.

2.3.4 Risk of Infectious Disease from Stormwater

An issue that is sometimes raised with regard to stormwater is whether the indicator bacteria in stormwater signal the same risk to human health as the indicator bacteria in combined sewage. While the methods for control of microbial contamination from combined sewage and from stormwater may differ, it is well-documented in the microbiological literature that where there are high fecal coliform counts, there is reason to suspect that human pathogens are present, from humans and/or from animals and birds.

2.4 METHODOLOGY FOR DEVELOPMENT OF UPSTREAM RIVER FLOWS AND LOADS

Alber and Chan's (1994) estimates of pollutant loads to Boston Harbor indicate that only two sources are larger than CSOs and stormwater: MWRA wastewater treatment plant effluent and upstream tributary rivers. While there are other sources, such as direct atmospheric deposition and groundwater, the quantification of upstream river flows and loads is critical. MWRA wastewater treatment plant effluent will no longer be discharged to the harbor at the future planned condition time period (1997), while estimation of pollutant loadings from rivers is described in this section.

2.4.1 Upstream River Flows

Flows and fecal coliform loads were previously estimated only for the upstream boundaries of those receiving water areas in which MIT modeled fecal coliform counts, that is, the Amelia Earhart Dam at the mouth of the Mystic River, the Watertown Dam at the upstream end of the CSO-impacted reach of the Charles River, and the Milton Lower Mills Dam on the Neponset River (Metcalf & Eddy, 1994c). To complete the picture of upstream boundary loads, we also estimated flows for this report at the upstream end of the Upper Mystic River receiving water segment (Lower Mystic Lake to Earhart Dam), at the upper end of the lower Charles River segment (near Cottage Farm, where the river widens into the Charles Basin), and at the boundary between the Charles River and the Inner Harbor (the new Charles River Dam).

To estimate the flow discharging to the upper Mystic segment, we subtracted the area draining directly into the CSO-receiving water segment between the Lower Mystic Lake and the Amelia Earhart Dam (11.98 square miles, excluding the Alewife Brook drainage area) from the total Mystic River drainage area (65 square miles) to get the drainage area of the Mystic River above the CSO-impacted segment (53.02 square miles). The ratio of drainage areas (0.81) was multiplied by the flows calculated by Metcalf & Eddy (1994c) at the Amelia Earhart Dam. Hence, for the three month design storm, the upstream flow is approximately 200 million gallons; for the one year design storm, the upstream flow is about 240 million gallons; and a typical year, the volume entering the upstream boundary is about 14,900 million gallons.

The Charles River was modeled by MIT for the most important parameter, fecal coliform. To compare CSO, stormwater, and upstream loads of other pollutants, we estimated the flows downstream of the Watertown Dam.

The flow at the Cottage Farm area, the boundary between our "upper Charles" and "lower Charles" segments, was estimated to be equal to the flow at the Watertown Dam plus the CSO and stormwater flows into the upper Charles segment. This may slightly underestimate the flow since it does not include groundwater input directly to the upper Charles segment. The CSO and stormwater inputs to this segment are small compared to the river flow at the Watertown Dam. For the three month storm, the estimated flow just upstream of Cottage Farm is 2.73 million cubic meters; for the one year storm, the flow is about 3.12 million cubic meters, and the total annual flow is 327 million cubic meters (86,000 million gallons).

At the Charles River Dam, the boundary between the "lower Charles" and "upper Inner Harbor" segments, the flow during design storms was estimated as the sum of the upstream flow into the lower Charles segment plus the CSO and stormwater flows into the lower Charles segment. The flow through the dam is estimated as 3.61 million cubic meters in the three month storm and 4.68 cubic meters in the one year storm. The same method gives an annual flow of 347 million cubic meters. This compares well with the annual flow estimate made by Alber and Chan (1994) for recent (wet) years of 388 million cubic meters (102,000 million gallons).

2.4.2 Upstream River Concentrations

With the exception of fecal coliform, very few data are available on the concentrations of key pollutants in rivers entering at the boundaries of our CSO receiving water area. Alber and Chan (1994) have compiled data from Boston Harbor's tributaries. Most of the available data are for the Charles River. A summary of estimated riverine pollutant concentrations is presented in Table 2-7.

For the upstream boundaries to the areas modeled by MIT, Metcalf & Eddy (1994c) estimated fecal coliform loads for the three-month and one-year design storms using a buildup/washoff model calibrated to measured data. The storm fecal coliform loads from the upper Charles segment to the lower Charles segment, and from the lower Charles segment to the upper Inner Harbor, were derived from the MIT model of the Charles River.

For the upstream boundary of the upper Mystic segment, a rough estimate was made in order to compare riverine loads to the loads from CSOs and stormwater. We used the wet-weather data collected in the routine MWRA CSO Receiving Water Monitoring Program at the confluence of the Alewife Brook and the Mystic River, since the Alewife Brook is likely the largest upstream source to the Mystic River. "Wet-weather" is defined here as a total rainfall on the sampling date and previous two days of one-half inch or greater. Since the three-month and one-year storms are rather large storms, we assumed the fecal coliform count was equal to the 75th percentile of the wet weather data for the three-month storm (600 per 100 ml) and equal to the 90th percentile of the wet weather data for the one-year storm (2200/100 ml). These counts were multiplied by the estimate of upstream boundary flow to provide estimates of the boundary load.

MWRA CSO Program staff sampled for BOD_5, TSS, and nutrient concentrations during two storms in November 1992 at five stations in the Charles River between the Watertown Dam and the downstream new Charles River Dam, and at the Amelia Earhart Dam on the Mystic River; during one storm late in September 1993, at the new Charles River Dam, Amelia Earhart Dam on the Mystic River, and the Lower Mills dam on the Neponset River; and during one storm late in October 1993 at eleven stations in the Charles River between the Watertown Dam and the downstream new Charles River Dam (Metcalf & Eddy 1993a, 1994a).

Concentrations of BOD and TSS at the boundary to the "Upper Charles River" segment were estimated by calculating the arithmetic mean concentrations at the Watertown Dam. The arithmetic means of all Charles River BOD and TSS data were used to estimate these concentrations at the Charles River Dam and to estimate the concentration entering the Charles River Basin from upstream. Arithmetic means of data collected at the Amelia Earhart Dam were used to estimate BOD and TSS concentrations at the mouth of the Mystic River. Concentration

TABLE 2-7. ESTIMATED RIVERINE POLLUTANT CONCENTRATIONS

Parameter	Unit	Charles River (Watertown)	Charles River (upper end of Basin)	Charles River (New Charles River Dam)	Mystic River (upstream)	Mystic River (Earhart Dam)	Neponset River (Lower Mills Dam)
TSS	mg/l	7.4	7.4	7.4	6.5	6.5	7.4
BOD_5	mg/l	12.3	12.3	12.3	6.4	6.4	5.7
Fecal Coliform	#/100 ml						
3 month storm		1921 (a)	950 (b)	244 (b)	600 (a)	1568 (a)	7673 (a)
1 year storm		2820 (a)	1680 (b)	483 (b)	2200 (a)	2507 (a)	5772 (a)
Ammonia	mg/l	0.1	0.1	0.1	0.1	0.1	0.1
Nitrate + Nitrite	mg/l	0.84	0.62	0.62	0.48	0.48	0.32
TKN	mg/l	0.9	0.9	0.9	0.9	0.9	0.9
Total P	mg/l	0.08	0.08	0.08	0.08	0.08	0.08
Copper	mg/l	4.2	4.2	4.2	4.2	4.2	4.2
Zinc	mg/l	3.3	3.3	3.3	3.3	3.3	3.3

(a) Coliform count is a flow-weighted average derived by dividing the riverine load calculated by Metcalf & Eddy (1994c) by the river flow.

(b) Coliform count is a flow-weighted average derived by dividing the riverine load past that point, calculated by the MIT model (see Appendix A), by the river flow past that point.

in flow entering the upstream end of the Upper Mystic River segment (e.g., the Alewife Brook) were assumed to be the same as those at the dam.

We used the arithmetic mean of the high and low estimates presented by Alber and Chan (1994) for Boston Harbor tributaries to estimate pollutant concentrations in the Neponset River.

The laboratory detection limits used for TKN, ammonia, and total phosphorus did not allow quantification of the concentrations; these detection limits were used to help estimate an upper bound for river concentrations. Nutrient data are available from the USGS gaging station in Dover (USGS, cited in Alber and Chan, 1994). These data probably represent a lower bound, since Dover is upstream of many of the sources of pollutants to the Charles River. We used the arithmetic means of the TKN data, and of the total phosphorus data collected by USGS as the estimated concentrations of these pollutants in the rivers. For ammonia, we used the CSO Program laboratory detection limit of 0.1 mg/l as an estimate of river water concentration because ammonia was detected in some of the wet weather samples.

For nitrate + nitrite, the arithmetic mean of the Amelia Earhart Dam data was used for the Mystic River, the arithmetic mean of the Watertown Dam data for the upstream concentration in the upper Charles River, and the arithmetic mean of all CSO program Charles River data for other locations in the Charles River. Since these were as recent CSO program data for the Neponset River, the USGS value of nitrate + nitrite (0.32 mg/l) was used.

There are very few data on metals concentrations, thus, the load of copper and zinc from rivers is uncertain. The concentrations of copper and zinc estimated by Alber and Chan (1994) for Boston Harbor tributaries were used.

Loads were estimated by multiplying concentrations by the flow estimated by Metcalf & Eddy (1994c) or in this report for the design storms and typicalized year.

2.5 DEVELOPMENT OF LOADS FROM OTHER SOURCES

To determine whether other sources were important, the loads from various sources were compared using the estimates made by Alber and Chan 1994. These estimates of other sources are for the entire harbor. The relative importance of the load from the atmosphere or from groundwater is not expected to vary between segments. However, a few segments may have locally important industrial inputs, which are noted in the following receiving water segment chapters. Also, certain sources not considered by Alber and Chan (1994) may be locally important - for example, boats as a source of oil or fecal coliforms to the Inner Harbor, or oil terminal areas as a source of oil and grease to the Mystic/Chelsea confluence area.

Other potentially important sources of the pollutants considered in this report include groundwater and atmospheric deposition (Alber and Chan, 1994). We examined the relative loads of groundwater and atmospheric deposition to CSOs and stormwater by comparing groundwater and atmospheric loadings from Alber and Chan's "North Harbor" area to CSO and stormwater loadings from the marine portion of the CSO receiving waters.

Alber and Chan (1994) present total pollutant loadings by source type for "North Harbor" which includes the Mystic River/Chelsea Creek Confluence, Upper Inner Harbor, lower inner harbor, Fort Point Channel, Reserved Channel, Constitution Beach, Northern Dorchester Bay, Southern Dorchester Bay, the main shipping channel and the Spectacle Island/Long Island area.

2.5.1 Direct atmospheric deposition

Compared to CSO and stormwater, the atmosphere could be a significant source of total nitrogen to the North Harbor (145 tonnes/year compared to 23 tonnes/year from CSO and 73 tonnes/year from stormwater, Alber and Chan 1994). However, some of our receiving water segments have small surface areas and thus, the direct input of nitrogen from the atmosphere to these segments is probably small.

The contribution of direct atmospheric deposition to total nitrogen is almost entirely due to wet deposition of NO_3 and dry deposition of NO_x (Alber and Chan 1994). The atmosphere contributes relatively little ammonia.

2.5.2 Groundwater

Compared to CSO and stormwater, groundwater could be a significant source of copper, total nitrogen, and total phosphorous to the North Harbor (Alber and Chan, 1994, see Table 2-8). We did not calculate groundwater loads by segment for this report.

2.6 METHODOLOGIES AND ASSUMPTIONS FOR RECEIVING WATER MODELING

Detailed receiving water quality modeling was conducted for the Charles River and Boston Harbor. This modeling, which is further described in Appendix A, was limited to fecal coliform bacteria, which are a good measure of the short term impacts of CSOs. Loadings were derived from i) EXTRAN and RUNOFF models of the wastewater system, ii) the RUNOFF models of stormwater drainage and iii) boundary loading models based on RUNOFF calibrated to field measurements (Metcalf & Eddy, 1994d).

Based on the model results, exceedances of fecal coliform criteria at the various resource areas of the receiving water sub-areas were determined. These exceedances were measured in hours for the 3-month and 1-year storm for the following conditions:

- Existing conditions, all sources (3 month storm only)
- Future planned conditions, CSO only

TABLE 2-8. ESTIMATED CONTRIBUTION OF SHORELINE SOURCES TO THE NORTH HARBOR (FROM ALBER AND CHAN 1994)

Source	Copper (kg/yr)	Total Nitrogen (tonnes/yr)	Total Phosphorus (tonnes/yr)
CSO	489	23	8.7
Stormwater	619	73	7.2
Airport	314	13	0.8
Tributaries	2,651	852	85.2
Groundwater	593	60	6.0

- Future planned conditions, all sources
- Future planned conditions, non-CSO sources

These simulations provide quantitative estimates of the relative roles of CSOs, stormwater and other sources in fecal coliform exceedances.

2.7 WATER QUALITY INFORMATION COMMON TO ALL SEGMENTS

2.7.1 Bacteria

In most receiving water segments, the most serious problem associated with CSOs is contamination of water by pathogenic microorganisms, as indicated by the presence of fecal coliform bacteria. Through five years (1989-1993) of monitoring of the CSO receiving waters, focusing on microbiological monitoring, MWRA has developed a good understanding of water quality in Boston Harbor and its tributary rivers.

The monitoring data for each receiving water segment are presented in the following chapters. Data are presented as box plots to allow comparison with the standards, because the standards are defined in terms of the statistical distribution of measurements.

Figure 2-1 illustrates how a frequency distribution is indicated in a box plot. Each horizontal line in a box represents a value (read on the vertical axis) that includes the indicated percent of the data. (For example, the 75th percentile is the value which 75% of the measurements fall below and 25% fall above. Values are shown for the 10th, 25th, 50th (median), 75th, and 90th percentiles. Single measurements beyond this range (outliers) are indicated as dots. The geometric mean is close to the median (50th percentile); it is indicated in the descriptive statistics table below each figure.

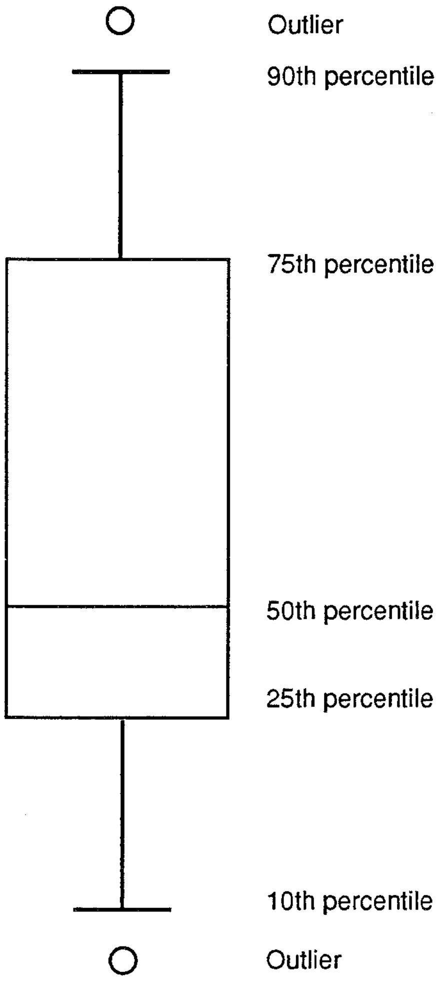


FIGURE 2-1. EXAMPLE BOX PLOT

The box plots highlight the range and central tendencies of the data, and allow for visual comparison of the results among stations and to the standards. In class B and SB waters, suitable for swimming, the geometric mean fecal coliform count should be less than 200 colonies/100 ml, with 90% of the samples having less than 400 colonies/100 ml. The "boating" standard (*i.e.* the class C/SC standard) is a geometric mean of 1000 col/100 ml, with 90% of the samples below 4000 col/100 ml. The shellfishing standard is based on most probable number (MPN), and is not completely comparable to the MWRA monitoring data, but as a rough guide, waters approved for open shellfishing may not exceed a geometric mean MPN of 14 colonies/100 ml, while waters approved for restricted shellfishing with depuration may not exceed a geometric mean MPN of 88 colonies/100 ml. The fecal coliform data are displayed on a logarithmic scale in all the box plots. The "swimming" and "boating" standards are shown on the figures for comparison. To help elucidate the influence of CSOs and stormwater, the data have been divided into "dry", "damp", and "wet" sampling days. Samples were classified as "dry" when there was no rainfall on the day of sampling and on two days prior to sampling. "Damp" weather samples were collected when the three-day cumulative rainfall was between 0 and 0.5 inches. "Wet" weather samples were collected on days when the three-day cumulative rainfall was greater than or equal to 0.5 inches.

It can take a large storm to see a significant elevation over the high, variable dry weather background (Rex, 1993). Improvements to the sewer system have been made (Alber *et al.*, 1993, MWRA, 1993a). However, after the first four years of monitoring, sophisticated statistical techniques did not reveal any statistically significant changes in bacteriological water quality due to improved sewer system operations from water quality changes. The high variability of the data means that more samples will have to be collected in order to detect statistically significant change (Solow, 1993).

In many receiving water segments, stormwater contributes most of the fecal coliform load, and in every segment, it is a substantial component of the load. This is discussed for each receiving water in the following chapters. The risk of infection from stormwater is discussed in Section 2.3.4 above. We believe it is prudent to assume that the presence of indicator bacteria in excess of state standards represents a human health risk, regardless of the source.

2.7.2 Dissolved oxygen

Dissolved oxygen data from MWRA monitoring are also shown on box plots. The plots have a linear scale, and the class B/SB standard of 5 mg/l is indicated. Box plots are presented for bottom and surface dissolved oxygen data. The same structure used for the fecal coliform box plots (Section 2.7.1) is used for the dissolved oxygen data.

2.7.3 Bottom Pollutants and Alterations

Information on sediment enrichment and contamination, and on benthic communities, comes from a number of studies and reviews, which are identified in the relevant chapter. There are no sediment quality standards in Massachusetts; to allow comparison between one area and another, we compare sediment quality data to Massachusetts standards for the classification of dredged material (314 CMR 9.00, cited in Cahill and Imbalzano, 1991) and/or to water quality criteria proposed by Long and Morgan (1990, cited in Cahill and Imbalzano, 1991). The Long and Morgan values were not intended to be used as standards, but they may help assess relative levels of contamination between CSO receiving water segments. These values are given in Table 2-9. Where PAH data are available, rather than list all compounds measured, we have summed the six most commonly measured PAHs, following the example of MacDonald (1991). This provides a useful summary number, since the meaning of "total PAH" can vary between studies depending on which compounds were analyzed. Readers interested in more detail on individual organic compounds may consult the original reports on each study.

2.7.4 Nutrients and chlorophyll

Nutrient and chlorophyll data come from a number of sources, described in the following chapters. The state standard for nutrients is a narrative one. To qualitatively rate receiving water segments as "healthy", "fair", or "poor", nutrient concentrations have been compared to guidelines suggested in published reports (Table 2-10). In the marine segments, nutrient data are compared to nutrient ranges given in EPA's guidelines for use attainability in estuaries (U.S. EPA undated). Marine chlorophyll concentrations are evaluated using Wetzel's (1983) method for estimating the trophic status of estuaries.

In freshwater segments, nutrient concentrations are compared to ranges given in Mass DEP's summary of water quality for 1992 (Mass DEP, 1992), Appendix II - Massachusetts lake classification program. Except possibly for the lower Charles River, Mystic River (above the Amelia Earhart Dam), and Back Bay Fens segments, the receiving waters cannot be considered lakes; however, the lake ranges in Mass DEP (1992) were used as guidance.

2.7.5 Toxicity

For the analysis of existing conditions, we have assumed that any whole effluent acute toxicity (WET) associated with unchlorinated CSO discharges is minimal and limited to a small mixing zone around the discharge except for the toxicity associated with chlorinated discharges (whole effluent toxicity) from the existing CSO screening and chlorination facilities.

TABLE 2-9. SEDIMENT QUALITY LEVELS FOR COMPARISON TO DATA

	Massachusetts State Sediment Classifications (dredged material)			Long and Morgan (1990) Effects Range	
	I	II	III	Low (ER-L)	Medium (ER-M)
Metals					
Arsenic	<10	10-20	>20	33	85
Cadmium	<5	5-10	>20	5	9
Chromium	<100	100-300	>300	80	145
Copper	<200	200-400	>400	70	390
Lead	<100	100-200	>200	80	145
Mercury	<0.5	0.5-1.5	>1.5	0.15	1.3
Nickel	<50	50-100	>100	30	50
Silver				1	2.2
Zinc	<200	200-400	>400	120	270
Total PCBs	<0.5	0.5-1.0	>1.0	0.05	0.4
PAHs					
fluoranthene				0.6	3.6
pyrene				0.35	2.2
chrysene				0.4	2.8
benz(a)anthracene				0.23	1.6
phenanthrene				0.225	1.38
benzo(a)pyrene				0.04	2.5
$tPAH_6$				1.8	14

All values in ppm dry weight (ug/g)

$tPAH_6$ is the sum of the six commonly measured PAHs, listed above.

TABLE 2-10. RANGES OF NUTRIENT CONCENTRATIONS USED TO EVALUATE WATER QUALITY

	Riverine		Estuarine	
	$NH_3 + NO_3$	Total P	Total N	Total P
"healthy"	<0.15	<0.01	<0.6	<0.08
"fair"	0.15-0.3	0.01-0.05	0.6-1.8	0.08-0.20
"poor"	>0.3	>0.05	>1.8	>0.20

Units in mg/l

This assumption was also made in the 1990 CSO Facilities Plan (MWRA, 1990) and is based on the following:

- Sampling of CSO effluent shows minimal acute toxicity.
- CSO discharges are short in duration, and it is difficult to compare their impacts to existing standards.
- CSO effluent would provide similar toxicity concerns as treatment plant effluent, but much more dilute. Most toxicity due to CSOs will be associated with chlorination.
- Small mixing zones would dissipate any toxicity impact associated with CSOs.

Nature of CSO discharges and standards. CSO discharges persist from a few minutes to perhaps a couple of days at very variable concentrations of contaminants (Wallace *et al.*, 1990) while the acute toxicity tests used to determine the impact of potential contaminants in CSOs are conducted over four days at uniform contaminant concentrations. As a result, most CSO testing data are likely to overestimate the toxicity impacts of CSOs on receiving waters. Nationally, EPA has recognized the importance of this issue and is in the process of developing specific wet weather standards for discharges during storms.

Acute toxicity test results. As part of its NPDES mandated monitoring of CSO discharges, MWRA conducted acute WET tests at its permitted discharges at Cottage Farm, Prison Point, and Somerville Marginal (Aquatec 1991a, 1991b, 1991c, 1991d, 1991e, 1992). Tests were conducted on fish and invertebrates every other month from March, 1991 to February, 1992. Because the effluent at these facilities is chlorinated, dechlorination was performed before the toxicity tests were done. At all the facilities, the LC50 (the concentration of CSO effluent at which half the test animals died) was reached at 90 to 100% of CSO effluent, with the LC50 occurring with 100% or full-strength CSO effluent much of the time.

CSO effluent compared to MWRA primary effluent. The CSO WET test results show approximately one-half to one-third the toxicity of primary effluent at the Deer and Nut Island treatment plants. This toxicity roughly correlates with the strength of the two effluents:

treatment plant effluent is generally two to three times more concentrated than the CSO effluent at these facilities. A detailed characterization of the sources of toxicity in the Deer Island effluent conducted by U.S. EPA's Duluth laboratory showed that all the acute toxicity in the Deer Island effluent was due to the presence of surfactants and the impacts of effluent chlorination (Ankley, 1989). Because the retention time of effluent in MWRA's CSO screening and chlorination facilities is so short, the residual chlorine in CSO effluent is generally much higher than in the primary effluent discharged at Deer Island (Bigornia-Vitale and Sullivan, 1994). Other sources of toxicity are likely to be insignificant compared to chlorine.

Spatial extent of impact to receiving waters. These sampling results indicate that any toxicity associated with CSO discharges beyond chlorination impacts should be small and ameliorated by dilution greater than a factor of two (2 parts receiving water to 1 part effluent). Analysis of mixing zones around the harbor shows that, for nearly all CSOs during the vast majority of storm events, a two-fold dilution is exceeded within a very short distance of the outfall.

2.7.6 Mixing Characteristics

There is a wide range in the physical characteristics of the various water bodies in the study area. These characteristics range from deep, wide, marine, tidal waters, such as the Inner Harbor, to shallow, free-flowing, narrow streams, such as the upper Charles River to the wide, fresh water, low-velocity deeper portion of the Charles River impoundment. These physical characteristics govern, to greater or lesser degrees, the mixing, stratification, plume dispersion and other hydrodynamics of CSO discharges on the water body.

In an effort to understand the unique effects of CSO discharges on each receiving water, we examine, in the following chapters, the mixing characteristics of one or more CSOs in each of the fourteen receiving water segments. In general, this mixing includes near field, intermediate field, and far field mixing. Near field mixing occurs closest to the outfall and is caused by the momentum and or buoyancy of the effluent relative to the receiving water. Intermediate field mixing is caused by receiving water currents and turbulence over distances too small to be resolved by the receiving water models (QUAL2EXP or TEA/ELA). Far field mixing is also caused by receiving water currents and turbulence, but at larger distances which can be resolved by the models.

Where possible, mixing is characterized by the volumetric dilution, defined as the ratio of mixed effluent plus receiving water flow divided by the original effluent flow. The reciprocal of dilution gives the ratio of effluent concentration to discharge concentration. For example, consider an effluent with initial contaminant concentration of 10 mg/L. If near field processes produce a dilution of 5 at a distance of 30 meters from the outfall, the concentration 30 meters away would be 2 mg/l. Further, if the combination of near field plus intermediate field processes produce a dilution of 10 at distance of 100 meters from the source, the concentration 100 meters away would be 1 mg/L.

2.8 CSO RECEIVING WATER SEGMENTS

The following sub-watersheds are considered in this report:

- Upper Charles River (above Cottage Farm)
- Lower Charles River (Cottage Farm and below)
- Back Bay Fens, Muddy River/Stony Brook
- Alewife Brook
- Upper Mystic River (freshwater segment)
- Mystic/Chelsea Confluence (Mystic River below Amelia Earhart Dam, and Chelsea Creek)
- Upper Inner Harbor (west of Commonwealth Pier)
- Fort Point Channel
- Lower Inner Harbor (east of Commonwealth Pier)
- Reserved Channel
- Constitution Beach
- Northern Dorchester Bay
- Southern Dorchester Bay
- Neponset River

Table 2-11 lists the CSOs discharging into each of these areas; Figure 2-2 indicates the location of each segment.

Receiving waters were segmented by considering a number of factors that vary between segments: water quality, number of CSOs, uses of the receiving water and adjacent shoreline, and water body hydrodynamics. For example, the Inner Harbor was separated into the Upper Inner Harbor and the Lower Inner Harbor since the Upper Inner Harbor has better water quality, fewer CSOs, less recreational boating and more shipping, extensive transportation-related land use, slightly better flushing and less stratification than does the Lower Inner Harbor.

TABLE 2-11. CSOs DISCHARGING INTO EACH RECEIVING WATER SEGMENT

Upper Charles River	BOS032, BOS033, CAM005, CAM007, CAM009, CAM011
Lower Charles River	BOS028, BOS042, BOS049, CAM017, CAM018 *, CAM019 *, MWR010, MWR018, MWR019, MWR020, MWR021, MWR022, MWR023 (Stony Brook), MWR201 (Cottage Farm)
Back Bay Fens, Muddy River/Stony Brook	BOS046
Alewife Brook	CAM001, CAM002, CAM003, CAM004, CAM400, CAM401, SOM001, SOM001A, SOM002, SOM002A, SOM003, SOM004, MWR017 (Alewife) *
Upper Mystic River	SOM005 *, SOM006 *, SOM007, SOM007A
Mystic/Chelsea Confluence	BOS013, BOS014, BOS015, BOS017, CHE002, CHE003, CHE004, CHE007 *, CHE008, SOM009, SOM010, MWR205 (Somerville Marginal)
Upper Inner Harbor	BOS009, BOS010, BOS012, BOS019, BOS050, BOS052, BOS057, BOS058, BOS060, MWR203 (Prison Point)
Fort Point Channel	BOS062, BOS064, BOS065, BOS068, BOS070, BOS072, BOS073
Lower Inner Harbor	BOS003, BOS004, BOS005, BOS006, BOS007
Reserved Channel	BOS076, BOS078, BOS079, BOS080
Constitution Beach	MWR207 (Constitution Beach; formerly BOS002)
Northern Dorchester Bay	BOS081, BOS082, BOS083, BOS084, BOS085, BOS086, BOS087
Southern Dorchester Bay	BOS088, BOS089 (Fox Point), BOS090 (Commercial Point)
Neponset River	BOS093, BOS095

* Believed inactive, and not included in sewer system model

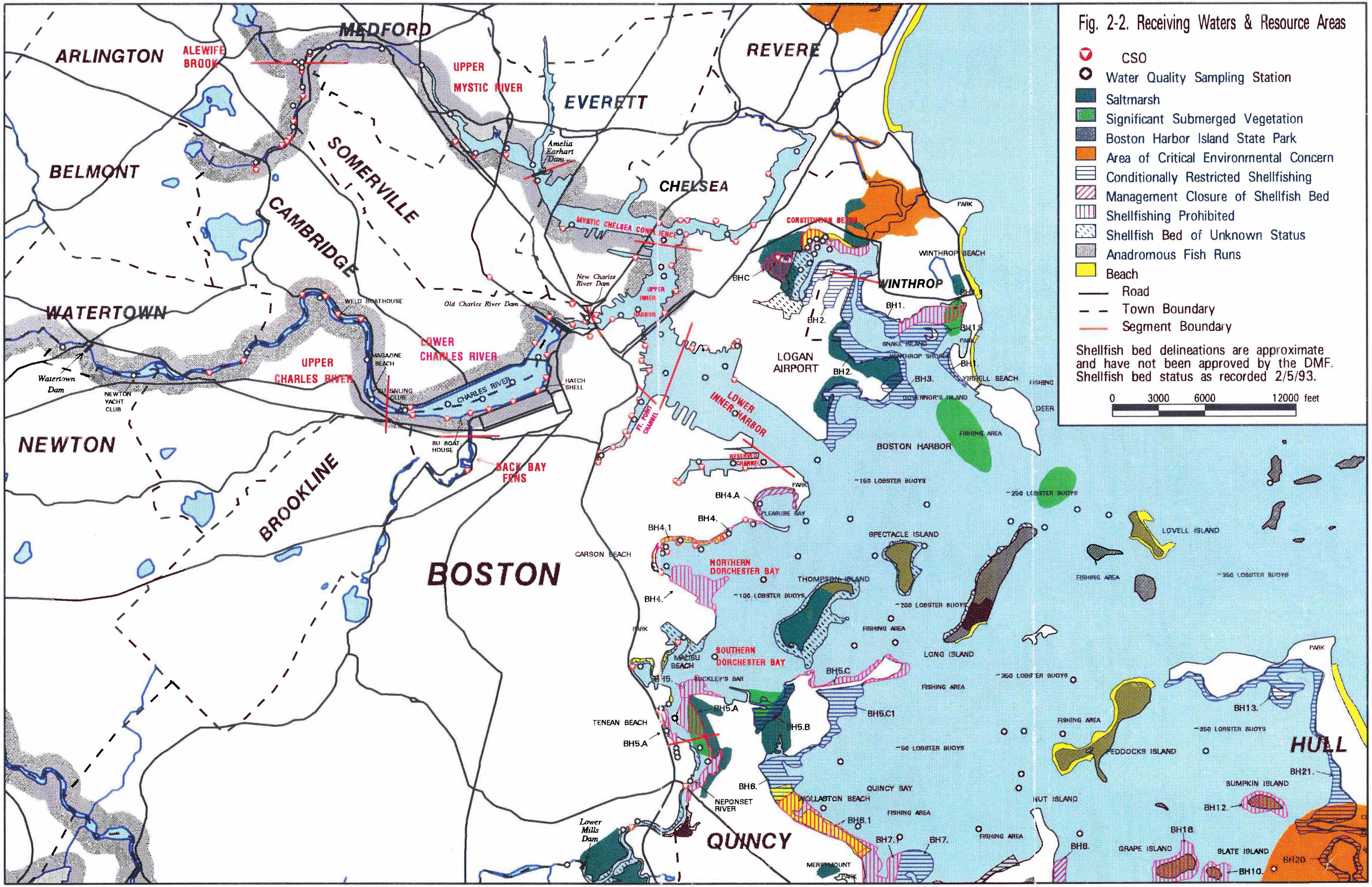


Fig. 2-2. Receiving Waters & Resource Areas

CHAPTER 3
UPPER CHARLES RIVER

3.1 DEFINITION OF RECEIVING WATER SEGMENT

The upper Charles River subarea includes the Charles River between the Watertown Dam and the Cottage Farm (Boston University) Bridge (Figure 3-1). The river is bounded on the north by Watertown and Cambridge, and on the south by Newton and Boston. At the USGS gage in Waltham near the Watertown Dam, the average river flow between 1931 and 1992 is approximately 8.6 m^3/sec (or 305 ft^3/sec). In this stretch the river has a slow current and is shallow (less than 4 meters in depth). The six CSOs located in this segment are relatively inactive. The upper Charles River receiving water segment in this report excludes the Cottage Farm CSO (MWR 201) and therefore, differs somewhat from previous MWRA reports (MWRA, 1993a).

3.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The stretch of the Charles River from the Watertown Dam to the Charles River Dam in Boston (Mile 9.8 to 1.2) is designated as "Class B - Fishable/Swimmable and other compatible uses" (Mass DEP 1990). The Class B uses include primary and secondary contact recreation, and the expectation that the river supports healthy aquatic life, the consumption of fish (*i.e.*, no health advisories) and is an aesthetic resource.

The primary recreational use of the upper Charles River is boating. Watertown has a public boat landing. There are two additional launching areas further downstream that are used mainly for powerboat access to the river. There is a new canoe and kayak rental facility near the Eliot Bridge. Private boating facilities include the Newton and Watertown Yacht Clubs and several collegiate crew boathouses. Boating events such as regattas are often held on this stretch of the river.

The land along the upper Charles River segment is heavily developed and used for nearshore recreation (the Charles River Reservation) including playgrounds, rinks, recreation centers, and pools. This area is bordered by major roads, including Soldiers Field Road, Storrow Drive and Memorial Drive. Parkland and/or developed walkways provide linkages along much of the river; the bicycle path along either side of the river is used by pedestrians as well as cyclists. This parkland also serves as launching areas for sailboards. Magazine Beach near the B.U. Bridge was historically used for swimming; an MDC pool is now operated in this area.

Away from the river's edge, the section from the Watertown Dam to the Charles River Dam is mainly urban residential. Near the mouth, there is the intensive commercial land use of downtown Boston and East Cambridge. The banks are generally parklands bordered by major roads (Soldiers Field Road/Storrow Drive, and Memorial Drive).

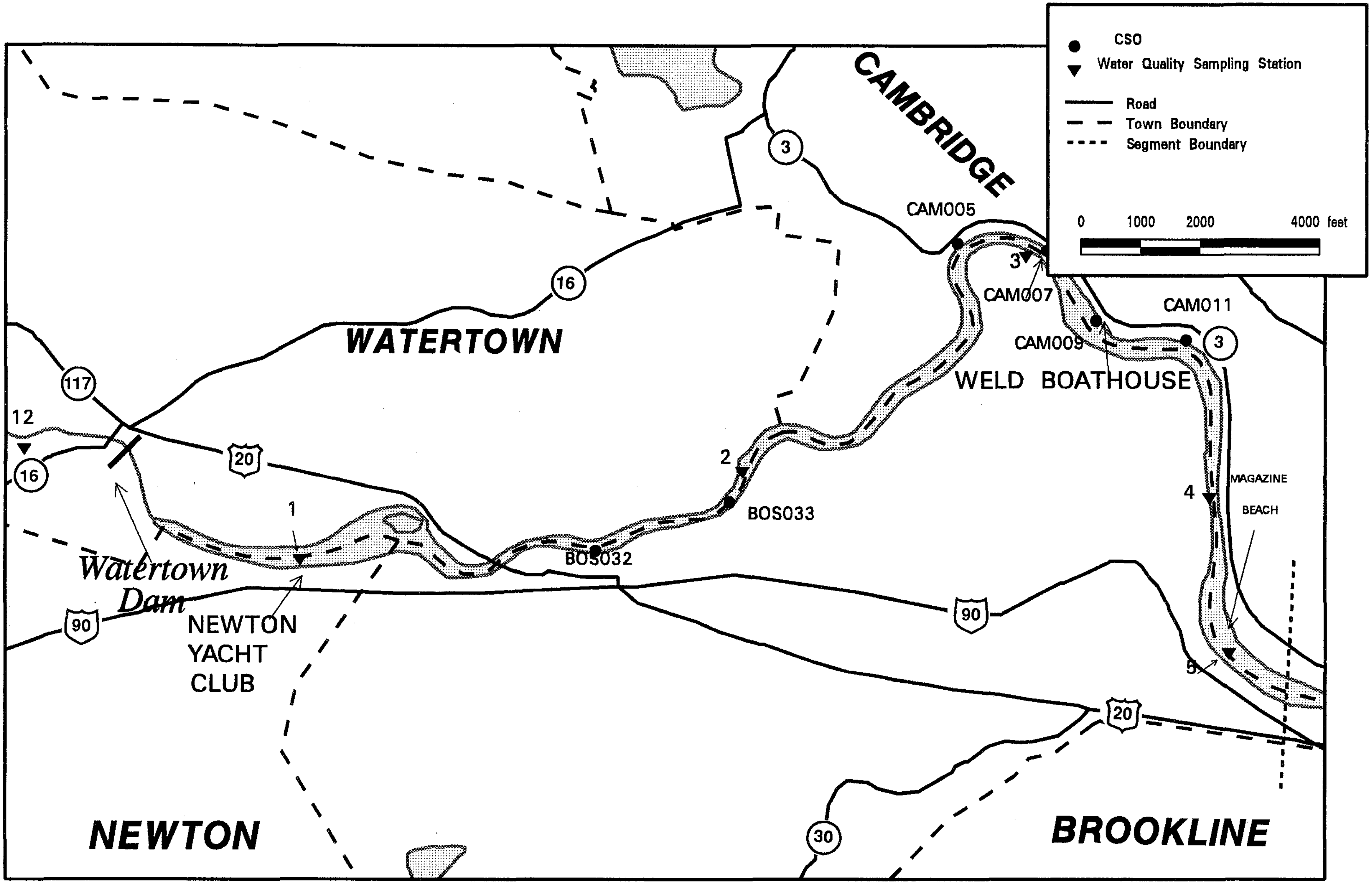


FIGURE 3-1. UPPER CHARLES RIVER

The river supports a large run of anadromous blueback herring each spring. There is a fishway at the Watertown Dam. Some of the herring may spawn in this segment.

3.3 CHARACTERIZATION OF WATERSHED

The Charles River is the longest river in Massachusetts and its water quality is impaired by many natural and anthropogenic activities. This section focuses on the watershed of the Upper Charles River (upstream of the Watertown Dam). The watershed is discussed with regard to its possible effect on water quality in the Upper Charles River receiving water segment.

3.3.1 Location

The watershed is located in eastern Massachusetts; the river drains 806 km^2 and meanders 130 km from its headwaters of Echo Lake, Hopkinton to its mouth at Boston Harbor (Figure 3-2). Towns with either a large portion of their land area in the watershed and/or which withdraw water for water supply are listed by population, land area and density in Table 3-1. (MassDWR, 1988, pg 33).

3.3.2 Topography and Soils

The profile of the river is in Figure 3-3 (USGS 1991). There are a series of wetlands in the central portion of the watershed, after which the river elevation drops to approximately mean sea level over several dams - the lowest is the Watertown Dam. According to Hall (1986), this is the approximate upstream boundary of tidal influence when the Charles River was an estuary. Below the Watertown Dam, the river is essentially a backwater of the Charles River Dam as it passes through highly urbanized Cambridge and Boston to Boston Harbor.

According to the United States Department of Agriculture (1989), the predominant soils in the upper five to six feet in the portion of the watershed above Newton (Norfolk County) is "Hinckley-Merrimac-Urban" along river and "Canton-Charlton-Hollis" away from the river. Both types of soils are poor for septic systems since they readily absorb effluent but do not adequately filter it. A review of the detailed soil types along the river banks in the portion of the watershed in Norfolk County indicate that they have a high susceptibility to erosion as indicated by their "K" values (0.49). In portions of the watershed immediate to the banks, the susceptibility is moderate (0.24).

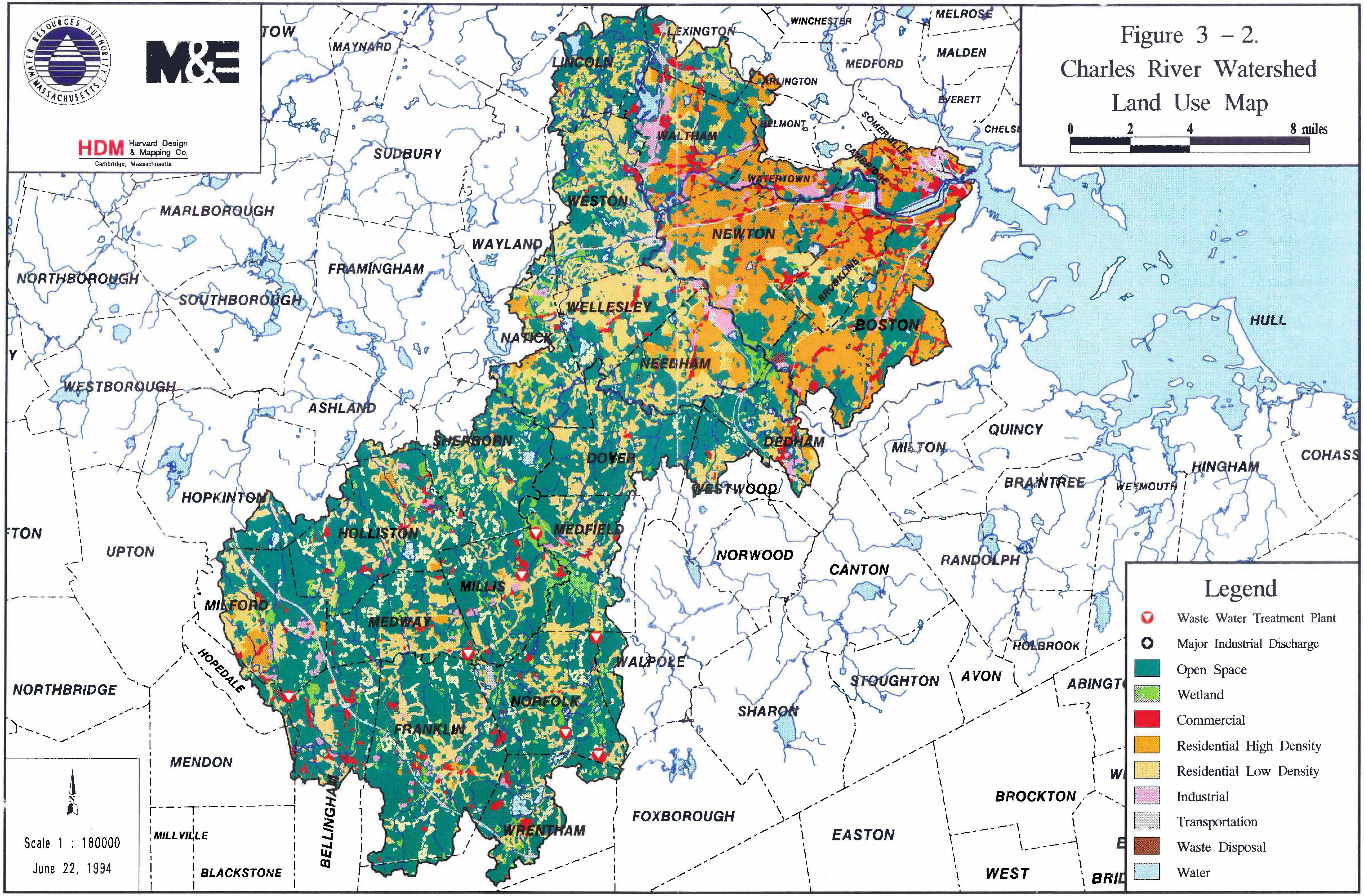
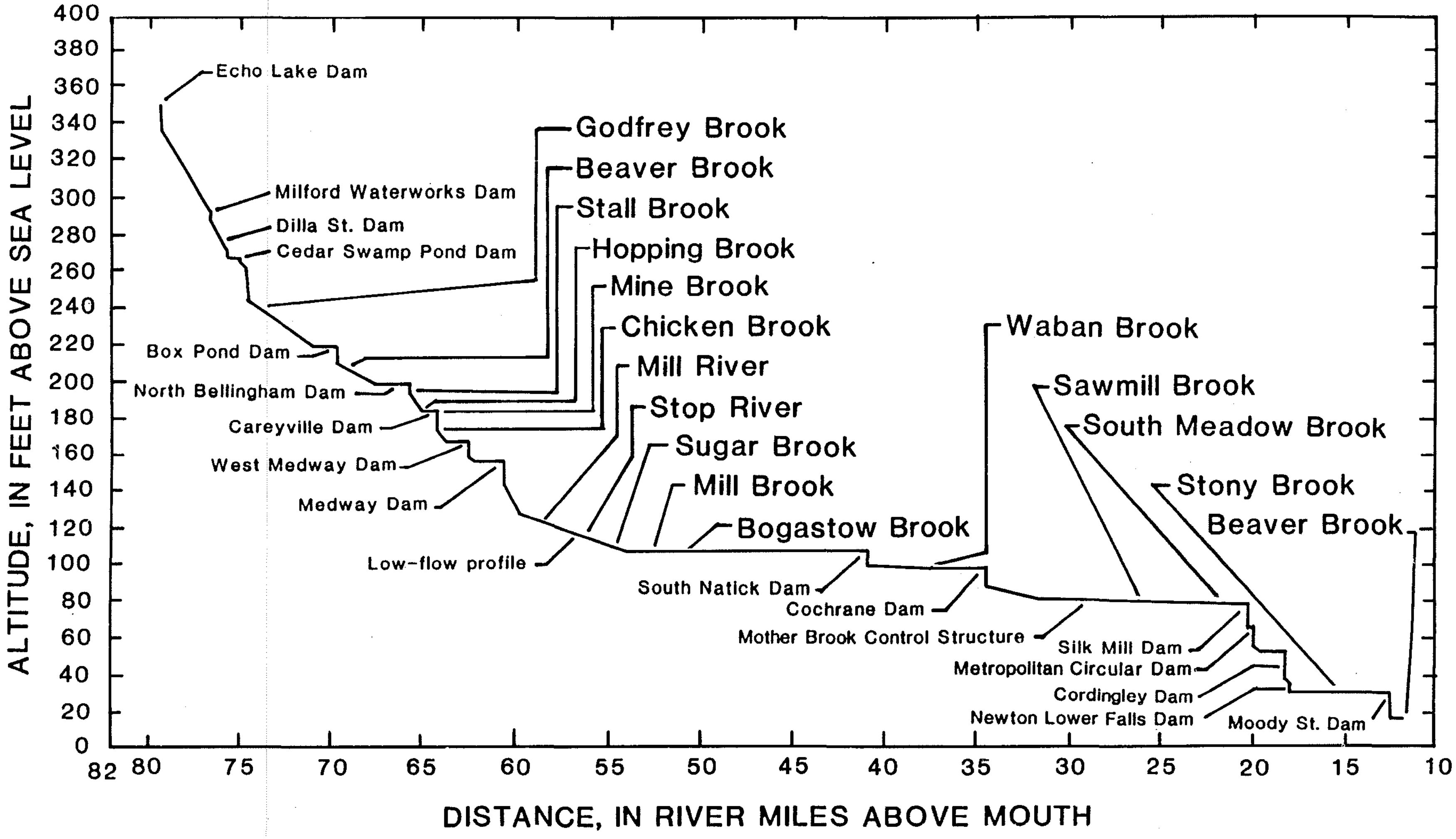


Figure 3 – 2.
Charles River Watershed
Land Use Map



SOURCE: USGS WATER RESOURCES
INVESTIGATION REPORT
88-4173, 1991

FIGURE 3-3. CHARLES RIVER PROFILE

TABLE 3-1. 1985 MASSACHUSETTS CENSUS LAND AREA AND DENSITY CHARLES RIVER BASIN
(Arranged in descending order of size)

Location	1985 Population	Land Area (sq. mi.)	Density (persons/mi^2)
Boston	601,095	50.55	12,252
Cambridge	86,865	26.98	11,891
Newton	82,925	22.56	8,552
Brookline	58,152	19.06	7,775
Waltham	57,955	18.91	4,564
Watertown	32,189	18.17	4,243
Natick	30,280	17.32	2,576
Needham	27,870	16.14	2,222
Wellesley	27,052	15.98	2,189
Milford	24,038	15.46	1,895
Dedham	23,729	15.32	1,603
Franklin	17,865	15.00	1,188
Bellingham	13,677	14.96	744
Westwood	13,174	14.64	723
Holliston	12,606	13.66	706
Weston	10,743	12.73	662
Medfield	10,330	12.25	661
Medway	9,037	11.67	620
Norfolk	8,210	11.09	546
Wrentham	7,223	10.68	536
Lincoln	6,902	10.50	461
Millis	6,689	7.09	320
Dover	4,581	6.80	296
Sherborn	4,350	4.14	270

Source: 1985 State Census

3.3.3 Dams, Highways, and Other Man-Made Features

As shown in Figure 3-3, the Charles River main stem has many dams built on it. The dams slow the flow of the river and trap contaminated sediments. The Charles River Basin and the dams at the river mouth are described in Chapter 4.

3.3.4 Wetlands

There are 22,000 acres (88 km^2) of wetlands in the Charles River watershed (Mass DEM/DWR, 1988). Most of the wetlands are in the central portion of the watershed. In fact, the brown/olive-green color of the river is derived from its contact with wetland vegetation. The wetlands provide the important functions of wildlife habitat, filtration of pollutants, and flood buffering. In fact, 8,100 acres are under the control of the US Army Corps of Engineers for the explicit purpose of flood control and are referred to as Natural Valley Storage Areas.

3.3.5 Watershed Towns, Upstream Land Use, and Upstream Pollution Sources

There are 24 communities in the Charles River watershed (See Table 3-1/Figure 3-2). Those in the downstream, urbanized portion of the watershed have the greatest population densities.

Land use in the watershed is also shown in Figure 3-2. Far upstream, most of the watershed is forested, switching over to primarily residential near the Watertown Dam. Several major highways cross the river or border it for long stretches. In the lower reaches of this upstream section, there are some large areas of industrial and commercial activity. Figure 3-2 also shows the treatment plant discharges upstream of the Watertown Dam (Mass DEM/DWR, 1988, pg 60-1).

According to Mass DEM/DWR (1988), several towns in the Charles River watershed are served totally or partially by individual on-site septic systems. Based upon the 1985 State Census, there are 102,700 people with on-site systems. There are also commercial and industrial activities discharging to on-site systems. However, all of these systems do not discharge into the Charles River Basin since not all of the land areas of these towns are in the watershed.

The 1977 Upper Charles River Watershed Section 208 Report (MAPC, 1977a) and the 1977 Lower Charles River Watershed Section 208 Report (MAPC, 1977b) both found some of the nonpoint pollution sources in the basin to be "failing septic systems, improperly sited and operated landfills, poor storage and excessive applications of road salt, and stormwater runoff..." (MAPC 1977a, pg. 3-8).

Table 3-2 shows number of disposal sites in each town of the watershed which are confirmed or are to be investigated. Most disposal sites are in the furthest downstream communities. The 305(b) report for Massachusetts (Mass DEP, 1993b) assesses the use attainment status of each reach of the river (Table 3-3).

3.4 SOURCES OF POLLUTION

3.4.1 General

The largest pollutant sources to the upper Charles River sub-area are upstream sources (above the Watertown Dam), stormwater and combined sewer overflows. There are no known industrial or cooling water discharges. Dry weather sewage flows, apparently from illegal connections to CSOs and storm drains, have been observed. There is extensive boating activity on the Charles River; power boats and marinas are a potential source of pollutants such as oil, grease, and bacteria from marine heads. Causes of pollution and their sources are listed in Table 3-3 for the entire Charles River Basin.

Estimated flows and loads of stormwater, CSOs, and upstream sources are shown in Figures 3-4 and 3-5. Flows and loads from CSO are for "future planned conditions" (*c.* 1997), so the actual flows and loads generally are slightly higher. For example, for the three-month storm, CSO flows in the Upper Charles River segment are actually about 33% higher under "future planned" conditions.

3.4.2 Stormwater Discharges

Part of the area draining directly to this segment has separate storm drains. The stormwater volume in the design storms and annually is much larger than the CSO volume.

3.4.3 Upstream Inputs

High concentrations of many pollutants have been measured at the Watertown Dam. In particular, the upstream contribution of indicator bacteria (MWRA, 1991; Rex, 1993), PAHs (Battelle 1990), and nutrients (CH2M Hill 1989; E. Romanow, UMass/Boston, pers. comm. 1993) may affect the water quality of the upper Charles River segment.

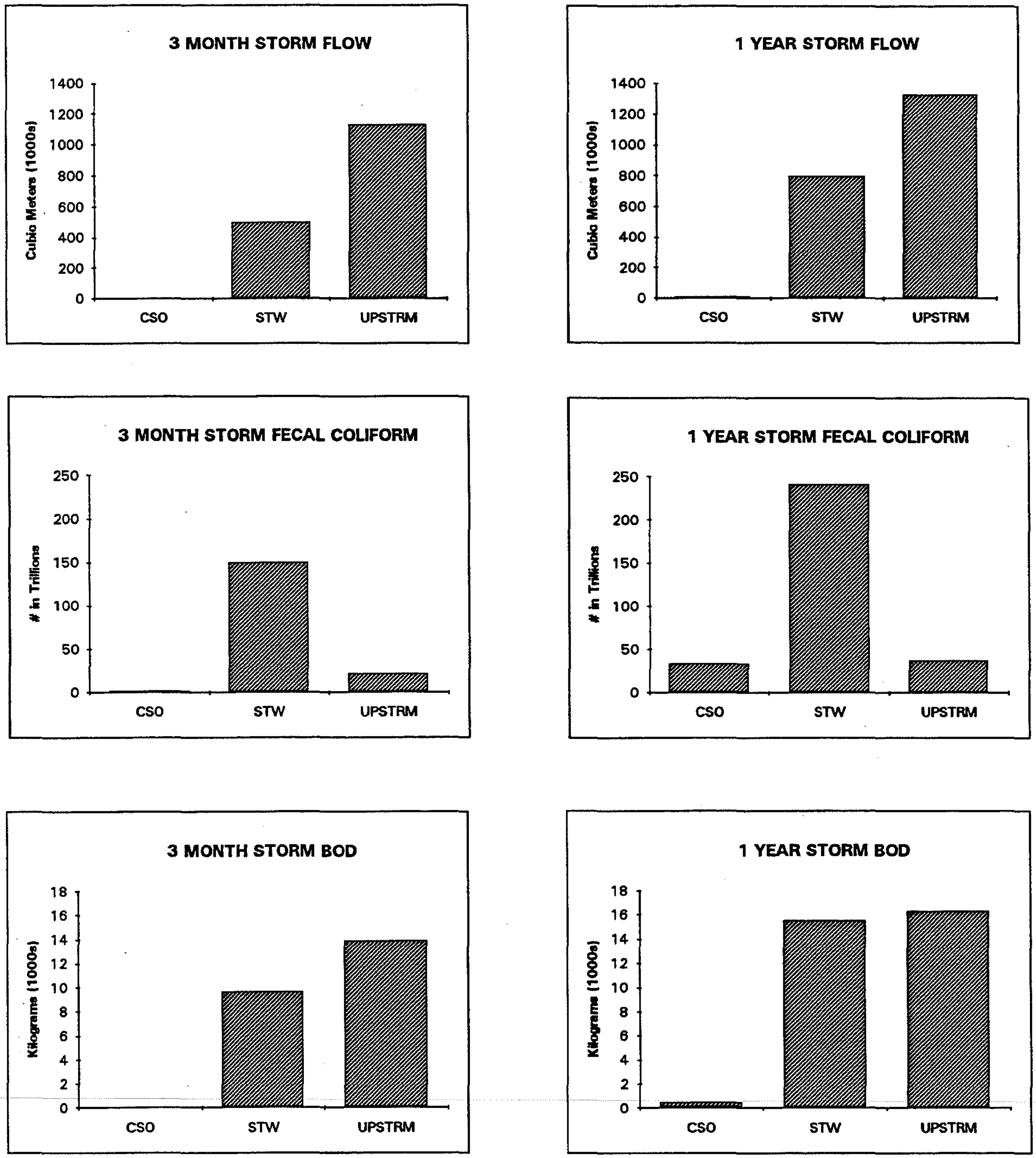


FIGURE 3-4. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - UPPER CHARLES RIVER

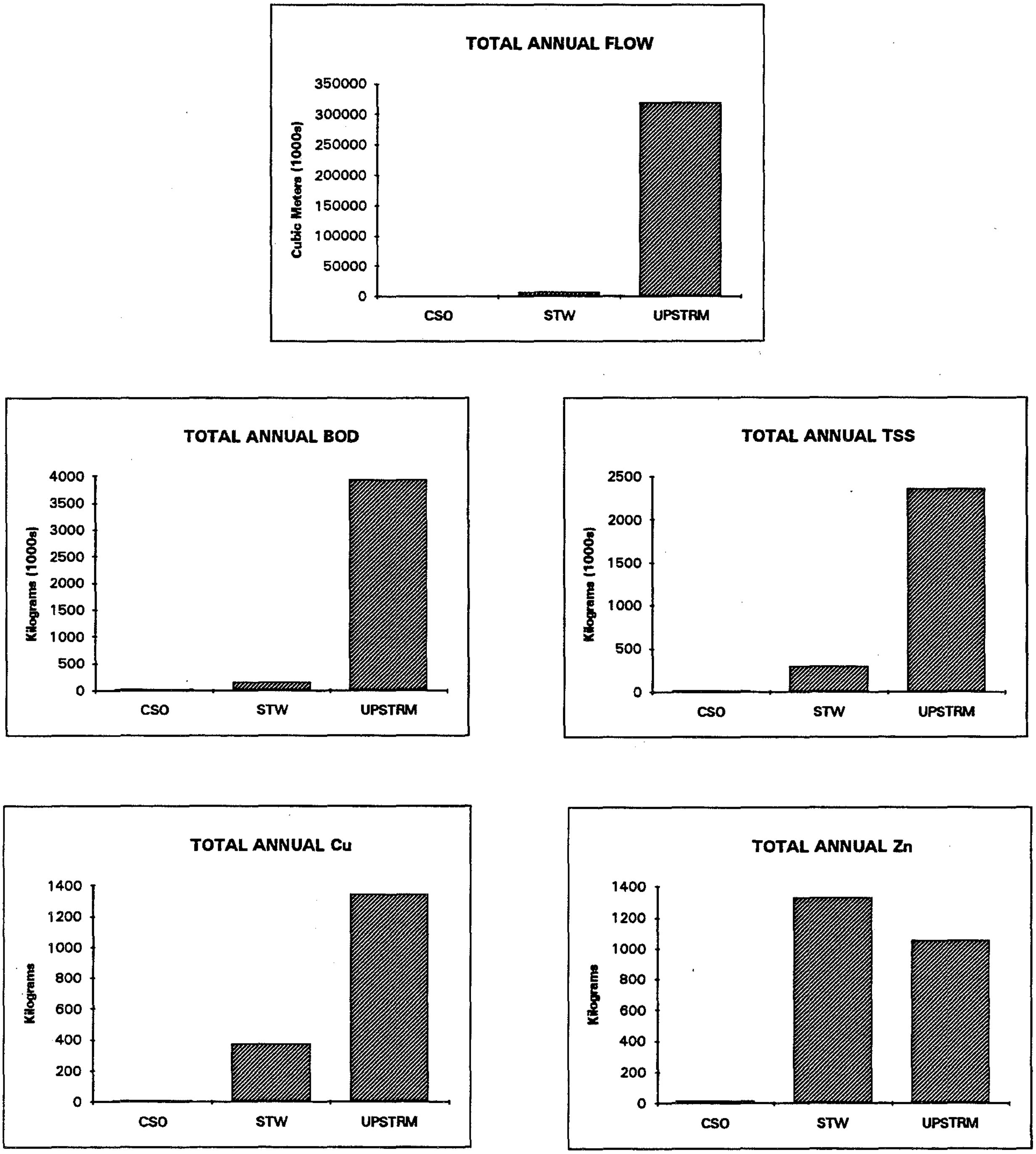


FIGURE 3-5. FUTURE PLANNED FLOWS AND LOADS - UPPER CHARLES RIVER
(a) FLOWS, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

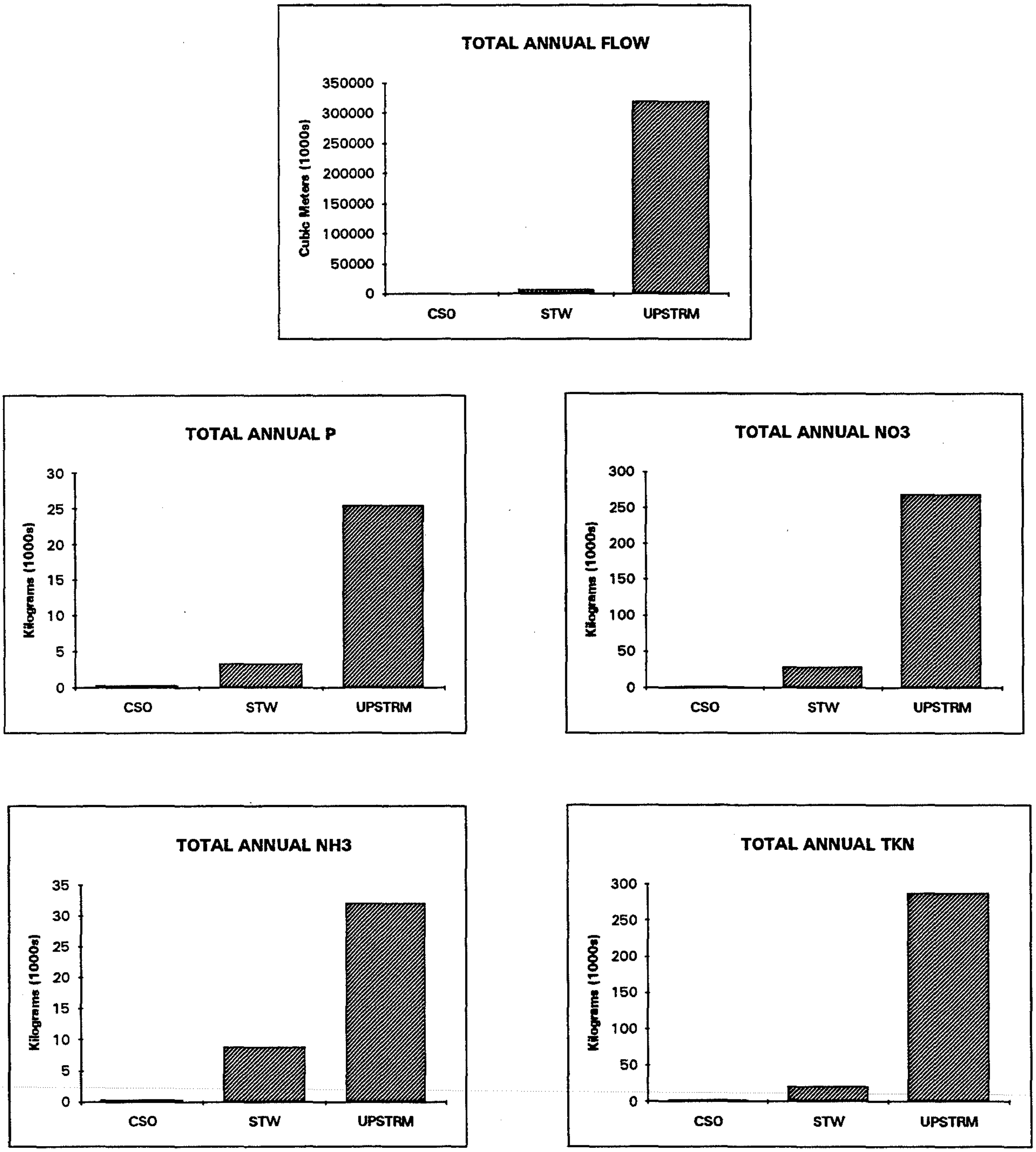


FIGURE 3-5. FUTURE PLANNED FLOWS AND LOADS - UPPER CHARLES RIVER
(b) FLOWS, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

TABLE 3-2. DISPOSAL SITES IN THE CHARLES RIVER WATERSHED THAT HAVE BEEN CONFIRMED OR ARE TO BE INVESTIGATED

Boston - 507	Natick - 51	Bellingham - 9	Norfolk - 11
Cambridge - 125	Needham - 43	Westwood - 15	Wrentham - 9
Newton - 78	Wellesley - 16	Holliston - 9	Lincoln - 9
Brookline - 34	Milford - 20	Weston - 10	Millis - 13
Waltham - 77	Dedham - 32	Medfield - 6	Dover - 8
Watertown - 42	Franklin - 11	Medway - 3	Sherborn - 2

Source: MassDEP, 1993b.

TABLE 3-3. 305(b) SUMMARY, CHARLES RIVER BASIN AND COASTAL DRAINAGE AREA

Location	River Miles	Class	Status	Causes	Sources
Charles River					
Headwaters to Dilla Street	78.9 - 76.5	A/WWF	S/T	Nutrients Pathogens	On-site wastewater systems (septic tanks) Urban run-off/storm sewers
Dilla Street to Milford WWTP	76.5 - 73.4	B/WWF	NS	Pathogens Organic enrichment/DO Nutrients	Combined sewer overflow Urban run-off/storm sewers
Milford WWTP to outlet Box Pond (Bellingham)	73.4 - 70.3	B/WWF	NS	Pathogens Nutrients Organic enrichment/DO Cause unknown	Municipal point sources Land disposal Combined sewer overflow
Outlet Box Pond (Bellingham)to outlet Populatic Pond (Norfolk)	70.3 - 58.9	B/WWF	PS	Not Applicable	Not Applicable
Outlet Populatic Pond (Norfolk) to South Natick Dam	58.9 - 41.0	B/WWF	S	Not Applicable	Not Applicable
South Natick Dam to Chestnut Street (Needham)	41.0 - 33.0	B/WWF	S/T	Not Applicable	Not Applicable
Chestnut Street (Needham) to Watertown Dam	33.0 - 9.8	B/WWF	PS	Pathogens Organic enrichment/DO	Combined sewer overflow Urban run-off/storm sewers
Watertown Dam to Science Museum (Charles River Basin)	9.8 - 1.2	B/WWF	NS	Organic enrichment/DO Metals Oil and grease Pathogens	Urban run-off/storm sewers In-place contaminants Combined sewer overflow

TABLE 3-3 (Continued). 305(b) SUMMARY, CHARLES RIVER BASIN AND COASTAL DRAINAGE AREA

Location	River Miles	Class	Status	Causes	Sources
Muddy River					
Back Bay Fens	4.2 - 0.0	B/WWF	NS	Pathogens Metals Organic enrichment/DO Priority organics Nutrients	Urban run-off/storm sewers Combined sewer overflow In-place contaminants
Mother Brook					
Mother Brook Dam (Dedham) to confluence with Neponset River (Boston)	11.9 - 8.8	B/WWF	NS	Nutrients Pathogens	Urban run-off/storm sewers Combined sewer overflow
Headwaters (Wrentham) to Norfolk-Walpole MCI	8.8 - 4.1	B/WWF	NA	Not available	Not available
Norfolk-Walpole MCI to confluence with Charles River	4.1 - 0.0	B/WWF	PS	Organic enrichment/DO	Natural Municipal point sources
Beaver Brook					
Outlet Beaver Pond to confluence with Charles River (Bellingham)	1.7 - 0.0	B/WWF	S/T	Oil and grease Nutrients Metals Pathogens	Urban run-off/storm sewers On-site wastewater systems (septic tanks) Land disposal Landfills

Source: MassDEP 1993

Notes:
S = Supporting its designated uses
PS = Partially supporting its designated uses
NS = Not supporting its designated uses
S/T = Designated uses are supported but threatened
NA = Information not available
WWF = Warm water fishing

3.4.4 Dry Weather Inputs

The high dry weather bacteria counts in the Charles River indicate a dry weather source, either the upstream reach of the river and/or illegal connections to storm drains or CSOs. Receiving water model calibration (see Appendix A) indicates that since the counts do not decrease downstream, there must be dry weather inputs along the length of the river as well as at the Watertown Dam. Dry weather discharges have been observed by MWRA sampling staff, for example in the vicinity of the Western Avenue bridge.

Sanitary sewage inflows to Charles River storm drains are suspected (BWSC 1991), including one (7C006) in West Roxbury that discharges to the Charles River far upstream of the segment considered here. BWSC has a program of identifying and remediating these flows.

3.4.5 CSO Discharges

None of the combined sewage discharges into the upper Charles River are treated. These CSOs seldom overflow, (Rex, 1993; Table 6-6 in MWRA, 1993a) with the exception of BOS033, which overflows after about a quarter-inch of rain. CAM011B and CAM014 have been inactive for many years.

3.5 HYDRODYNAMICS

3.5.1 Hydrography

There are several tributaries to the Charles River above the Watertown Dam, which are indicated on Figure 3-2. Mother Brook is a diversion built in 1640 (Hall, 1986) to transfer approximately one-third of the flow from the Charles River to the Neponset River. The water exits over a dam from the Charles River and was originally used to provide additional water to mills on a small tributary to the Neponset River. According to Hall (1986), the present major use of the diversion is flood control.

The Charles River is gaged at four locations: Dover, Mother Brook, Wellesley, and Waltham. The analyses discussed below are based upon data collected since 1960; prior to 1960, there was extensive flow regulation with, for example, flows dropping as low as 0.025 m^3/s at the Dover gage in 1941, 1952, and 1957 (Mass DEM/DWR 1989). The average flow at the USGS gaging station in Waltham between 1931 and 1992 was 305 ft^3/sec (8.6 m^3/sec).

The low flow months of the Charles River are June through October; the high flow months are February through April. At the mouth, the highest average monthly flow is 26 m^3/s in March and the lowest monthly flow is 4 m^3/s in September. Flow in the river does not fluctuate rapidly as the wetlands buffer the high flows and the aquifers buffer the low flows. Recently, there has been public concern that river flows may be declining in the low-flow summer months, possibly due to aquifer withdrawals for water supply. The dams upstream of the Charles River Dam are operated as run of the river; that is, they do not provide significant storage, although they provide a dampening of flows.

3.5.2 Nearfield Mixing

CSOs in this reach discharge from the shore into shallow, fresh receiving water; hence, their plumes tend to mix vertically over the river depth. Furthermore, the discharge flows are small relative to the river flow, suggesting good dilution potential. Because of the small river width and depth in these reaches, ambient currents often exceed 0.1 m/s, causing the plumes to remain close to the shoreline. However, due to the narrow width, effluent should mix cross-stream within a distance of one kilometer (order of magnitude), which is typical of the distance separating adjacent CSOs. Estimates made for a typical CSO event (discharge from BOS032 during the storm of August 17-18, 1992), suggest that dilutions of about 25, 100, and 200 are obtained at distances of 30, 100, and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994).

3.5.3 Farfield Modeling

Fecal coliform distributions in the Charles River after a storm were modeled using the one-dimensional river water quality model QUAL2EXP (see Appendix A). In order to calibrate the model to the observed high dry weather background, a dry weather load of fecal coliform was input along the length of the river.

In the Upper Charles River segment, the model results show elevated fecal coliform counts, particularly three to five kilometers below the Watertown Dam. Coliform counts generally peak one-half day after the start of the storm and gradually diminish back to background over four or five days.

3.6 SUMMARY OF RECEIVING WATER QUALITY

Existing water quality conditions in the Upper Charles River segment are summarized on Figure 3-6.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	◍	●	●	always violates std. apparent dry sources	sailboarding boating	●	upstream, CSOs, SW dry weather sources
	Dissolved Oxygen (1,6)	○	○	○		aquatic life	○	
Aesthetics	Solids and Floatables (1)	○	●	◍	floatables after rain	passive recreation aquatic life	◍	CSO, SW
	Color and Turbidity (1)	○	○	○		passive recreation		
	Odor (2)	○	○	○		passive recreation		CSO, SW
	Oil and grease (1,8)	○	●	◍		passive recreation	○	
	Bottom pollutants or alterations (3)	N/A	N/A	◍	elevatedPAH, possibly upstream source?	aquatic life	◍	upstream
	Nutrients (4,5,8) (algal blooms)	◍	◍	◍		passive recreation	○	upstream
	Toxic Pollutants (4,5)	◍	◍	◍	Cu, Cd violate @ Watertown Dam	aquatic life	◍	upstream, SW
	Temperature (6)	○	○	○		aquatic life	○	
	pH (8)	○	○	○	almost all samples within standard	aquatic life	○	

Key:

●	poor quality or high risk
◍	fair quality or moderate risk
○	good quality or low/no risk
?	insufficient data

CF = Cottage Farm CSO facility
SW=stormwater
N/A= not applicable
PAH=polycyclic aromatic hydrocarbons

Sources of information on present conditions
1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993-94
3 - Battelle, 1990
4 - MWRA, 1993a (Interim CSO Report)
5 - UMass/Boston data
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989

FIGURE 3-6. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - UPPER CHARLES RIVER

3.6.1 Bacterial Contamination

Fecal coliform data from the first five years (1989-1993) of MWRA CSO receiving water monitoring are shown in Figure 3-7. These box plots show the 90th, 75th, 50th (median), 25th, and 10th percentiles of fecal coliform counts; open circles represent outliers. For comparison, the Class B standard is plotted on the figure; for swimming, the geometric mean (approximately equal to the median for these data) must be no more than 200 per 100 ml, with no more than 10% of the samples above 400 per 100 ml. The data have been segregated into "wet", "damp", and "dry" sampling days. "Dry" samples are those collected on days with no rain on the day of sampling or on the preceding two days. The number of samples collected varies between approximately 50 and 100 at each station.

Indicator bacteria levels in the upper Charles River violate the Class B Massachusetts primary contact water quality standard; fecal coliform counts exceed 200 colonies/100 ml during both wet and dry weather (Rex, 1993). In addition, there may be a risk to boaters from sewage-borne pathogens in the water, as the river typically does not meet the less stringent secondary contact standard of 1000/100 mg (Rex, 1993). Monitoring stations upstream of all CSOs have high bacteria levels related to rainfall, indicating an upstream wet-weather source of sewage (Rex, 1993); during some monitoring periods, levels were highest at the Watertown Dam, upstream of all known CSOs (Rex, 1991). Other studies (Mass DEP, 1990) have also shown high bacteria levels at the Watertown Dam, consistent with those found by MWRA.

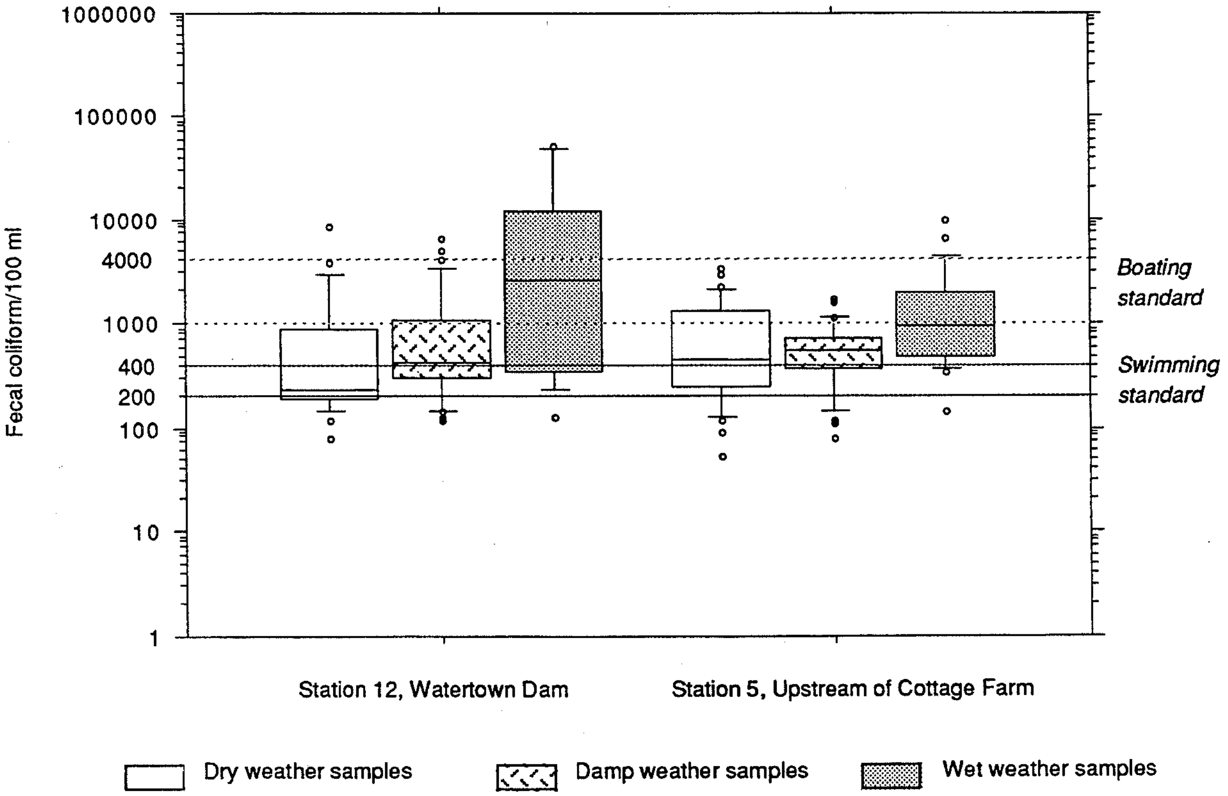
3.6.2 Dissolved Oxygen

Dissolved oxygen data at selected stations from the first five years of MWRA CSO receiving water monitoring are shown in Figure 3-8. These box plots show the 90th, 75th, 50th (median), 25th, and 10th percentiles of dissolved oxygen; open circles represent outliers. For comparison, the Class B/SB standard is 5 mg/l. The data have been segregated into surface and bottom samples, however, at shallow stations, only surface samples were collected. The number of samples collected varied from approximately 50 to 100 at each station. All the measurements were taken at mid-day, when dissolved oxygen levels are typically highest. Dissolved oxygen levels in surface water of the upper Charles River segment generally meet the water quality standard in wet and dry weather (Rex, 1993).

3.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

Floatables are usually seen along the water's edge after rain (Rex, 1993). Shopping carts thrown from the footbridge upstream of the Watertown Dam are a continual problem.

In the CH2M Hill sampling in 1988, the upstream station (Watertown Dam) was the only one for which mean wet weather concentrations of suspended solids exceeded mean dry weather concentrations.



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
12	Dry	22	80	8500	435
12	Damp	31	120	6900	541
12	Wet	14	135	52000	2448
5	Dry	28	55	3450	528
5	Damp	35	80	1800	523
5	Wet	22	145	9700	1134
	TOTAL	152	55	52000	662

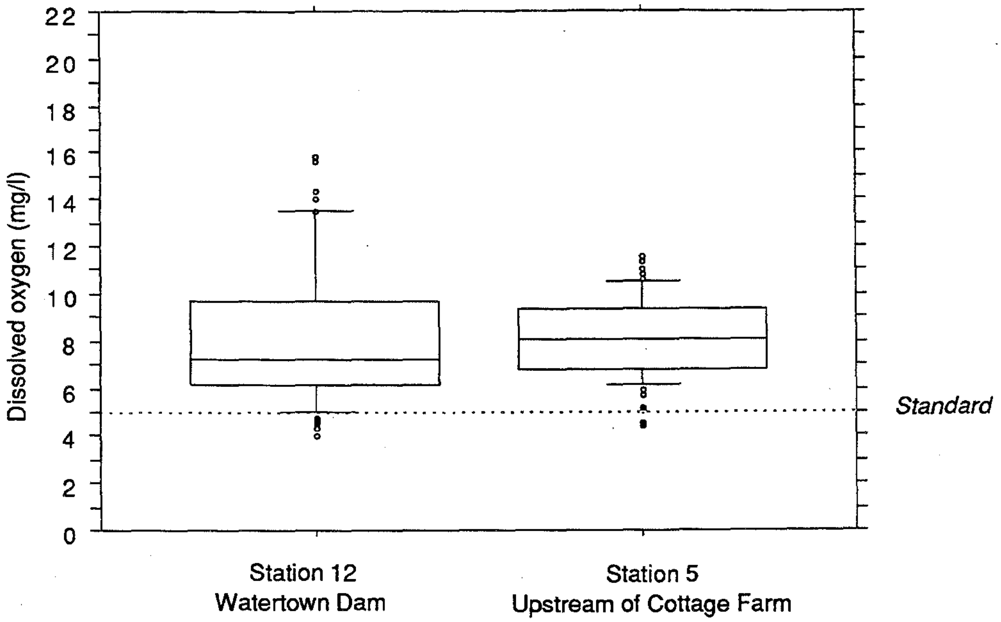
* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 3-7. FECAL COLIFORM MONITORING DATA FOR UPPER CHARLES RIVER (1989-93)



Station	No. of Samples	Concentration (mg/l)			
		Mean	Median	Minimum	Maximum
12	61	8.2	7.2	4.0	15.8
5	74	8.1	8.0	4.5	11.6
TOTAL	135	8.1	7.5	4.0	15.8

FIGURE 3-8. DISSOLVED OXYGEN CONCENTRATIONS IN UPPER CHARLES RIVER - SURFACE SAMPLES (1989-93)

3.6.4 Oil and Grease

Oily slicks are usually seen along the water's edge after rain (Rex, 1993). Sampling in 1988 indicated oil and grease concentrations of 5 mg/l at the Watertown Dam (CH2M Hill, 1989).

3.6.5 Bottom Pollutants or Alterations

Very little data are available on sediment quality in the upper Charles River. A pilot study conducted for MWRA included one station near the Newton Yacht Club, upstream of the CSOs (Battelle, 1990a); the data for this station are shown in Table 3-4. The investigators were not able to distinguish an effect of CSOs from this study. However, they did conclude that elevated levels of polycyclic aromatic hydrocarbons (PAH) at the Newton Yacht Club site indicate an upstream (of CSOs) source of PAH (Battelle, 1990a; see also Chapter 4).

In these samples, lead and tPAH exceeded the "ER-M" value proposed by Long and Morgan (1990) as a threshold over which sediment contamination is likely to impact biota (Table 2-9); zinc fall below the ER-M but exceeded the Long and Morgan's "ER-L" value above which they suggest that biological effects are possible.

We are aware of no data on benthic biology of the Charles River.

TABLE 3-4. SUMMARY OF UPPER CHARLES SEDIMENT CONTAMINATION MEASUREMENTS (BATTELLE, 1990a)

Parameter	$tPAH_6$	Cd	Cr	Cu	Mn	Pb	Zn
Concentration	63.86	1.7	55	60	277	145	201

All measurements are in $\mu g/g$: $tPAH_6$ is the sum of six commonly measured PAHs: fluoranthene, pyrene, chrysene, benz(a)anthracene, phenanthrene and benzo(a)pyrene.

3.6.6 Nutrients

Very few data exist on nutrient levels in this part of the Charles River. Data collected during two storms in November 1992 (Table 3-5) have detection limits that were too high to allow quantification of the actual nutrient concentrations (Metcalf & Eddy, 1993a). Earlier measurements of nutrient levels in the Charles River from the Watertown Dam were made by DWPC (1988a) and CH2M Hill (1989).

TABLE 3-5. RANGES OF SELECTED PARAMETERS MEASURED IN UPPER CHARLES RIVER

	Sampling Program		
Parameter	CH2M Hill	Mass DEP	Metcalf & Eddy
pH	6.4-7.6	7.0-8.5	
Oil and Grease (mg/l)	5-5	--	
Orthophosphate (mg/l)	0.0-0.1	0.10-0.11	
Total P (mg/l)	0.1-0.3	0.15-0.21	<0.15
TKN (mg/l)	0.1-0.3	0.4-1.5	<1.00 - 1.5
NH_3 (mg/l)	0.1-0.3	0.10-0.17	<0.50
NO_3 (mg/l)	0.2-41.0	0.2-0.4	0.58 - 0.89 ($NO_2 + NO_3$)
TSS (mg/l)	--	1.5-15	--
Total Solids (mg/l)	--	190-230	--
Chlorophyll (mg/m^3)	--	2.8-33.48	--

(a) Source: CH2M Hill, 1987; Samples collected at Watertown Dam, Station SS1
(b) Source: Mass DWPC 1988a; Samples collected at Watertown Dam, Station CH9.8
(c) Source: M&E 1993a; Results presented are ranges of values measured in samples collected at 3 stations in Upper Charles River

Based on DEP guidance for estimating the nutrient status of lakes (DEP, 1992), the upper Charles appears to be of poor quality in terms of nutrients. This standard may be too conservative for this part of the river.

3.6.7 Toxic Pollutants and Toxicity

Samples were collected at the Watertown Dam for the 1990 CSO Facilities Plan (CH2M Hill, 1989). Of the nine metals analyzed, copper and cadmium exceeded USEPA acute and chronic aquatic life criteria (Rex, 1989). Concentrations of copper and cadmium were higher in dry weather than in wet weather at the Watertown Dam. Also, concentrations of these metals were higher at this sampling location than at the stations downstream (see also Chapter 4) (Rex, 1989).

Researchers at UMass/Boston have collected samples for metals analysis on a transect along the Charles River from Hopkinton to the Cambridge Boathouse. The data show a spike in metals concentrations at the Watertown Dam (Elva Romanow, UMass/Boston, pers. comm. to M. Alber, MWRA 1993).

3.6.8 Temperature

Temperature in the upper Charles River did not exceed the state Class B standard of 83° F in any of the routine receiving water monitoring between 1989 and 1992 (MWRA, 1991; Rex, 1993; unpublished MWRA Harbor Studies data).

3.6.9 pH

In the 1990 MWRA CSO Facilities Plan sampling, only a few pH measurements in the upper Charles River (Watertown Dam) fell outside of the state standard range of 6.5-8 (CH2M Hill, 1989). Most of the samples for this program were collected during wet weather. Mass DWPC made one pH measurement above 8 in their 1987 sampling at the Watertown Dam.

3.7 USE ATTAINMENT

3.7.1 Watershed Context

The diverse watershed and land use conditions of the Charles River Watershed impact the present water quality of the river. A reach-by-reach review of the quality of the river compared to its classes (Table 3-3) shows these impacts (MassDEP 1993a). Most of the river and its major tributaries do not fully support their designated uses. With the exception of one reach (from Norfolk to South Natick), all reaches on either the Charles River or its tributaries that currently support all designated uses have one or more uses threatened by pollution sources.

A review of the causes and sources of either non-support of a use or a threat to a use in Table 3-3 shows that stormwater runoff and combined sewer overflow, where applicable, are major sources of pollution in all assessed areas of the watershed. Part of the upper portion of the watershed is impacted by municipal point sources.

3.7.2 Existing Water Quality and Affected Uses

Figure 3-9 shows how water quality problems in the upper Charles River affect designated uses. This matrix indicates whether the water quality standards or criteria for specific pollutants, including numeric and narrative limits in the state water quality standards, are met for the

Figure 3-9. Beneficial uses affected by water quality in Upper Charles River

Class B

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			No FCA
Aquatic Life	ok	ok	ok	ok	ok	C	?				?		C		
Primary Contact Rec.								C	?	?	W			W	
Secondary Contact Rec.								W							
Aesthetics									?	?	W	ok	C	W	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

relevant beneficial uses. For those criteria that we estimate are not met, the matrix indicates whether the non-attainment appears to be only in wet weather (W) or continuous (C). In the upper Charles River segment, bacteria affects the use of the river for primary contact recreation (swimming) in both wet and dry weather and come close to impairing its use for secondary contact recreation (boating and fishing) in wet weather. This segment also has aesthetic problems with floatables, oil and grease during wet weather, and high nutrient levels under all conditions that may affect aquatic life as well as aesthetics.

3.7.3 Baseline ("Future Planned") Water Quality and Affected Uses

CSO loads of pollutants may decrease slightly between existing and baseline ("future planned") conditions, as SOPs and Intermediate Projects are completed, system pumping capacity continues to increase, and Cambridge continues its sewer separation efforts. However, for many of the water quality problems in this segment, pollutant loads from stormwater from upstream and from possible dry weather illegal inputs appear to dominate the load. If these loads are assumed to remain unchanged under baseline conditions, beneficial uses will continue to be affected. In general, baseline water quality will be similar to existing water quality.

In order to estimate the contribution of CSOs alone to the bacteria counts in the Charles River, the receiving water model was run with all the other pollutant sources eliminated except for CSO baseline loads (see Table 3-6 below and Appendix A). In that scenario, the CSO load of bacteria would not cause violation of the boating standard (1000 fecal coliform/100 ml) in the three-month design storm, but would cause the swimming standard (200/100 ml) and the boating standard to be violated in the one-year design storm.

Table 3-6 summarizes bacterial impacts in the upper Charles River segment. Current "wet" conditions include all rainstorms of greater than 0.5 inches over three days (see Figure 3-8 and is made up mostly of events smaller than the three-month and one-year design storms. "Non-CSO" includes upstream inputs and dry-weather loads as well as stormwater.

Table 3-7 summarizes the level of use of this segment and the factors affecting attainment or non-attainment of the uses.

TABLE 3-6. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN UPPER CHARLES RIVER

Resource Area	Current Conditions		3-Month Storm Event				1-Year Storm Event		
	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Upper Charles River									
Swimming[a]	Violates	Violates							
Boating[b]	OK	OK							
Newton Yacht Club									
Swimming[a]			Cont.	Cont.	0	99	Cont.	0	99
Boating[b]			35	35	0	35	34	0	33
Weld Boat House									
Swimming[a]			Cont.	Cont.	0	Cont.	Cont.	52	Cont.
Boating[b]			64	64	0	64	71	27	68
Magazine Beach[a]			Cont.	99	0	Cont.	Cont.	58	Cont.

Notes:
Cont. indicates that the violation is continuous.
(a) Swimming (hours fecal coliform count > 200/100 ml)
(b) Boating (hours fecal coliform count > 1000/100 ml)

TABLE 3-7. USE ATTAINMENT FACTORS - UPPER CHARLES RIVER

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	Low	3	Upstream sources Illicit discharges Stormwater CSOs
Secondary Contact Recreation	High	2	Upstream sources Illicit discharges Stormwater CSOs
Aquatic Life	(?)	1-2(?)	Runoff Upstream sources Low river flow
Fish Consumption	Moderate(?)	1(?)	(??)
Aesthetics	High	2	CSO Stormwater Illicit discharges

* Preliminary determination; may be corrected through public participation process.
** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 4
LOWER CHARLES RIVER

4.1 DEFINITION OF RECEIVING WATER SEGMENT

The lower Charles River receiving water segment, commonly referred to as the Charles River Basin, includes the Charles River between the Cottage Farm (Boston University) Bridge and the new Charles River Dam (Figure 4-1). The river is bounded on the north by Cambridge and Charlestown, and on the south by Boston. In this stretch, the river has virtually no current and is wide and deep (about 7 m).

The Charles River Dam and Locks is located at the mouth of the river. The dam's major purpose is to maintain the level of the "Charles Basin", the large pool created by the dam and extending from the dam to approximately the Boston University Bridge. Major pollutant sources in this section are dominated by the Cottage Farm CSO Facility and discharges from the Stony Brook System. As noted in Chapter 3, the lower Charles River receiving water segment includes the Cottage Farm CSO (MWR 201) and therefore, differs from previous reports (MWRA, 1993a).

4.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The Charles River Basin is designated as "Class B - Fishable/Swimmable and other compatible uses" (MassDEP 1990) in accordance with the national goal for fishable/swimmable waters. Boating is the primary recreational use of the lower Charles River, including powerboats and a number of boathouses serving rowers and sailors. The Community Boating program which provides sailing instruction and rental opportunities to the public also operates along this section of the river. This section of the river is frequently used for special water-based events. There are two powerboat marinas on Cambridge side.

The Lechmere Canal enters the Charles River just above the old dam; the canal is surrounded by upscale shopping and residences, and the canal itself is used for paddle boating and by river sightseeing tour boats. The Miller's River enters between the two dams. The area around the Miller's River is used for industry and transportation (elevated highways, railroads) and this area will see continued change as part of the Central Artery/Third Harbor Tunnel Project.

The Charles River Reservation is prominent along this river section and this parkland is heavily used by the public for passive recreation and to take advantage of the MDC operated swimming pool and other MDC recreational facilities. Paths in this area are heavily used by many pedestrians as well as cyclists. The Hatch Shell's stage is here and is a major focal point for public activities during the summer.

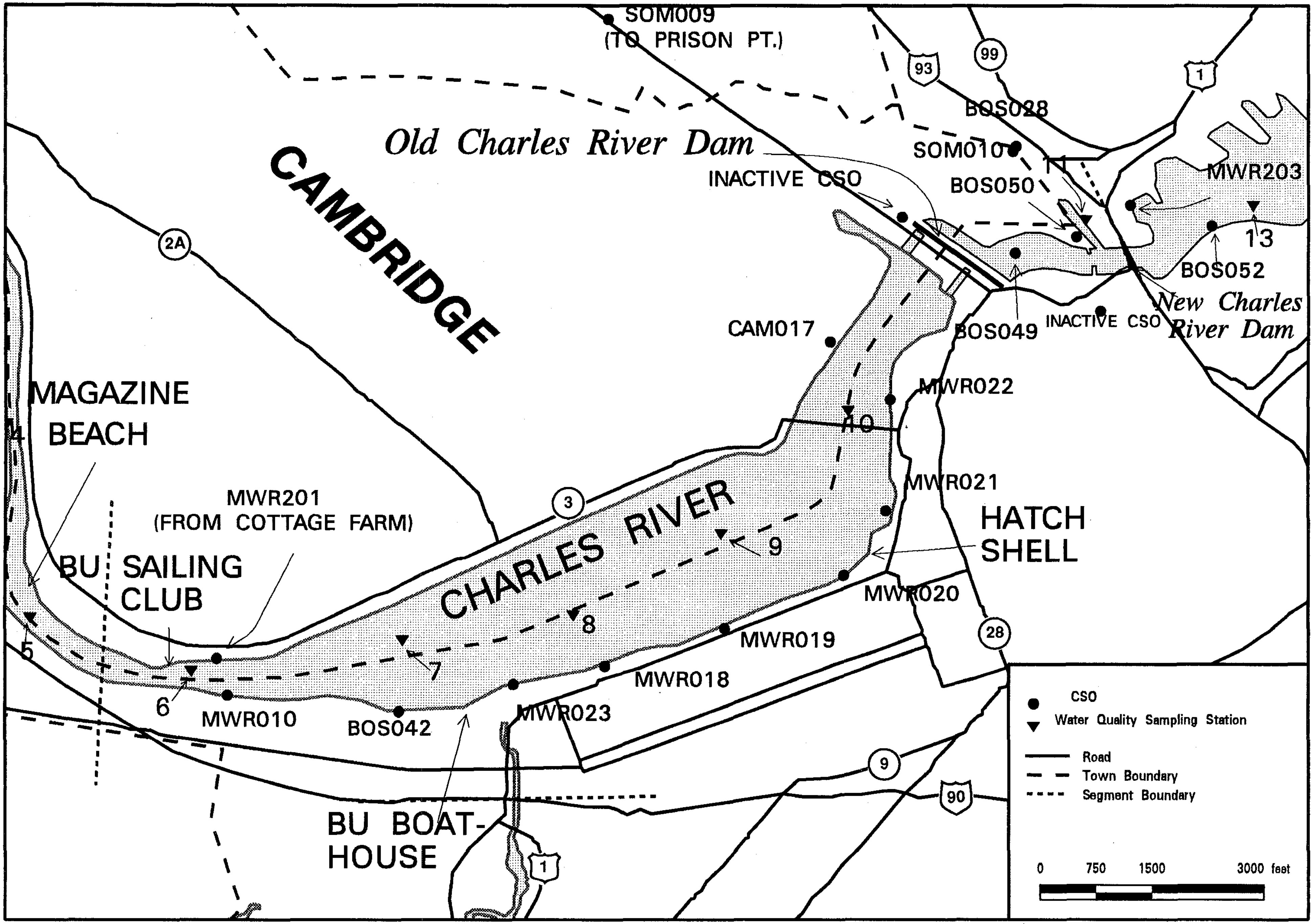


FIGURE 4-1. LOWER CHARLES RIVER

There is a fishway in the new Charles River Dam, and during anadromous fish runs anglers fish from the pedestrian walkway over the dam. Tens of thousands of blueback herring migrate upstream through the locks and the fishway each year.

4.3 CHARACTERIZATION OF WATERSHED

The portion of the river below the Watertown Dam has been transformed from a tidal estuary to a dam backwater with essentially a man-made lake where the mouth of the estuary used to be. The banks and immediate shoreline of the Charles River Basin, instead of being marshland, are now lined with seawalls. While there is generally parkland along the river banks below the Watertown Dam, almost all the drainage below the dam is from urban land use.

During the 1800's, both sides of the Charles River downstream of the BU Bridge had been filled and built upon. This created a demand for control of the tidal action in the lower Charles River as well as for an aesthetically pleasing body of water. The solution was the "Old" dam, which was finished in 1910 and which effectively helped create a permanent waterpark (Hall, 1986). The dam had several locks for navigation and all that remain of them is the current boat channel. Filling and enhancement of the basin continued up until the early 1950's when Storrow Drive was built.

The new Charles River Dam at the river mouth, completed in 1978, replaced the older one (now beneath the Museum of Science) and was constructed in part to reduce the intrusion of salt water from Boston Harbor into the river and to provide pumps to pump out the Basin during exceptionally high tides. The new dam contains locks to allow vessel traffic. Saltwater inflow through the locks perpetuates a permanent, strong salinity stratification in the Charles River Basin. Because of the very slow flushing of this dammed river, and because of the strong stratification that inhibits vertical mixing and prevents recreation of the bottom layer, the bottom waters of the basin are hypoxic. Bubblers were installed to mix and aerate the basin waters near the Science Museum, but have not functioned on an ongoing basis, although they have been observed to be working recently.

4.4 SOURCE OF POLLUTION

4.4.1 General

The largest pollutant sources to the lower Charles River sub-area are combined sewer overflows, stormwater, and upstream sources (see Section 3.4). Dry weather sewage flows, apparently from illegal connections to CSOs and storm drains, have been observed by MWRA monitoring staff.

Cambridge Electric has two cooling water discharges in the Charles Basin with a total permitted flow of about 105 million gallons per day (K. Colhane, DEP, pers. comm. to W. Leo 1994). Estimated flows and loads of stormwater, CSOs (future planned), and the Stony Brook are shown in Figures 4-2 and 4-3. In this segment, "future planned" 3-month storm CSO flows are approximately 28% greater than existing CSO flows.

4.4.2 Stormwater Discharges

The volume of stormwater entering the Charles River is much larger than the flows contributed by CSOs (MWRA 1990, Metcalf & Eddy 1994). Stormwater may also contribute most of the bacteria load (MWRA, 1993), although recent stormwater measurements (BWSC, 1993) indicate the concentrations of bacteria in stormwater are much lower than was estimated in the 1990 MWRA CSO Facilities Plan.

Sanitary sewage inflows to Charles River storm drains are suspected (BWSC, 1991). Almost all of the Boston side of the lower Charles River has combined sewerage while sewerage on the Cambridge side is partly separate. Most of the stormwater entering the lower Charles River is from Cambridge, however, there are not recent stormwater quality data from that area.

4.4.3 CSO Discharges

Most of the combined sewage entering the Charles River Basin is discharged via the Stony Brook or through the Cottage Farm CSO treatment facility. The Cottage Farm CSO (MWR201) discharge comprises about 60% of the total CSO flow into this segment for both the 3-month and the 1-year design storms. The Cottage Farm treatment facility discharges via three outfalls in midstream under the Cottage Farm Bridge (MWR201). The facility provides screening, floatables skimming, and disinfection, as well as 1.3 million gallons of storage sedimentation (MWRA, 1993a). In general, bacteria levels near the Cottage Farm discharge are less well-correlated with rainfall than those at other stations, consistent with effective disinfection (Rex 1993, unpublished MWRA Harbor Studies 1993 data). Combined sewage has been observed by MWRA staff to spill into the river from a holding tank when wave action forces river water in and out of the holding tank this has been addressed by adding chlorine to the holding tank. Although combined sewage at Cottage Farm receives treatment, sewage-related and other floatables, as well as surface slicks are routinely observed nearshore in the vicinity of the facility (Rex 1993).

The Cottage Farm facility has recently undergone extensive renovations (MWRA, 1993a). This rehabilitation, in addition to increased pumping capacity at Deer Island, eliminated dry weather overflows and appears to have decreased the wet weather discharge volume (MWRA, 1993a). The removal of conventional pollutants is variable between storms; an average over three storms gives removal rates of 28% for BOD and 46% for TSS (MWRA, 1993a).

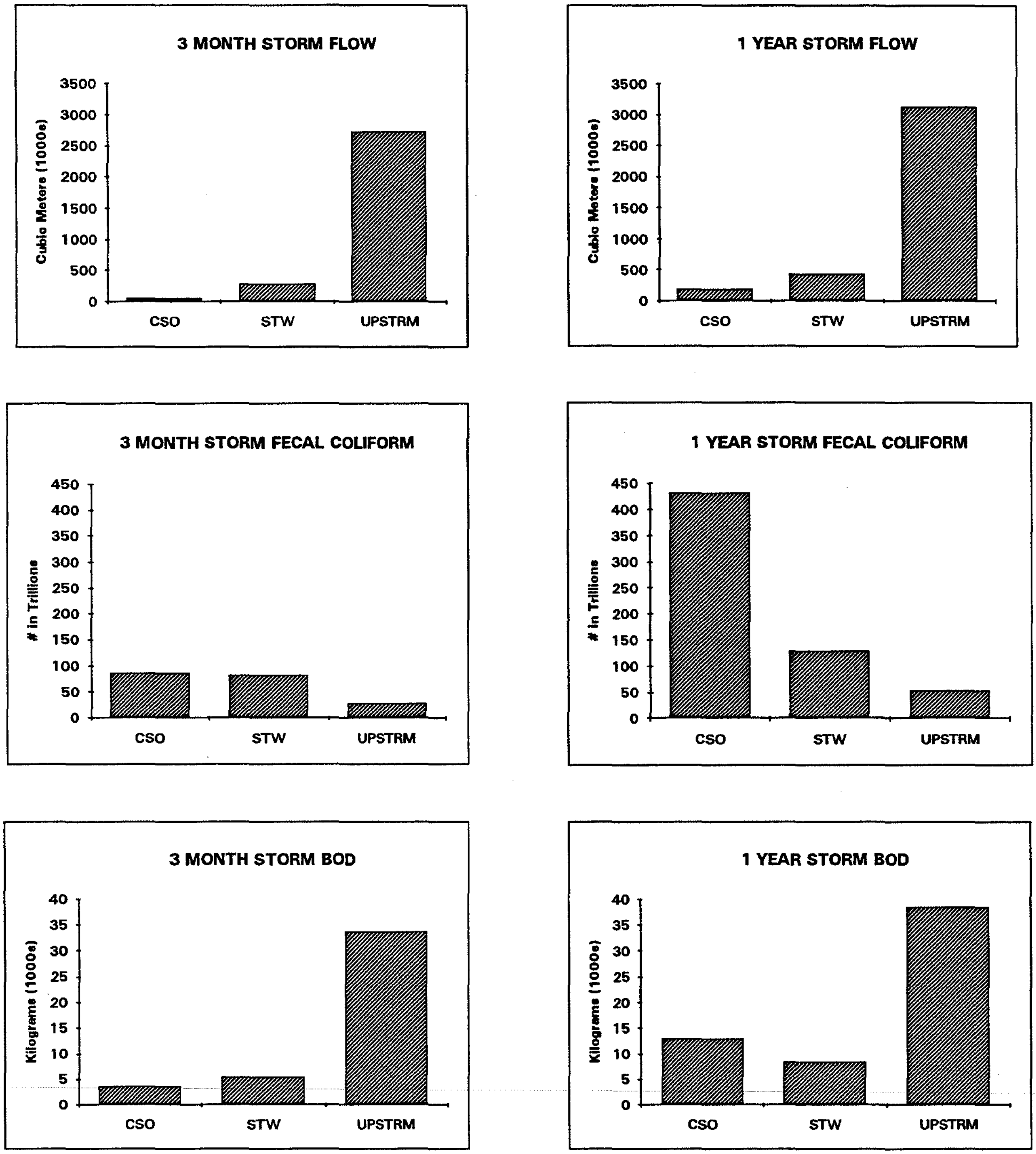


FIGURE 4-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - LOWER CHARLES RIVER

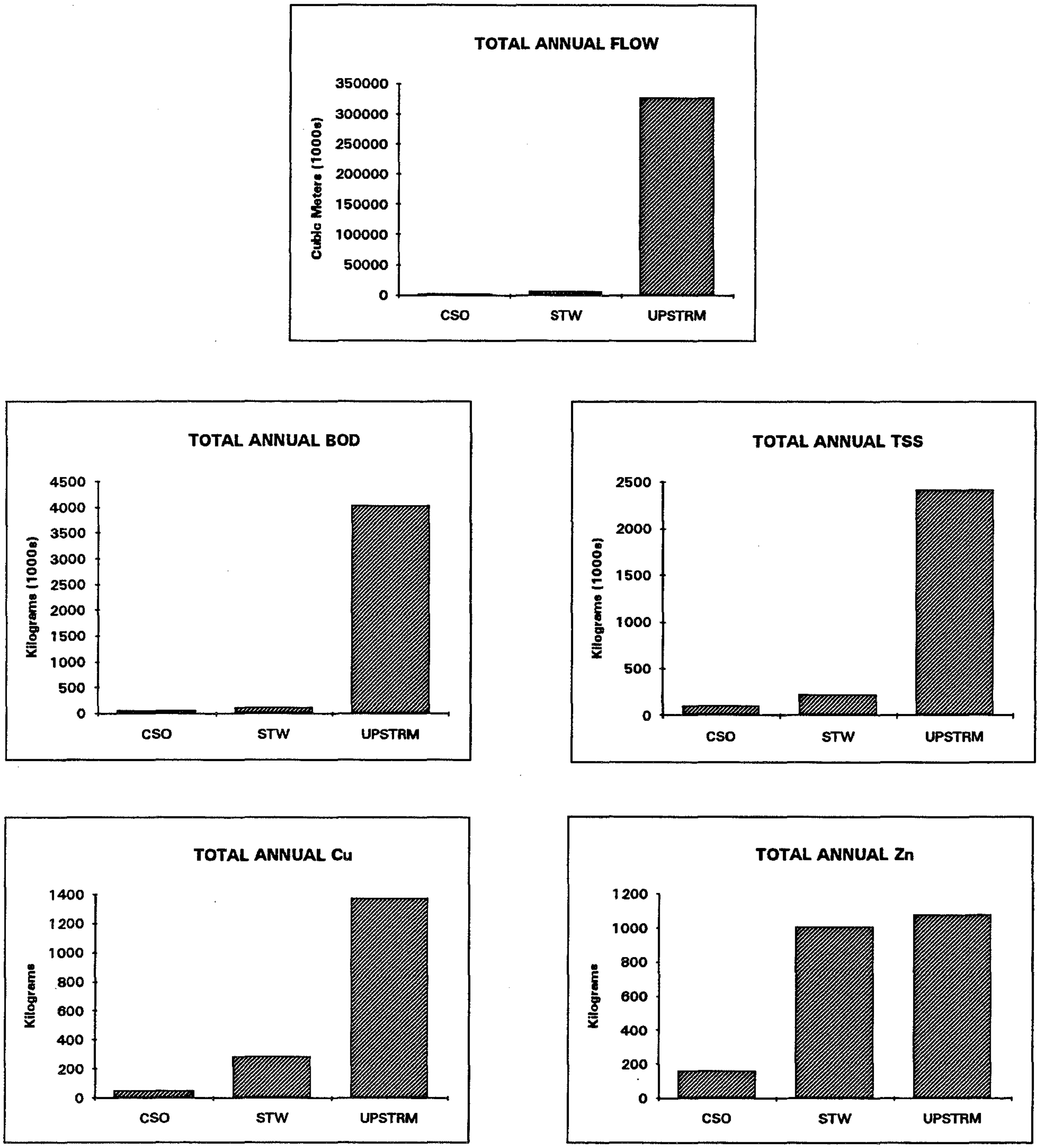


FIGURE 4-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS -LOWER CHARLES RIVER
(a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

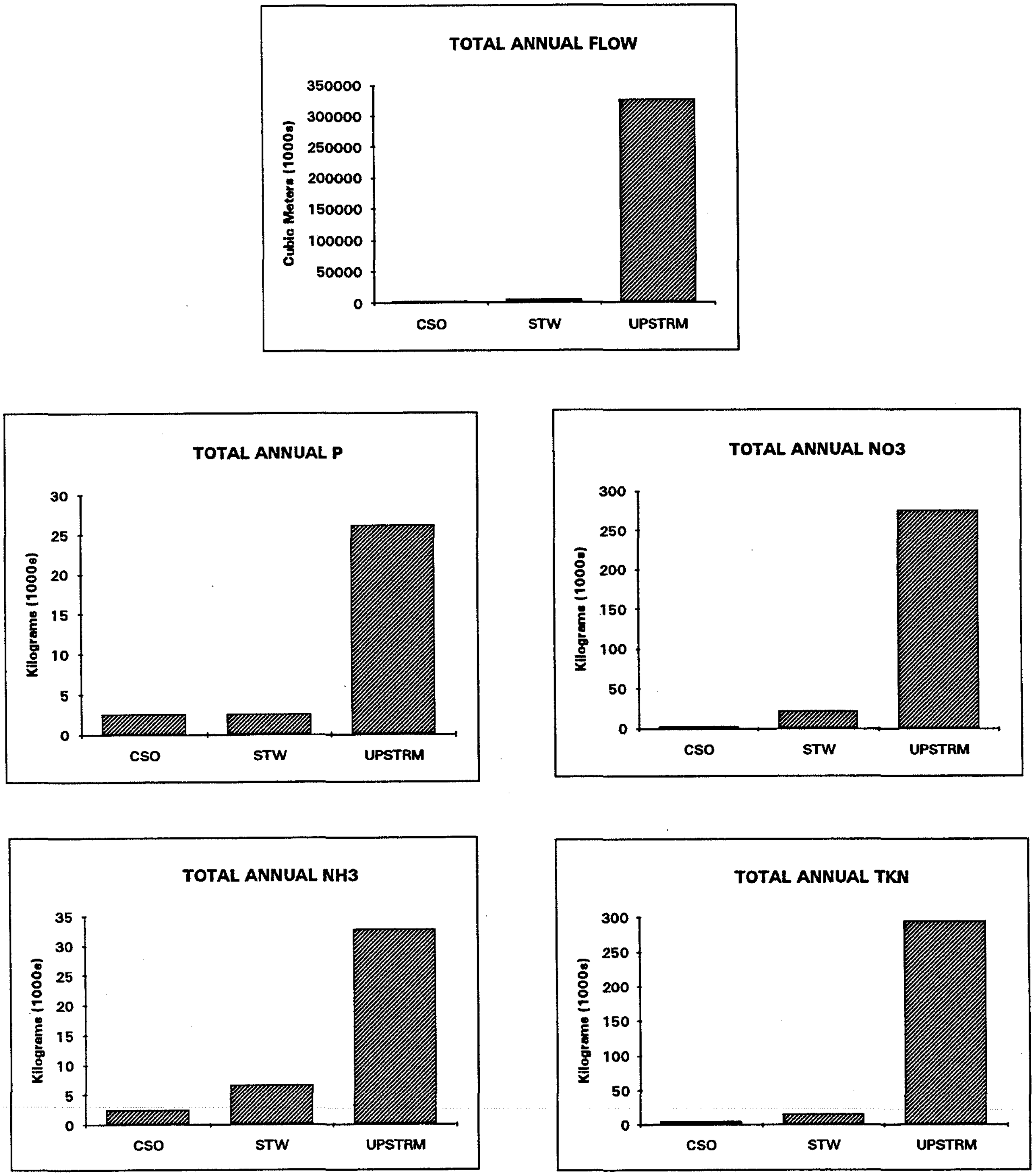


FIGURE 4-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS -LOWER CHARLES RIVER
(b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

With the exception of MRW023, the CSOs in the lower Charles River overflow only rarely (after an inch or more of rain) or did not overflow at all during the 1992 monitoring period (MWRA, 1993a; Table 6-6). CSO inspections indicated that some of these CSOs accumulate sediment or receive infiltration (MWRA, 1993a; Table 5-2).

4.4.4 Upstream Inputs

The Charles River Basin is affected by pollutant loads introduced upstream that enter this segment. The high concentrations of bacteria (MWRA, 1991; Rex, 1993) and nutrients upstream of the Cottage Farm Bridge have a strong influence on the water quality of the Charles River Basin. Because it is dammed, this segment tends to retain many pollutants. Estimated loads of pollutants from the upper Charles River segment entering the lower Charles River segment are shown on Figures 4-2 and 4-3.

4.4.5 Dry Weather Inputs

As in the upper Charles River segment, the high dry weather bacteria counts in the Charles River indicate a dry weather source. Model calibration (see Appendix A) indicates that in this segment, bacteria are likely to be entering in dry weather in the Stony Brook area and at Cottage Farm. Investigations of the Stony Brook system (Metcalf & Eddy, 1994a) indicate a considerable amount of dry weather sewage input. There may be other dry weather sources as well.

4.4.6 Stony Brook

The Stony Brook discharge, MWR023, includes a high proportion of base brook flow and stormwater (MWRA, 1993a). For example, in a three month storm, flow in the brook includes about 90 million gallons (340,000 m^3) of stormwater and base flow, and about 10 million gallons (38,000 m^3) of combined sewage. The brook flow enters the Charles River continuously at a rate of about 0.5 m^3/s, but during dry weather it does not include any stormwater or CSO flow. The Stony Brook receiving water segment is discussed in Chapter 5 of this report.

In spite of the expected dilution of sanitary sewage by base flow and stormwater, the wet-weather concentrations of pollutants in the discharge from MWR023 are similar to those from other outfalls (MWRA, 1993a). This untreated discharge appears to be the largest source of most pollutants to the lower Charles River.

4.4.7 Muddy River and Back Bay Fens

The Muddy River Conduit and the Back Bay Fens discharge into the Charles River in this segment. The water quality of these streams is poor (see Chapter 5). The amount of flow discharged is about 0.17 m^3/s (CDM, 1982; cited in Metcalf & Eddy, 1990).

4.5 CHARACTERIZATION OF WATERBODY HYDRODYNAMICS

4.5.1 Nearfield Mixing

The Charles River Basin is wide and deep, and the river flow is sluggish. Mass DEM/DWR (1989) estimates the average flow at the mouth as 11 m^3/s. The Charles River Dam releases flows on low tides. The tributaries to the Charles River below the Watertown Dam are the Muddy River and the Stony Brook. The Muddy River enters both via the Muddy River Conduit and the Back Bay Fens. Most of the discharge of combined sewage into the lower Charles enters through the Cottage Farm Treatment Facility or indirectly via the Stony Brook. These discharges are so large that they can only be poorly diluted by the Charles River flow. In particular, the Stony Brook flow can, during wet weather, be comparable in size to the Charles River flow.

Effluent from Cottage Farm discharges to the river through three vertically oriented diffuser pipes. Because of the limited distance between the tops of the pipes and the water surface, near field mixing is completed in about 3 meters from the diffusers and provides a dilution of only about two. Based on the August 17-18, 1992 storm and the results of a dye study conducted by CH2M Hill (1990), near plus intermediate field mixing provides a dilution of about 4 within less than 100 meters, by which time the plumes from adjacent diffusers merge, having mixed with all the available river flow.

During the same storm, the flow of the Stony Brook (base flow plus CSO and stormwater) was estimated to average over 20 m^3/s, about twice the Charles River flow at the Waltham gage on the same date. In this case, the maximum possible dilution of 1.5 is probably achieved in about half the river width, i.e., about 250 m.

The Cottage Farm CSO is the only large CSO in this segment. The mixing of other, smaller CSOs would be similar to those in the upper Charles segment, though the plumes would not be as elongated, because of the very slow current.

4.5.2 Farfield Modeling

Receiving water model results are shown in Appendix A. In the lower Charles River segment, the model results show very high fecal coliform counts near the Stony Brook discharge (12 km from the Watertown Dam). The highest counts are seen one-half to one day after the start of the storm and gradually diminish back to background over five or six days.

4.6 SUMMARY OF RECEIVING WATER QUALITY

Existing water quality conditions are summarized in Figure 4-4.

4.6.1 Bacterial Contamination

Fecal coliform data for the first five years of MWRA CSO receiving water monitoring are shown in Figure 4-5. Indicator bacteria levels in the lower Charles River violate the water quality standard; fecal coliform counts exceed 200/100 ml during both wet and dry weather (Rex, 1993).

Because this area is used extensively for sailboarders, who often have direct contact with the water, water quality in this segment presents a high risk to human health. There may also be risk to boaters, as the river does not meet the less stringent secondary contact criterion of 1000/100 ml after rainstorms (Rex, 1993).

4.6.2 Dissolved Oxygen

Dissolved oxygen data at selected stations from the first five years (1989-1993) of MWRA CSO receiving water monitoring are shown in Figure 4-6. Dissolved oxygen levels in surface water generally meet the water quality standard of 5 mg/l in dry weather. Bottom waters never meet the DO standard in the stratified section, downstream of the Harvard (Mass. Avenue) Bridge. This is due to the dam and resulting saltwater entrainment, and is likely exacerbated by BOD load from CSOs and stormwater.

A large Cottage Farm CSO facility discharge can apparently cause DO depression below the standard in surface water (Rex 1993). For example, the large storm on July 24-25, 1990 depressed surface dissolved oxygen at sampling stations upstream of the Stony Brook discharge both at and just downstream from the MWR201 outfall (MWRA, 1991). Dissolved oxygen fell from about 6.3 mg/l to about 3.3 mg/l during this storm event. At a station a short distance upstream of the Cottage Farm discharge, DO was depressed to about 4.5 mg/l. During this storm, the Cottage Farm facility discharged about 92 tonnes of BOD. In general, it is difficult to say whether the wet-weather effect on dissolved oxygen is due to combined sewage or stormwater. The Cottage Farm discharge is one of the few which can be related to DO depression.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	◍	●	●	always violates std. apparent dry sources	sailboarding boating	●	CSOs, SW, Stony Brook, dry weather sources
	Dissolved Oxygen (1,6)	◍	●	●	always poor in lower layer due to salt stratification	aquatic life fishing	◍	CSOs, SW, upstream, dam
Aesthetics	Solids and Floatables (1,2)	○	●	◍	sewage-related and other floatables near CF and Stony Brook	extensive passive recreation	◍	CSOs, SW
	Color and Turbidity (1,2)	○	◍	◍	river is naturally turbid?	aquatic life, extensive passive recreation		CSOs
	Odor (2)	○	○	○		extensive passive recreation		
	Oil and grease (1,2,8)	●	●	●	slicks nearshore near CF, SB, dams	extensive passive recreation	●	CSOs, SB; SW?
	Bottom pollutants or alterations (3)	N/A	N/A	●	believed azooic due to anoxia elevated metals	aquatic life	●	possibly CSOs for metals; anoxia physical
	Nutrients (4,5,8) (algal blooms)	●	●	●	Su 93 intense algae bloom, with odor	extensive passive recreation	◍	CSOs; other?
	Toxic Pollutants (4,5)	●	◍	◍	chlorine tox. from CF Cd, Cu violate WQ criteria	aquatic life fishing	◍	CSOs?
	Temperature (6)	○	○	○		aquatic life	○	cooling water
	pH (8)	○	◍	○	almost all samples within standard; occ. too high nr Stony Br.	aquatic life	○	Stony Br.; CF CSO meets permit limit

Key:
● poor quality or high risk
◍ fair quality or moderate risk
○ good quality or low/no risk
? insufficient data

CF = Cottage Farm CSO facility
SB= Stony Brook
SW=stormwater
N/A= not applicable

Sources of information on present conditions
1 - Rex, 1993
2 - MWRAmonitoring staff, pers. comm. 1993-94
3 - Battelle, 1990a
4 - MWRA, 1993a (Interim CSO Report)
5 - UMass/Boston data
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989

FIGURE 4-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - LOWER CHARLES RIVER

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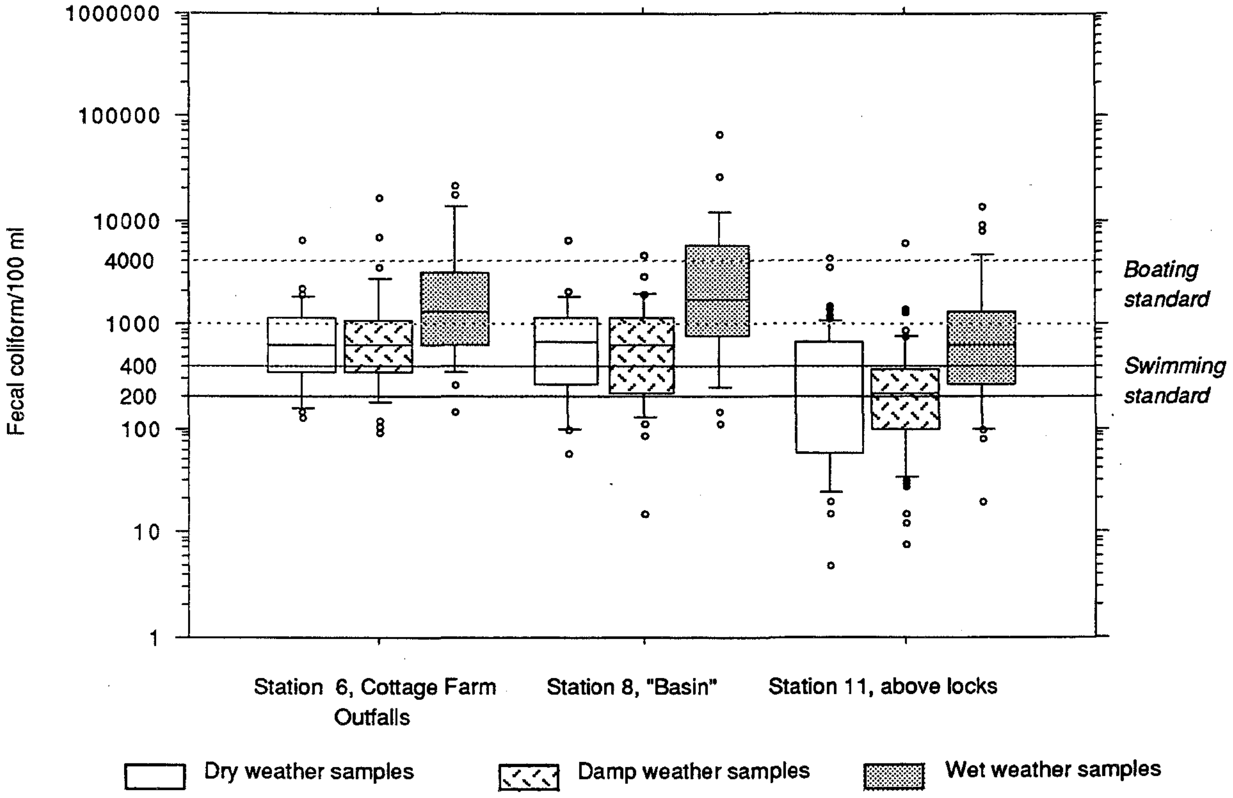


Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
6	Dry	28	135	6600	644
6	Damp	32	95	17500	708
6	Wet	22	148	22600	1556
8	Dry	33	58	6850	571
8	Damp	34	15	4850	553
8	Wet	24	118	69300	1893
11	Dry	63	0	4350	NA
11	Damp	69	8	6125	193
11	Wet	35	20	13700	623
	TOTAL	340	0	69300	NA

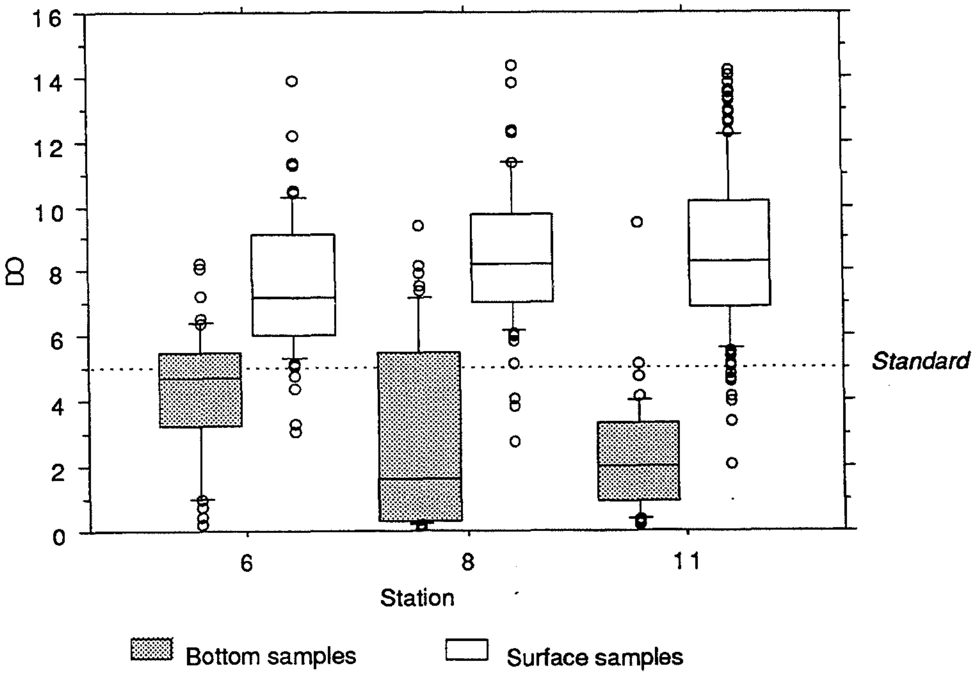
NA Not Available - Logarithm of Zero Cannot be Calculated
* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 4-5. FECAL COLIFORM MONITORING DATA FOR LOWER CHARLES RIVER (1989-93)



Station	Sample Type	No. of Samples	Concentration (mg/l)		
			Mean	Minimum	Maximum
6	Bottom	55	4.2	0.2	8.3
6	Surface	75	7.5	3.1	13.9
8	Bottom	51	2.9	0.1	9.4
8	Surface	75	8.5	2.8	14.4
11	Bottom	72	2.2	0.2	9.5
11	Surface	152	8.6	2.1	14.2
	TOTAL	480	6.3	0.1	14.4

FIGURE 4-6. DISSOLVED OXYGEN CONCENTRATIONS IN LOWER CHARLES RIVER (1989-93)

4.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

This discharge plume from the Cottage Farm facility can cause a visible boil of brown turbid water above the river surface. Floatables are usually seen along the water's edge after rain (Rex 1993), especially in the vicinity of the Cottage Farm facility and near the Charles River Dam. Floatables are also often seen in the vicinity of the Charles River Dam, where floatables accumulate from all sources, as well as in the Basin area, especially during and after rain.

4.6.4 Oil and Grease

Oily slicks are usually seen along the water's edge after rain (Rex 1993). A major oil slick was detected on October 10, 1993 in the area downstream of the MBTA Commuter Rail drawbridge and the Charles River Dam. The oil slick covered the water surface completely in that region. CH2M Hill sampling in 1988 indicated oil and grease concentrations of 5 mg/l at the Charles River Dam.

4.6.5 Bottom Pollutants or Alterations

Very few data are available on sediment quality in the lower Charles River. A pilot study conducted for MWRA included one station in the Basin near the dam (Battelle 1990). The investigators determined that CSOs may have resulted in elevated metals concentrations, but the higher levels downstream could also be due to differences in grain size and organic carbon content (Table 4-1) (Battelle 1990a). Other sources could also be significant contributors to metals concentrations.

In these samples, $tPAH_6$, chromium, copper, lead, and zinc exceed the "ER-M" concentrations proposed by Long and Morgan (1990) as sediment contamination levels at which biological effects are likely.

We are aware of no data on the benthic biology of the Charles River. It is likely that the Basin sediments are mostly devoid of animals due to anoxia in the bottom waters (see Section 4.6.2).

TABLE 4-1. SUMMARY OF LOWER CHARLES SEDIMENT CONTAMINATION MEASUREMENTS (Battelle 1990a)

Parameter	$tPAH_6$	Cd	Cr	Cu	Mn	Pb	Zn
Concentration	31.52	16	260	532	347	1258	983

All measurements are in $\mu g/g$; $tPAH_6$ is the sum of six commonly measured PAHs: fluoranthene, pyrene, chrysene, benz(a)anthracene, phenanthrene and benzo(a)pyrene.

4.6.6 Nutrients

Very few data exist on nutrient levels in the Charles River. Metcalf and Eddy collected data during two storms in November 1992, which are given in Table 4-2; unfortunately the detection limits chosen were too high to quantify the actual nutrient concentrations. Nutrients were among the parameters measured in 1988 by CH2M Hill (1989); these data are in Table 4-3.

TABLE 4-2. LOWER CHARLES WET WEATHER NUTRIENT MEASUREMENTS
All measurements in mg/l.

	TKN	NH_3	NO_2+NO_3	Total P
November 2-5, 1992 Charles River Dam	<1.00	<0.50	0.39	<0.15
November 25-28, 1992 Charles River Dam	1.1	<0.50	0.59	<0.15

Source: Metcalf & Eddy, 1993

TABLE 4-3. RANGES OF SELECTED PARAMETERS FROM CH2M HILL (1989) RECEIVING WATER MONITORING, LOWER CHARLES

Location Station	Stony Brook mouth RW1	Charles R. Dam SS2
pH	6.5-8.9	6.7-7.6
Oil & grease (mg/l)	5-180	5-5
Total P (mg/l)	0.1-20.0	0.0-0.3
TKN (mg/l)	0.6-2.7	1.0-1.1
NH_3 (mg/l)	0.5-2.4	0.4-0.7
NO_3 (mg/l)	0.2-2.7	0.4-37.0

Based on Mass DEP guidance for estimating the nutrient status of lakes (MassDEP, 1992), the lower Charles appears to be of poor quality in terms of nutrients. This part of the river is subject to intense algal blooms in the summer months. During the hot, dry summer of 1993, a particularly intense algal bloom caused a vivid green color and strong odor throughout the whole area between the new dam and the Cottage Farm Bridge.

4.6.7 Toxic Pollutants and Toxicity

Samples were collected near the Stony Brook outlet and at the Charles River Dam for the 1990 CSO Facilities Plan (CH2M Hill 1989). Of nine metals analyzed, only copper and cadmium showed a central tendency that appears to violate EPA acute and chronic criteria (Rex, 1989). In dry weather, Cd and Cu concentrations were higher than in wet weather at the Charles River Dam station (Rex, 1989).

A UMass/Boston study of harbor water column metals in 1991 included one station just upstream of the Charles River Dam; of five metals analyzed and compared to the standard, only copper showed a violation (G. Wallace, UMass/Boston, unpublished data).

More recently, researchers at UMass/Boston have collected samples for metals analysis on a transect along the Charles River from Hopkinton to the Cambridge Boathouse but these data have not yet been published.

4.6.8 Temperature

Temperature in the lower Charles exceeded the state standard of 83 °F only rarely during the routine receiving water monitoring between 1989 and 1992 (MWRA, 1991; Rex, 1993; unpublished MWRA Harbor Studies data).

4.6.9 pH

In the 1990 Facilities Plan sampling, pH measurements in the lower Charles near the Stony Brook outlet were sometimes higher than the range permitted by the state standard of 6.5-8 (CH2M Hill 1989). Most of the samples were taken during wet weather.

4.7 USE ATTAINMENT

There are significant existing water quality problems in the lower Charles River, both in dry and wet weather. Except for boating, the designated uses for this receiving water segment are generally not supported in any weather. The largest CSO discharge is the Cottage Farm Facility, where flows receive disinfection. This seems to indicate that bacteria levels are influenced by other sources. However, the chlorination of Cottage Farm flows does likely impact the health of aquatic life in the river. In addition, the aesthetics of this heavily used area are also significantly affected by CSO discharge.

4.7.1 Existing Water Quality and Affected Uses

The water quality problems and affected uses in this segment are summarized in Figure 4-7. Designated uses are generally not supported in the lower Charles River segment. High bacteria levels impact swimming in both wet and dry weather and boating in wet weather.

The presence of the new Charles River Dam exacerbates water quality problems in the lower Charles River. In particular, the salt wedge caused by sea water entering through the dam and then being trapped at the bottom of the basin causes a severe dissolved oxygen problem in the lower layer. BOD and nutrient loads from shoreline sources probable contribute to the dissolved oxygen problem. The combination of the dam, low river flow, and high nutrient load can cause intense algal blooms that affect aesthetics as well as river ecology.

The largest CSO discharge in this segment is the Cottage Farm Facility. Bacteria loads from this CSO are reduced by chlorination, but the chlorination likely impacts the health of aquatic life in the river. Floatables from CSOs and storm drains, and sewage plumes from the CSO facility, affect the aesthetic quality of this heavily used recreational area.

4.7.2 Baseline ("Future Planned") Water Quality and Affected Uses

Future planned conditions should be somewhat improved, as the CSO flow (and load) will be reduced. For the three-month design storm, the flow will be about 28% lower than under existing conditions. However, dry weather inflows are expected to continue to keep bacteria levels high even in dry weather, and stormwater will continue to cause elevated bacteria levels during storms.

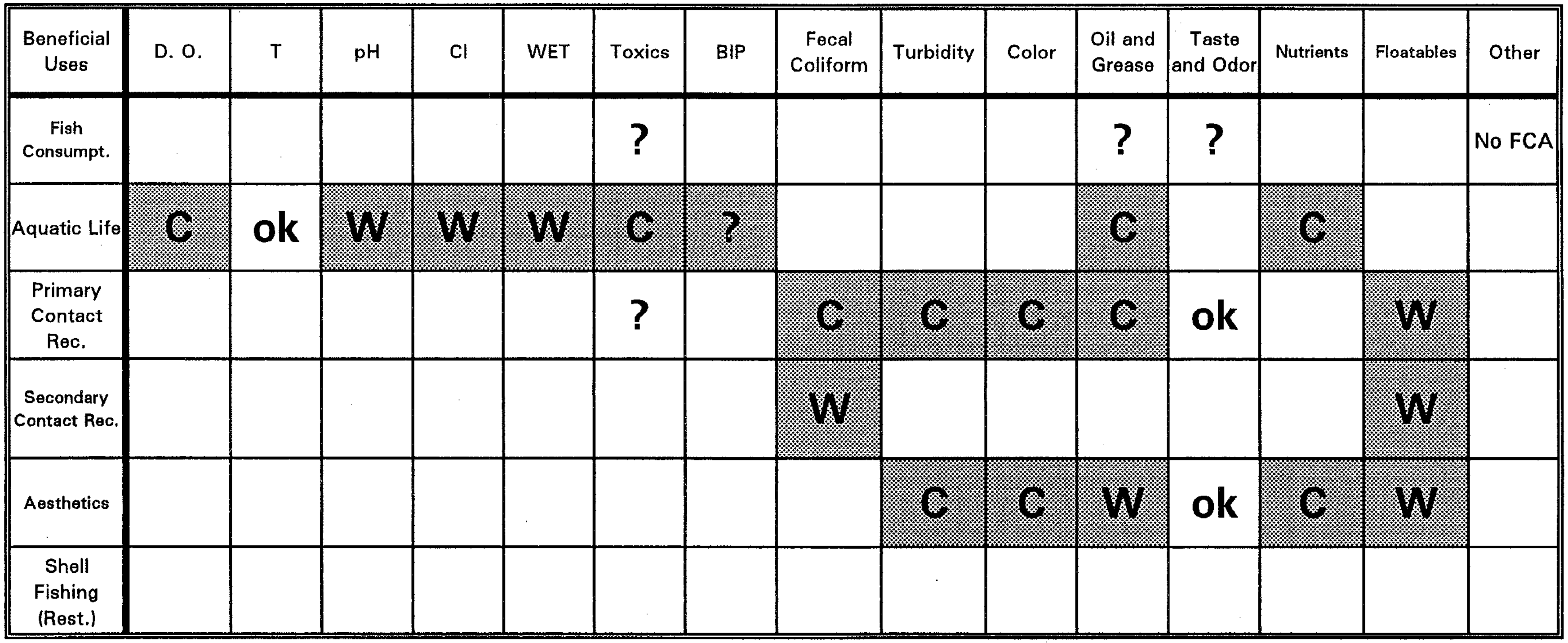
Table 4-4 summarizes the current status of bacteria impacts in the upper Charles River segment. "Non-CSO" includes upstream inputs and dry-weather loads as well as stormwater. Either CSO or non-CSO loads alone would cause non-attainment of the primary and secondary contact recreation standard in the three-month and one-year storms. Receiving water modeling results indicate that the three-month storm would cause the secondary contact recreation standard of 1,000/100 ml to be violated for 3-5 days after the storm over most of the segment.

Table 4-5 summarizes the level of use of this segment and the factors affecting attainment or non-attainment of the uses.

Figure 4-7. Beneficial uses affected by water quality in Lower Charles River

Class B

Use Criteria (1)



Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			No FCA
Aquatic Life	▨ C	ok	▨ W	▨ W	▨ W	▨ C	▨ ?				▨ C		▨ C		
Primary Contact Rec.						?		▨ C	▨ C	▨ C	▨ C	ok		▨ W	
Secondary Contact Rec.								▨ W						▨ W	
Aesthetics									▨ C	▨ C	▨ W	ok	▨ C	▨ W	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:

ok	Attained for Criteria
▨	Proven or Probable Non-Attainment
W	Wet Weather Non-Attainment
C	Wet and Dry Weather Non-Attainment

TABLE 4-4. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN LOWER CHARLES RIVER

Resource Area	Current Conditions		3-Month Storm Event				1-Year Storm Event		
	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Lower Charles River									
Swimming[(a)]	Violates	Violates							
Boating[(b)]	OK	Violates							
B.U. Boathouse									
Swimming[(a)]			Cont.	Cont.	53	Cont.	Cont.	83	Cont.
Boating[(b)]			70	67	18	61	83	50	74
Hatch Shell/ Community Boathouse									
Swimming[(a)]			Cont.	Cont.	27	Cont.	Cont.	Cont.	Cont.
Boating[(b)]			41	34	0	0	80	35	44
Charles River - Mouth									
Swimming[(a)]			32	21	3	0	37	32	4
Boating[(b)]			0	0	0	0	0	0	0

Note:
Cont. indicates that the violation is continuous.
(a) Swimming (hours fecal coliform count > 200/100 ml)
(b) Boating (hours fecal coliform count > 1000/100 ml)

TABLE 4-5. USE ATTAINMENT FACTORS - LOWER CHARLES RIVER

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	Moderate (sail boarding)	3	Upstream sources, Illicit Discharges, Stormwater, CSO
Secondary Contact Recreation	High	2	Upstream sources, Illicit Discharge, Stormwater, CSO
Aquatic Life	Moderate	3	Dam, low river flow, Chlorinated CSO, Runoff
Fish Consumption	Low(?)	1(?)	(?)
Aesthetics	High	2	CSO, Stormwater, Illicit discharges

* Preliminary determination; may be corrected through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 5
BACK BAY FENS/MUDDY RIVER

5.1 DEFINITION OF RECEIVING WATER SEGMENT

This chapter focuses on the Muddy River and the Back Bay Fens, which is the CSO receiving water segment; however, the Stony Brook is also described as it relates to water quality in the Fens. The Stony Brook downstream of the combined sewer areas is in an underground conduit; therefore, it is not considered a surface receiving water (1990 Massachusetts State Water Quality Standards). Although control of combined sewage discharges into the Stony Brook will be part of the MWRA CSO control plan, we consider it here simply as a source of pollutants to the Fens and the Charles River. Similarly, we do not consider the Muddy River conduit downstream of the Fens/conduit split. The Back Bay Fens/Muddy River/Stony Brook receiving water segment is shown as Figure 5-1.

5.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The Back Bay Fens/Muddy River/Stony Brook receiving water segment includes a portion of the Olmstead Park System, a National Historic Register District, consisting of a series of parks linked by continuous parkways curving south from the mouth of the Muddy River to Franklin Park. These receiving waters are designated "Class B, Fishable/Swimmable and other compatible uses" in accordance with national goals.

5.3 CHARACTERIZATION OF WATERSHED

5.3.1 Location

There is a total watershed area of 8.6 square miles with most of this area within the town of Brookline. The remaining watershed is in the cities of Boston and Newton. The Back Bay Fens is the most downstream 1½ miles of the Muddy River. The upper section is a small pond separated from the Lower Fens by twin 72" conduits. Most of the Muddy River flow does not enter the Back Bay Fens (Metcalf & Eddy, 1990).

5.3.2 Topography and Soils

The Muddy River watershed is dotted with small hills as is characteristic of glacially modified topography in New England. The downstream end of the watershed is flat, as the river winds through the filled land of Boston's Back Bay, once part of the Charles River estuary (U.S. Army Corps of Engineers, 1992). The upper Muddy River, from Jamaica Pond to Leverett Pond is

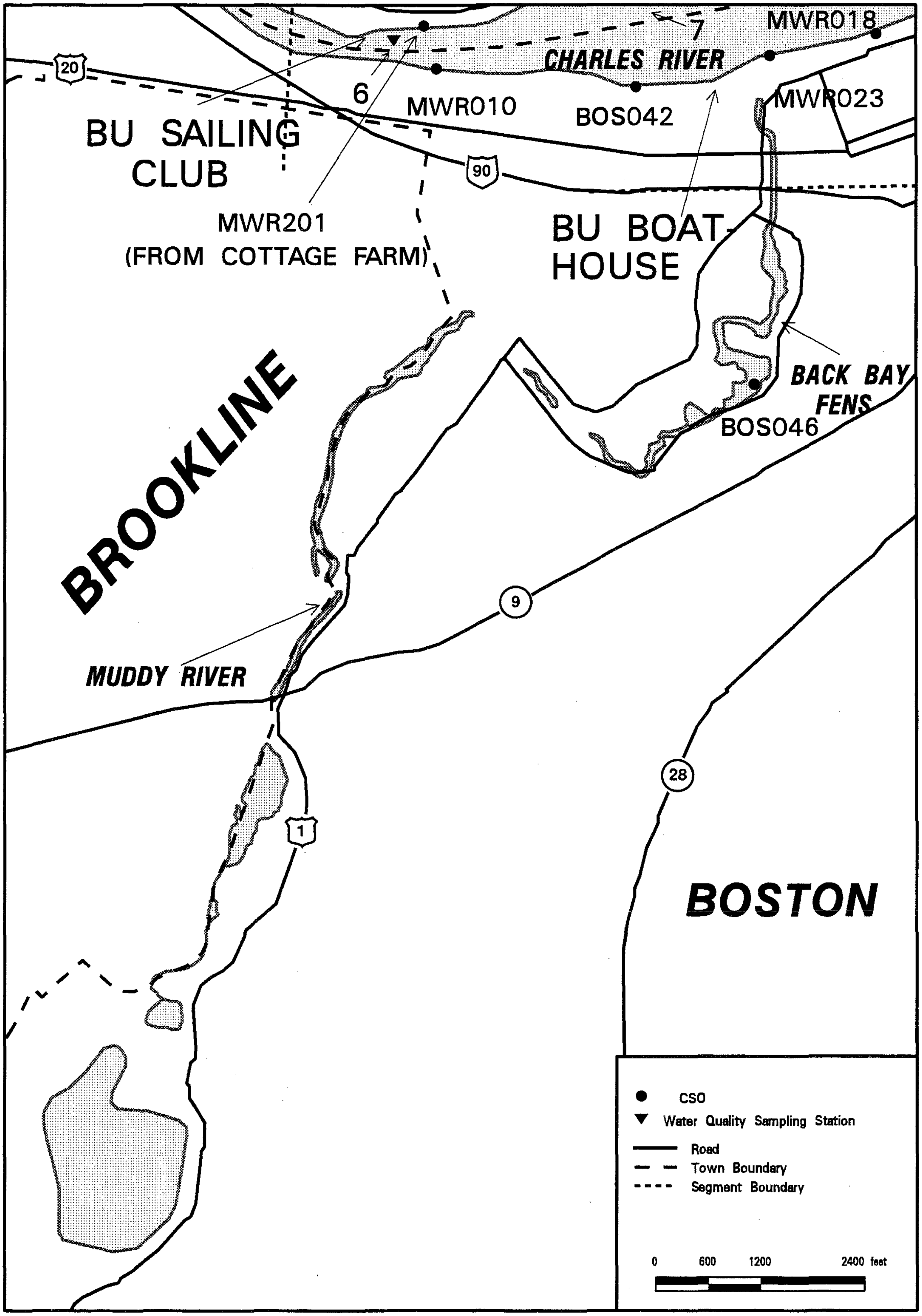


FIGURE 5-1. BACK BAY FENS/MUDDY RIVER

steep with an average slope of 2%. There are waterfalls in this half-mile stretch of the river. The slope of the lower 3 miles of the river is flat, with an average slope of less than 0.01%. Soil boring data indicate varying thicknesses of fill overlying variable deposits of peat, organic silt and silty fine sand overlying clay.

5.3.6 Dams, Highways, and Other Man-Made Features

This area is heavily crossed by roadways, many of which carry significantly more traffic than initially envisioned. Runoff from these roadways is likely to contribute pollutants such as salt, oil and grease, sediments and metals to nearby receiving waters. Soil boring data in the area adjacent to the Muddy River indicate varying thickness of fill overlying variable deposits of peat, organic silt and silty fine sand overlying clay.

5.3.7 Wetlands

The Back Bay Fens contains extensive stands of *Phragmites australis* as does the Muddy River. A few freshwater, herbaceous wetland plants were included in Olmstead's original plantings but the currently dominant vegetation of *Phragmites*, cattails, and loosestrife were not (U.S. Army Corps of Engineers, 1992).

5.3.8 Watershed Towns, Upstream Land Use, and Upstream Pollution Sources

The Muddy River has several major storm drain outlets that represent nearly 90 percent of the river's drainage area (U.S. Army Corps of Engineers, 1992).

5.4 SOURCES OF POLLUTION

5.4.1 General

The Muddy River upstream of the Fens is polluted by sewer cross-connections, storm drains and other sources; the Fens is further polluted by storm drain discharges and CSOs (Metcalf & Eddy 1990). Oil spills and leaking underground tanks have also contributed pollutants to the Muddy River (Metcalf & Eddy, 1990).

Flow and loads from combined sewage and stormwater are shown in Figures 5-2 and 5-3. Three-month storm CSO flows entering the Fens are not expected to change between now and "future planned" conditions.

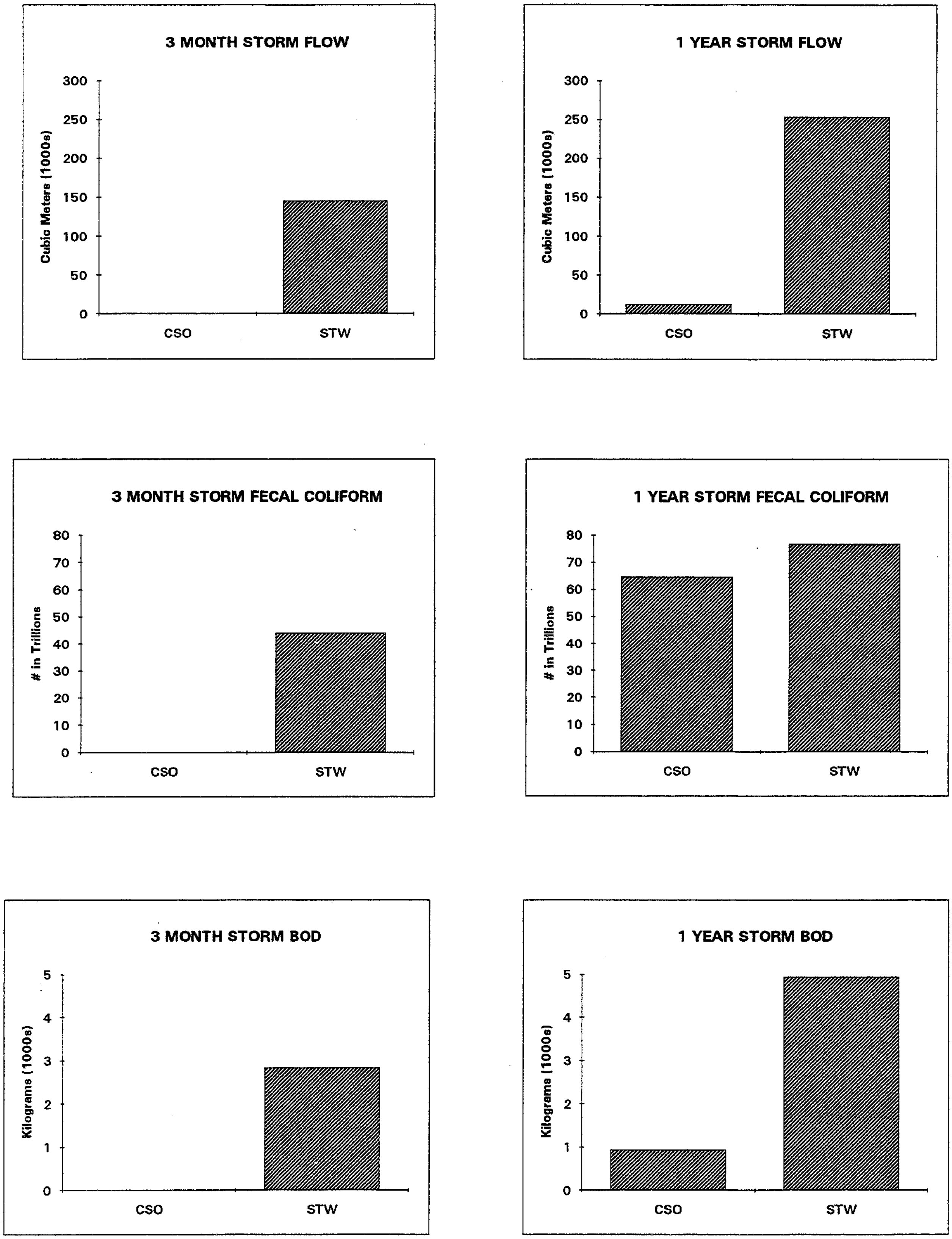


FIGURE 5-2. FUTURE PLANNED FLOWS AND LOADS FOR THE THREE MONTH AND ONE YEAR STORM EVENTS - BACK BAY FENS

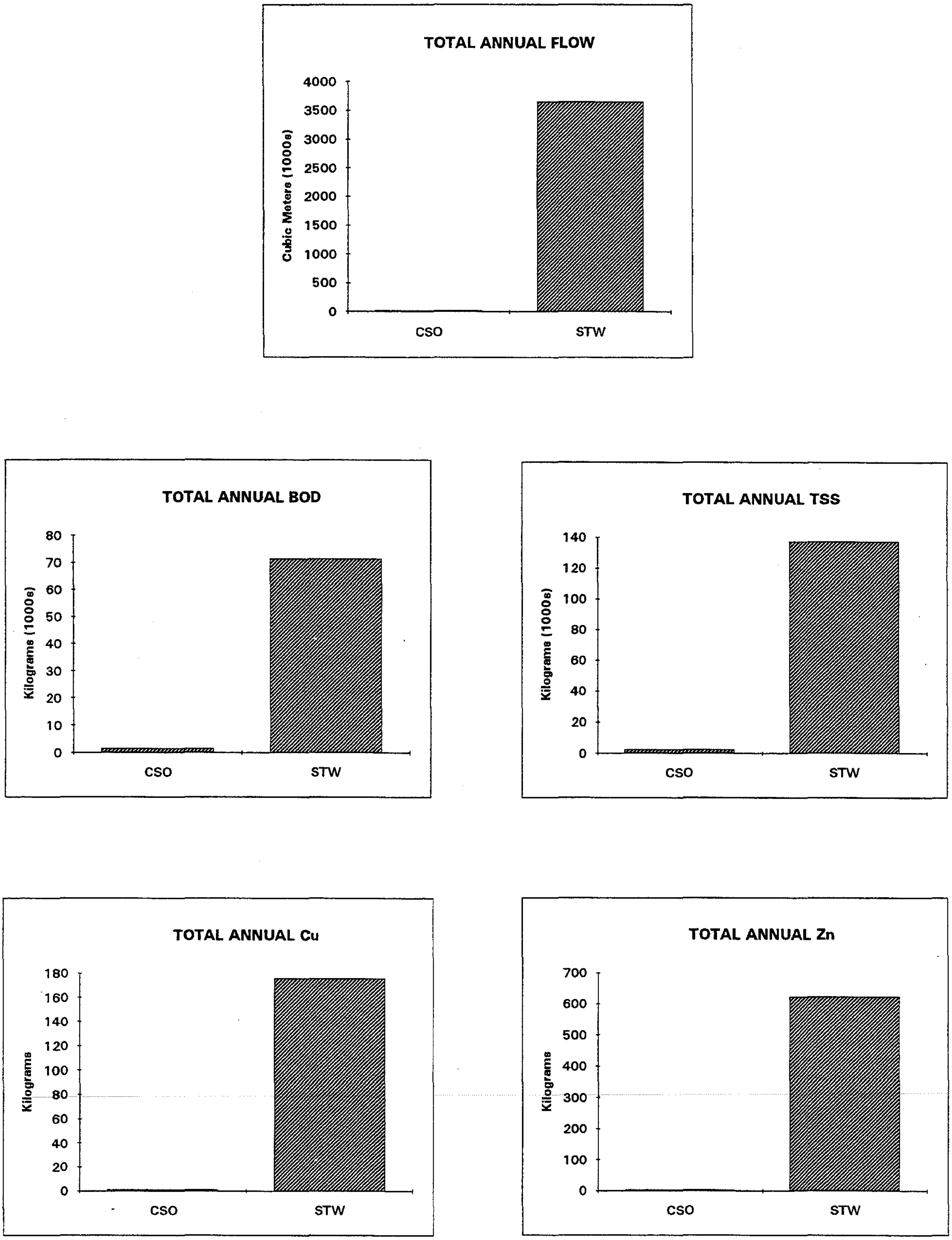


FIGURE 5-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - BACK BAY FENS
(a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

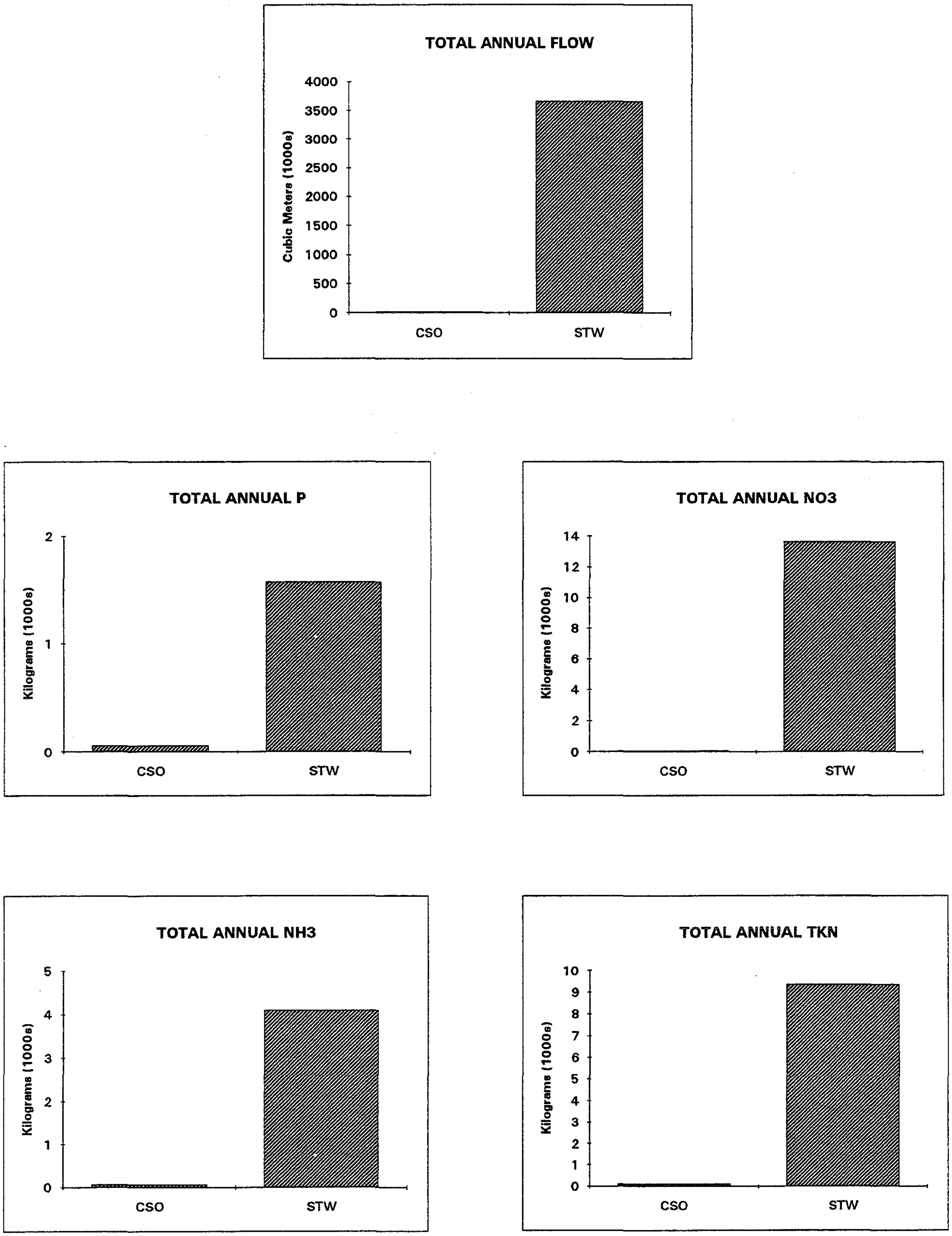


FIGURE 5-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - BACK BAY FENS
(b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

5.4.2 Stormwater Discharges

With the exception of the CSO discharges described below, the Muddy River watershed is served by a separate stormwater system (Metcalf & Eddy, 1990). In the Fens, there are 17 storm drains and two subsurface drains; the latter collect groundwater from under parks. Potential cross-connections between sewers and storm drains were identified in the Muddy River watershed, based on physical inspections (Metcalf & Eddy, 1990). Numerous cross-connections were subsequently confirmed by the town of Brookline. Oil inputs are also suspected; in the Fens, oil was found in one drain and in the river near the outlet (Metcalf & Eddy, 1990).

5.4.3 CSO Discharges

Combined sewage can overflow into the Back Bay Fens from two CSOs. Boston Gatehouse 1 (BOS046) is the overflow for the Stony Brook Conduit (SBC), and Boston Gatehouse 2 is the overflow for the Old Stony Brook Conduit (OSBC). Boston Gatehouse 2 is completely sealed. A local peak in many water quality problems is observed just downstream of the Fens Rose Garden, indicating a local source (Metcalf & Eddy, 1990).

The Stony Brook includes base flow, stormwater, and combined sewage; it is described in more detail in Metcalf & Eddy (1994a). It had been estimated that the Stony Brook overflows to the Fens about 56 times per year, contributing a combined sewage volume of about 1.6 x 10^6 m^3 (Metcalf & Eddy, 1990). However, more recent monitoring (MWRA, 1993) and modeling conducted for the MWRA shows much less flow and few overflows. In 1992 monitoring, approximately 1 inch of rain was required to cause an overflow at BOS046 (Table 6-6, MWRA 1993). The Stony Brook system portion of the model was updated and calibrated based on 1993 monitoring data (Metcalf & Eddy, 1994a and 1994d). Model results indicate that the BOS046 does not overflow in the three-month storm.

There are no CSOs upstream of the Brookline Gatehouse, where the Muddy River splits between the Fens and the Muddy River conduit.

5.4.4 Illegal Discharges

Calibration of a river model to water quality data indicate that there may be a dry weather discharge in the location of the CSO (Metcalf & Eddy, 1990). In addition, results of the 1993 monitoring in the Stony Brook drainage areas indicates the possible presence of illegal cross-connections.

5.4.5 Upstream Inputs

The portion of the Muddy River upstream of the Fens has poor water quality (Metcalf & Eddy 1990). However, most of the flow is diverted around the Fens through the Muddy River Conduit directly into the Charles River. In fact, Metcalf & Eddy (1990) note that low flow through the Fens exacerbates the water quality problems, and recommend that much of the Muddy River Conduit flow be re-directed through the Fens to improve flushing.

5.5 HYDRODYNAMICS

Because of the small size and stagnant nature of the Fens, this receiving water segment was not modeled. The Muddy River is a 3.5 mile waterway characterized by a series of interconnected ponds including: Jamaica Pond, Wards Pond, Willow Pond, Leverett Pond and the Back Bay Fens. The Back Bay Fens is extremely stagnant. Water quality problems in the Fens are exacerbated by low flow (Metcalf & Eddy, 1990). Estimated flow in the Muddy River is approximately 0.17 m^3/s on average (CDM, 1982 as cited in Metcalf & Eddy, 1990). The combined sewage is discharged as a free overflow which limits its mixing efficiency. The CSO discharge volume is large compared to the Muddy River flow, so the effluent receives only limited initial mixing.

5.6 SUMMARY OF RECEIVING WATER QUALITY

Existing water quality conditions are summarized on Figure 5-4. The water quality of the Back Bay Fens and the Muddy River is documented in detail in Metcalf & Eddy (1990).

5.6.1 Bacterial Contamination

Results of sampling conducted in 1986 by Mass DWPC, indicated that some stations in the Muddy River met the Class B bacterial water quality standard of 200/100 ml but most violated the standard (Metcalf & Eddy, 1990). Fecal coliform counts up to 12,000 MPN/100 ml were measured in the Fens (Metcalf & Eddy, 1990) and counts as high as 55,050 cfu/100 ml were measured by MWRA in 1992 (Figure 5-5).

5.6.2 Dissolved Oxygen

Dissolved oxygen in the Muddy River is very low, decreasing downstream to a daytime low of 2 mg/l in the Fens during sampling in 1986 (Mass DWPC, 1987). Measurements collected at Beacon Street in 1992 showed a minimum dissolved oxygen concentration of 0.3 mg/l (Figure 5-6) and a mean concentration of 1.2 mg/l. A study of diel variation of DO concentrations in 1974 showed ranges greater than 10 mg/l, from supersaturation to anoxia (1

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,2)	●	●	●	most samples exceed class B standard		?	SW, CSOs, dry weather flow
	Dissolved Oxygen (1,2)			●	huge diel swings some anoxia	aquatic life	●	low flow high sediment oxygen demand
Aesthetics	Solids and Floatables	?	?	?		passive recreation aquatic life		
	Color and Turbidity	?	?	?		passive recreation		
	Odor	?	?	?		passive recreation		
	Oil and grease (1)			●	aesthetic problem	passive recreation aquatic life	●	oil tank leaks, contam. SW
	Bottom pollutants or alterations (1)	N/A	N/A	●	*Phragmites* excessive sediment high contamination	aquatic life	●	low flow
	Nutrients (1) (algal blooms)	?	?	●	highly eutrophic	passive recreation aquatic life	●	low flow, SW
	Toxic Pollutants	?	?	?		aquatic life		
	Temperature	○	○	○		aquatic life	○	
	pH	○	○	○		aquatic life	○	

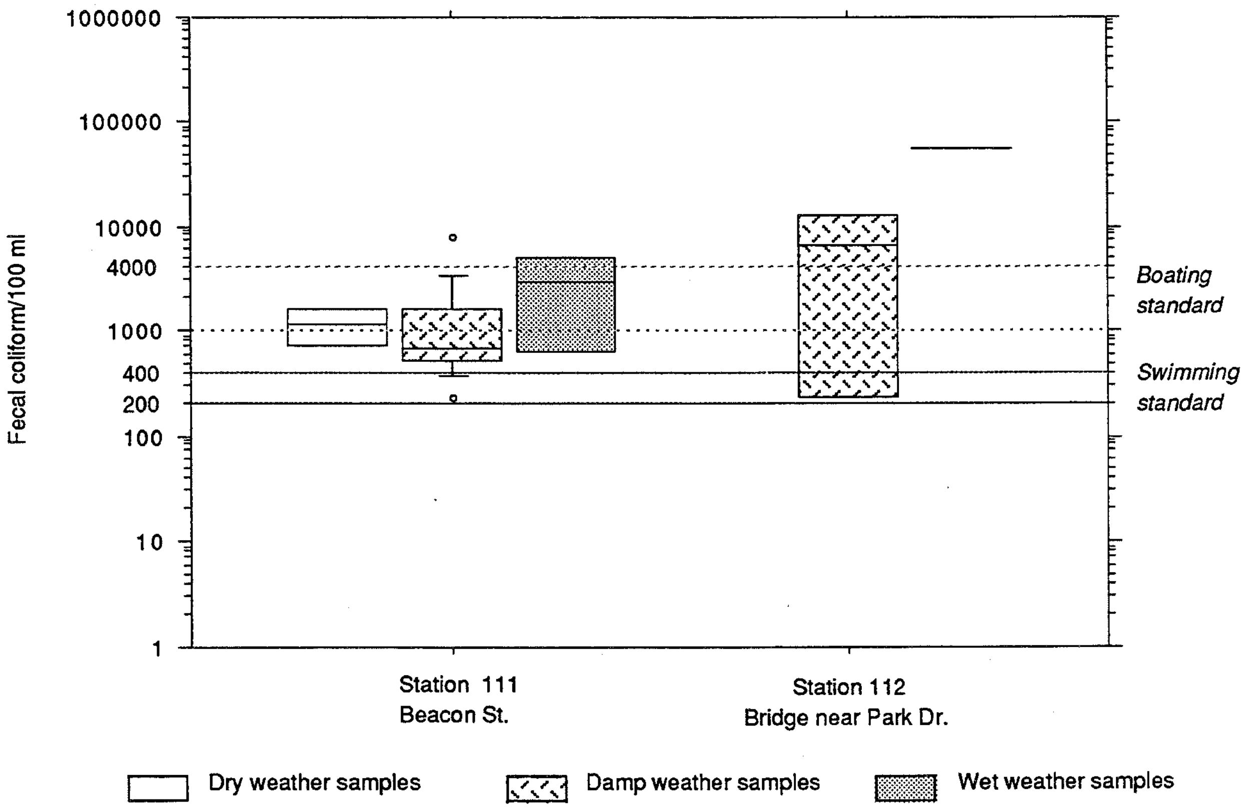
Key:

- ● poor quality or high risk
- ◍ fair quality or moderate risk
- ○ good quality or low/no risk
- ? insufficient data

SW=stormwater
N/A= not applicable

Sources of information on present conditions
1 - Metcalf & Eddy, 1990
2 - Harbor Studies data

FIGURE 5-4. SUMMARY OF EXISTING WATER QUALITY CODITIONS - BACK BAY FENS



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean
111	Dry	4	561	1751	1085
111	Damp	15	246	7951	947
111	Wet	2	641	5301	1843
112	Damp	2	241	12851	1760
112	Wet	1	55051	55051	55051
	TOTAL	24	241	55051	1277

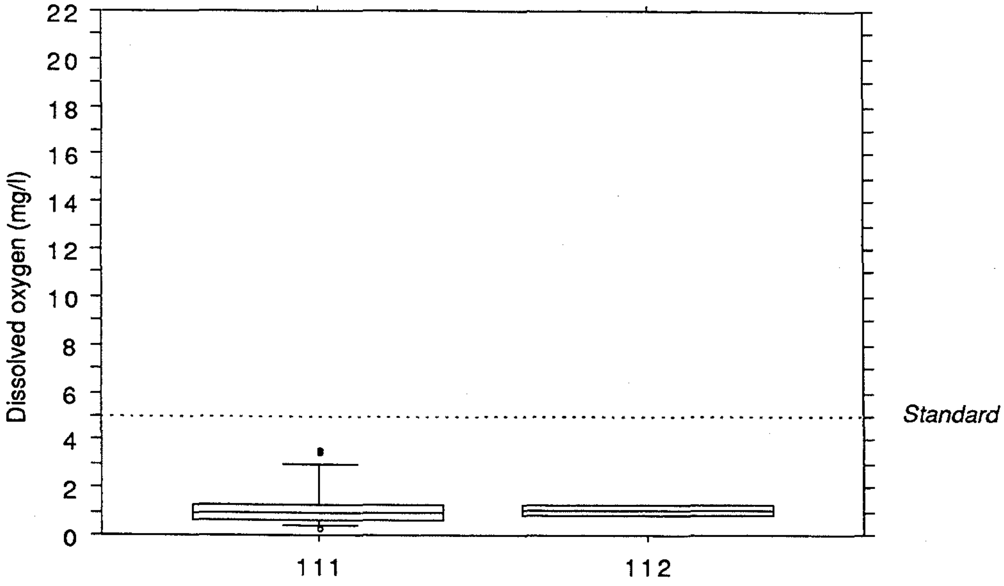
* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0"

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain > 0.5".

FIGURE 5-5. FECAL COLIFORM MONITORING DATA FOR BACK BAY FENS - SURFACE SAMPLES



Station	No. of Samples	Concentration (mg/l)			
		Mean	Median	Minimum	Maximum
111	21	1.3	1.0	0.3	3.6
112	3	1.0	1.1	0.7	1.3
TOTAL	24	1.2	1.0	0.3	3.6

Data were collected by MWRA in 1992

FIGURE 5-6. DISSOLVED OXYGEN CONCENTRATIONS IN BACK BAY FENS mg/l) (DWPC 1974, cited in Metcalf & Eddy 1990). BOD measured in the stream was moderately high, ranging from 1.2 to 4.6 mg/l (Mass DWPC, 1987). Metcalf & Eddy (1990) attribute the low dissolved oxygen concentration in the Fens to low flow, high sediment oxygen demand, and eutrophication.

5.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

Aesthetics is one of the problems in the Fens examples (Metcalf & Eddy, 1990). Invasive stands of *Phragmites* are also a problem in the Fens and in upstream sections of the Muddy River, causing increased sedimentation and reducing the diversity of native vegetation.

5.6.4 Oil and Grease

In much of the downstream reach of the Muddy River, oil and grease cause violation of the aesthetic standard (Metcalf & Eddy, 1990).

5.6.5 Bottom Pollutants or Alterations

Sedimentation in this receiving water segment is excessive not only because of the low flow in the Fens but also because the *Phragmites* traps sediment. Several studies, reviewed by Metcalf & Eddy (1990), collected sediment samples in the Fens. Comparison of sediment quality to state standards for disposal of dredged material indicates that concentrations of cadmium, copper, mercury, lead and zinc exceeded the Class III (highly contaminated) criterion (Metcalf & Eddy, 1990).

5.6.6 Nutrients

The Muddy River receiving water segment has high levels of nutrients, with concentrations generally increasing downstream (Metcalf & Eddy, 1990). Mass DWPC (1987) measured concentrations of total phosphorous ranging from 0.11 - 0.3 mg/l, nitrate ranging from 0.3 - 0.6 mg/l, and ammonia ranging from 0.1 to 0.56 mg/l. Based on the MassDEP lake criteria (MassDEP 1992), the Muddy River is of poor quality in terms of elevated nutrient concentrations.

5.6.7 Temperature

MWRA measurements in July 1992 (unpublished data) found a temperature range of 20.0°C to 25.0°C — within the class B standards.

5.6.8 pH

In the 1974 and 1986 Mass DWPC surveys, the Muddy River met the Class B pH standard of 6.5 to 8.0 (Metcalf & Eddy, 1990).

5.7 USE ATTAINMENT

The Fens has significant water quality problems and some of these are a result of this area not being flushed out with additional clear flow on a regular basis. The Fens is a major stormwater receiving water, while CSO flows are small in comparison. However, because of the very low flushing, it is likely that the CSO would cause water quality problems when it overflows during the largest storms, even in the absence of other sources of pollution. Figure 5-7 shows how water quality problems in the Back Bay Fens affect uses.

CSO loads of pollutants are expected to change only slightly between existing and baseline ("future planned") conditions. We expect that baseline water quality will be similar to existing water quality, and uses will continue to be impaired.

Table 5-1 summarizes bacterial impacts in the Back Bay Fens segment. Current "wet" conditions include all rainstorms of greater than 0.5 inches over three days (see Figure 5-5). We have very few wet weather data, but those were probably collected after events smaller than the three-month and one-year design storms.

Figure 5-7. Beneficial uses affected by water quality in Back Bay Fens

Class B

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			
Aquatic Life	▨ C	ok	ok	ok	ok	?	▨ ?				▨ C		▨ C		
Primary Contact Rec.						?		▨ C	?	?	▨ C	?		?	
Secondary Contact Rec.								▨ C							
Aesthetics									▨ ?	?	?	?	?	?	Phragmites
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

TABLE 5-1. IMPACTS OF FECAL COLIFORM FROM CSOs AND STORMWATER ON BACK BAY FENS

Muddy River/ Back Bay Fens	Current		3 month storm			1 year storm		
	Dry	Wet	CSO	SW	Both	CSO	SW	Both
Primary	***	***	OK	***	***	***	***	***
Secondary	***	***	OK	***	***	***	***	***

Key: CSO = CSO alone
SW = Stormwater alone
Both = CSO and stormwater
OK = Attains bacteria standard for class
*** = Violates bacteria standard for class
? = Partial attainment

TABLE 5-2. USE ATTAINMENT FACTORS IN BAY FENS

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	Low	3	SW, CSO
Secondary Contact Recreation	Low	3	SW, CSO
Aquatic Life	Low	3	eutrophic - low flow
Fish Consumption	Low-Moderate	?	oil leaks, SW
Aesthetics	High	3?	Phragmites

* Preliminary determination; may be collected through public participation process
** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 6
ALEWIFE BROOK

6.1 DEFINITION OF RECEIVING WATER SEGMENT

The Alewife Brook flows from the Little River in Belmont down to the Mystic River in Arlington/Medford (Figure 6-1). Essentially the entire length of Alewife Brook is a receiving water for combined sewage.

6.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The Alewife Brook is currently designated by Massachusetts as a Class B-Fishable/Swimmable water. Water uses of Alewife Brook include fishing and canoeing although the latter is somewhat restricted at this time. The brook is a critical part of the annual alewife migration to spawn upstream and this migration is currently being studied by the Mystic River Watershed Association and the state Riverways Program in an attempt to minimize any obstacles for the fish.

Much of the land along the Alewife Brook is held by the Metropolitan District Commission (MDC) as part of the Alewife Brook Reservation. However, this is a heavily developed urban area with major roads crossing the Brook and residential, commercial and office developments abutting the MDC properties. Currently, the MDC is working on a plan for this area in order to enhance the public use of the Reservation. Current park uses adjacent to the brook include pools, playgrounds and playing fields including the high school football field for Somerville. Land use in the Mystic River watershed, including Alewife Brook, is presented in Chapter 7 (Figure 7-2). The MWRA's Alewife Brook pump station, which pumps sewage from portions of Somerville, Cambridge, Belmont, Arlington, Lexington and Medford to the North Metropolitan Relief Sewer in Medford, also abuts the brook.

6.3 CHARACTERIZATION OF WATERSHED

6.3.1 Topography and Soils

Alewife Brook drains a generally flat area with the exception of some hills on its east side in Somerville.

With the exception of some areas "Freetown" soil open areas in the headwaters of Alewife Brook (USDA 1991), the Alewife Brook watershed is "Urban Land" or "Udorthents" (USDA 1991). "Urban Land" consists of soil that has been altered or obscured by construction such as buildings and parking lots. "Udorthents" are previous tidal marshes or swamps that have been

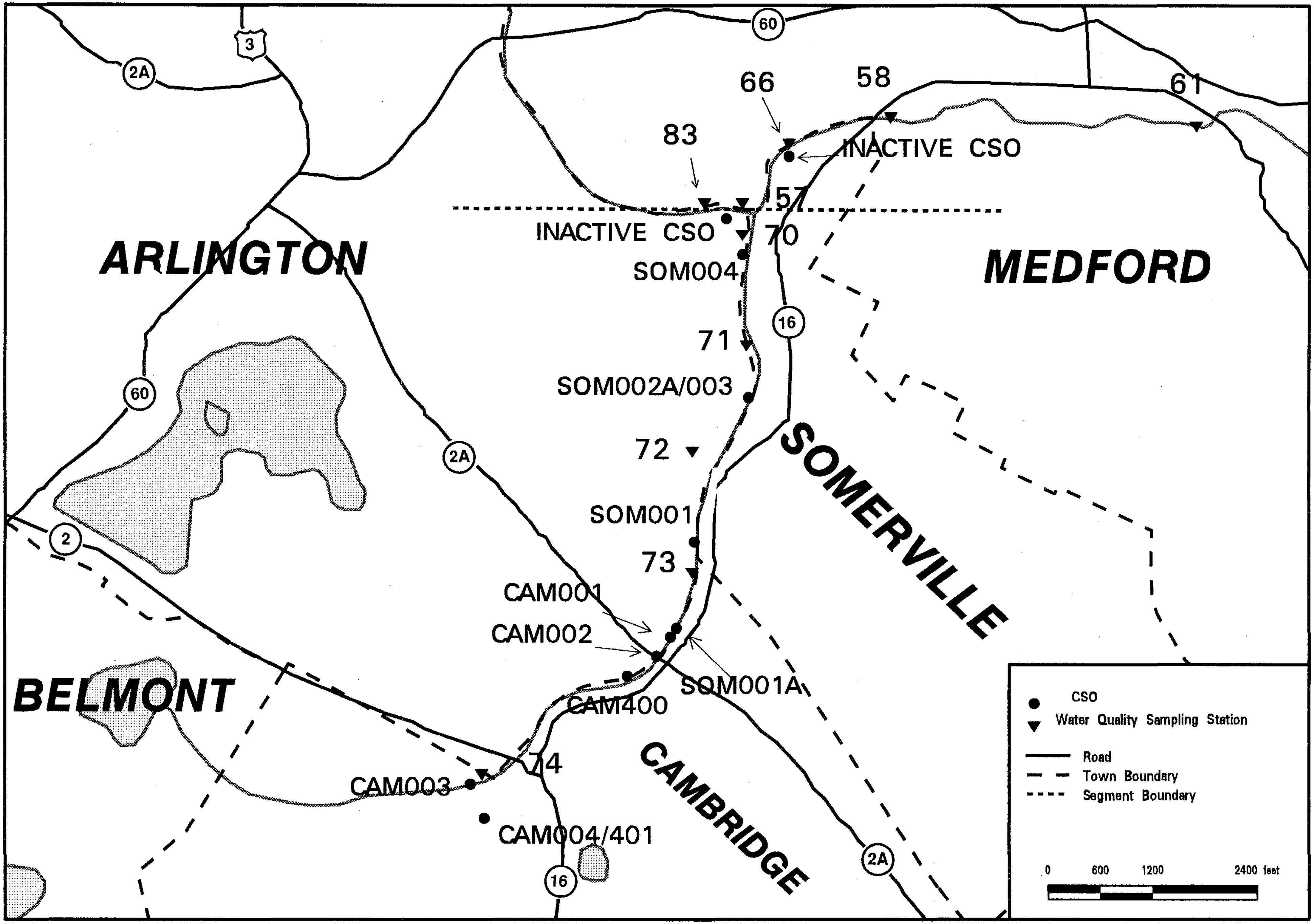


FIGURE 6-1. ALEWIFE BROOK

filled. Urban Land and Udorthents have varied characteristics. Freetown soils have moderate erosion potentials (K = 0.24) and pH less than 6.0.

6.3.2 Dams, Highways, and Other Man-made Features

Route 2 and a major intersection of Routes 2 and 16 are located in the upstream reaches of the Alewife Brook A major roadway, Alewife Brook Parkway (Route 16) parallels Alewife Brook for essentially its entire length. It is crossed by two major city streets, Massachusetts Avenue and Broadway.

6.3.3 Wetlands

There are extensive wetlands at the headwaters of the Alewife Brook which have been altered by extensive development of highway and office parks in the area in recent decades.

6.3.4 Watershed Towns, Upstream Land Use, and Upstream Pollution Sources

Little Pond is surrounded by residential land use. The Little River, which flows from Little Pond to Route 2 flows through a wetland surrounded by office buildings. The Little River appears to be in a fairly natural state.

6.4 SOURCES OF POLLUTION

6.4.1 General

The Alewife Brook is polluted by storm drains and CSOs. Estimated flows and loads of stormwater and CSOs (future planned) are shown in Figures 6-2 and 6-3. We estimate that CSO flows in this segment will decrease by about 22% between existing and "future planned" for the 3-month storm.

6.4.2 Stormwater Discharges

Figure 6-2 and 6-3 indicate that nearly all the wet-weather flow entering the Alewife Brook is stormwater. Stormwater probably also contributes most of the bacteria load.

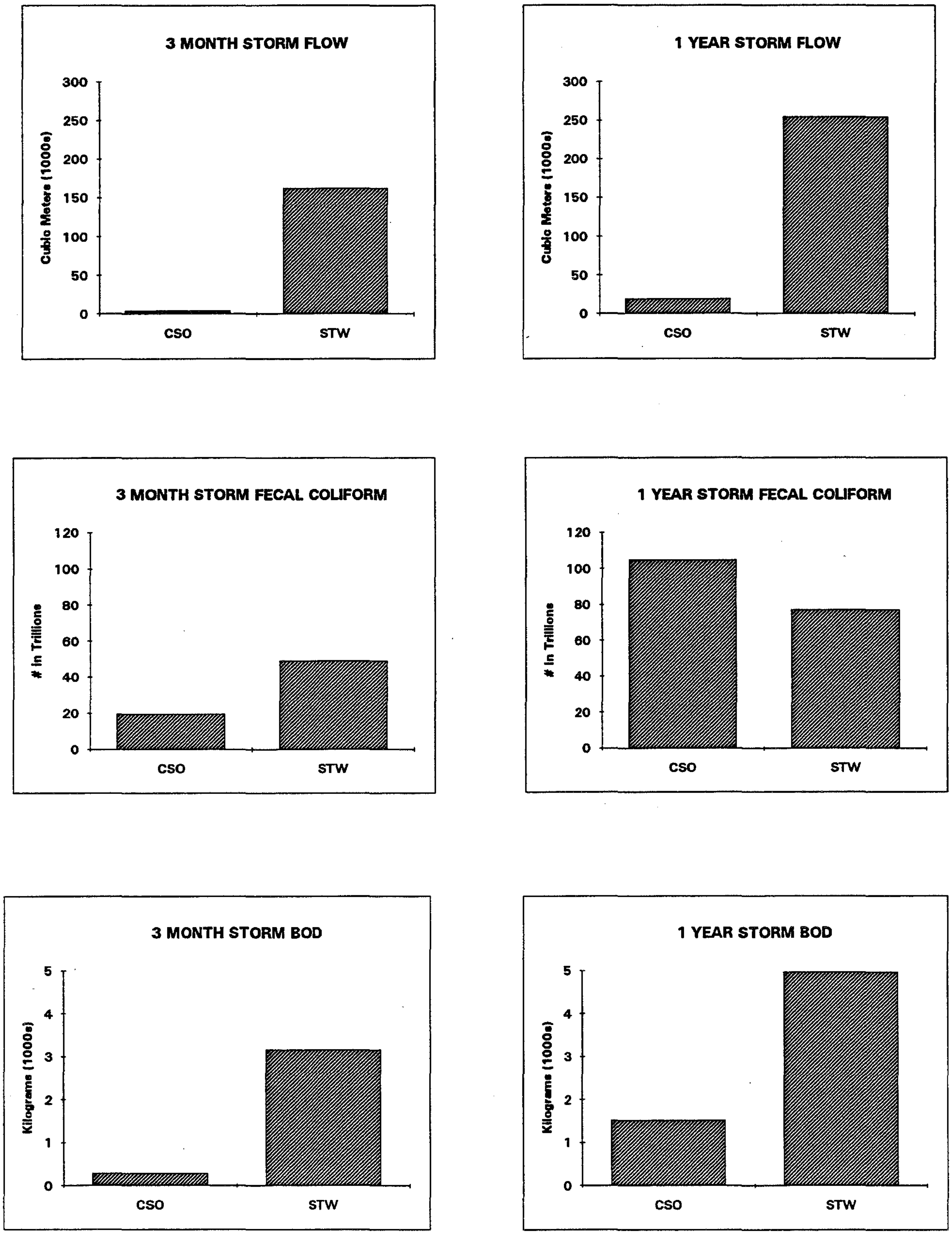


FIGURE 6-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - ALEWIFE BROOK

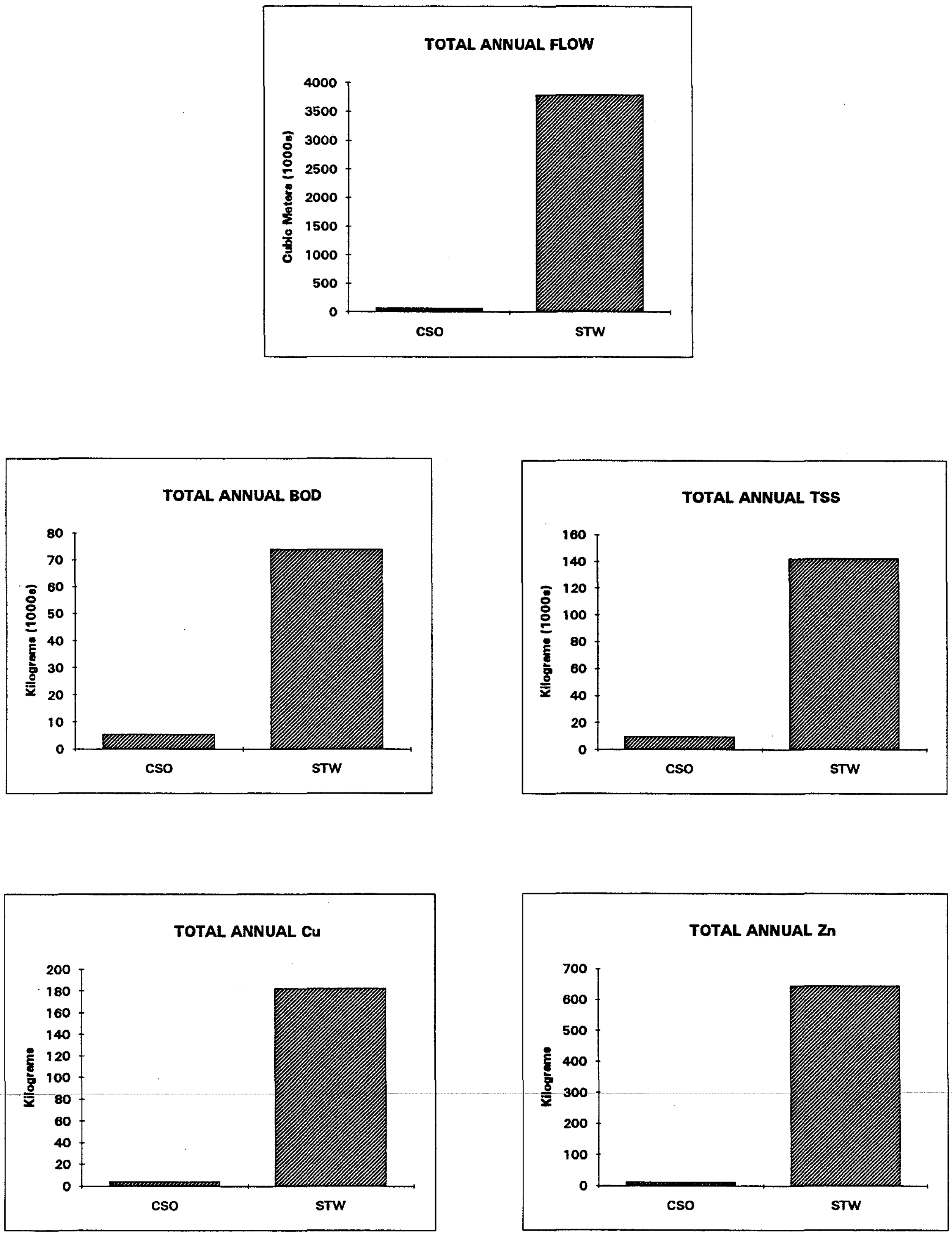


FIGURE 6-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - ALEWIFE BROOK
(a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

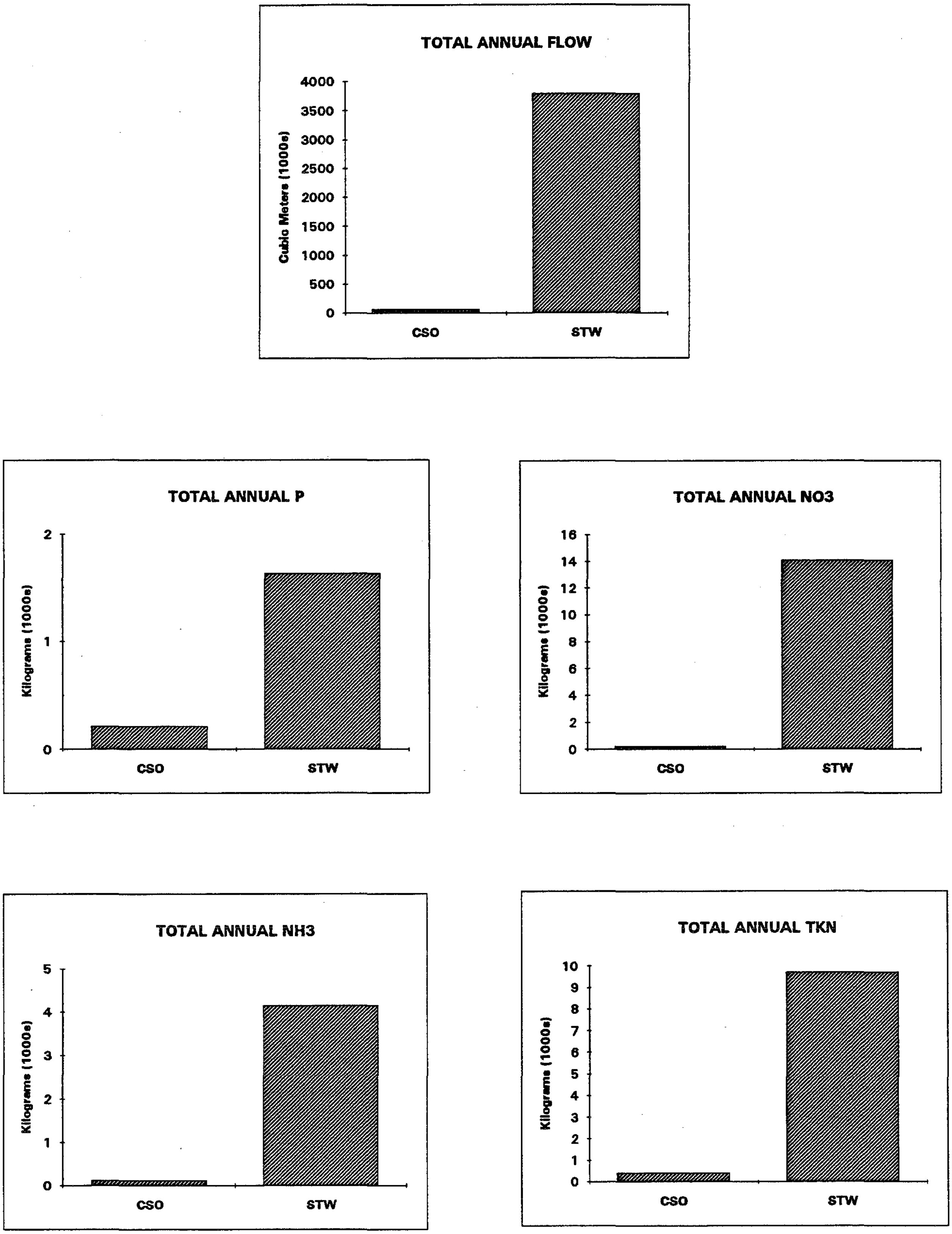


FIGURE 6-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - ALEWIFE BROOK
(b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

6.4.3 CSO Discharges

None of the CSOs discharging into the Alewife Brook are treated. All of the twelve CSOs were monitored during 1992 (MWRA 1993[1]); of these, four did not overflow during the monitoring period, three required one inch or greater of rain to cause an overflow, three required about 0.4 inches, and one overflowed after about 0.3 inches of rain (Table 6-6 in MWRA 1993).

In the 1992 inspections, one CSO appeared to be blocked, two others apparently received infiltration, and the dry weather flow was close to the overflow depth in a fourth.

There was formerly an overflow (MWR017) at the Alewife Brook Pumping Station near the mouth of the Alewife Brook. Because of pumping problems, this overflowed in dry weather as well as wet.

6.5 HYDRODYNAMICS

The brook is channelized between Route 2 and Massachusetts Avenue. Between Massachusetts Avenue and Broadway, the channel walls are stone. Most of the brook has a natural bottom but one section is lined with concrete. From Broadway to its confluence with the Mystic River, the channel appears most natural. The CSOs in Alewife Brook are relatively small and discharge into a confined freshwater body, similar on a smaller scale to the upper Charles River although narrower and with a slower current. Estimates made for a typical CSO event (discharge from CAM401 during the storm of August 17-18, 1992) suggest that dilutions of about 80, 300 and 600 are obtained at distances of 30, 100, and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994). Computer modeling of the brook was not done for this study.

6.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized on Figure 6-4.

6.6.1 Bacterial Contamination

The Alewife Brook is grossly polluted; average sewage indicator bacteria levels are up to ten times higher than applicable Massachusetts Surface Water Quality standards during wet weather, and well above standards during dry weather (Rex, 1993). There is little variation in bacterial water quality along the length of the brook (MWRA, 1991). Fecal coliform data from the first five years of MWRA CSO receiving water monitoring (1989-1993) are shown in Figure 6-5.

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[1] Two of the regulators were monitored together as they discharge via the same conduit.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	●	●	●	much, much higher than standard	fishing; canoeing	●	CSOs, SW
	Dissolved Oxygen (1,6)			◍	some very low day-time counts, mean is above std.	aquatic life fishing	○	CSOs, SW
Aesthetics	Solids and Floatables (1,2,5)	◍	●	●	sewage-related floatables, large and small trash	passive recreation aquatic life	●	CSOs, SW, vandals
Aesthetics	Color and Turbidity (1)	●	●	●	very turbid	extensive passive recreation	?	
Aesthetics	Odor (2)	○	○	○		extensive passive recreation		
	Oil and grease (1,4)	○	○	○		extensive passive recreation		
	Bottom pollutants or alterations (3)	N/A	N/A	●	PAH elevated at Mystic confluence downstream of CSOs	aquatic life	●	CSO? SW?
	Nutrients (4) (algal blooms)	●	●	●	meas. at confluence with Mystic	passive recreation aquatic life	●	
	Toxic Pollutants (4)	●	●	●	several violations of metals chronic and acute	aquatic life	●	CSOs
	Temperature (6)	○	○	○		aquatic life	○	
	pH (4)	○	○	○		aquatic life	○	

Key:

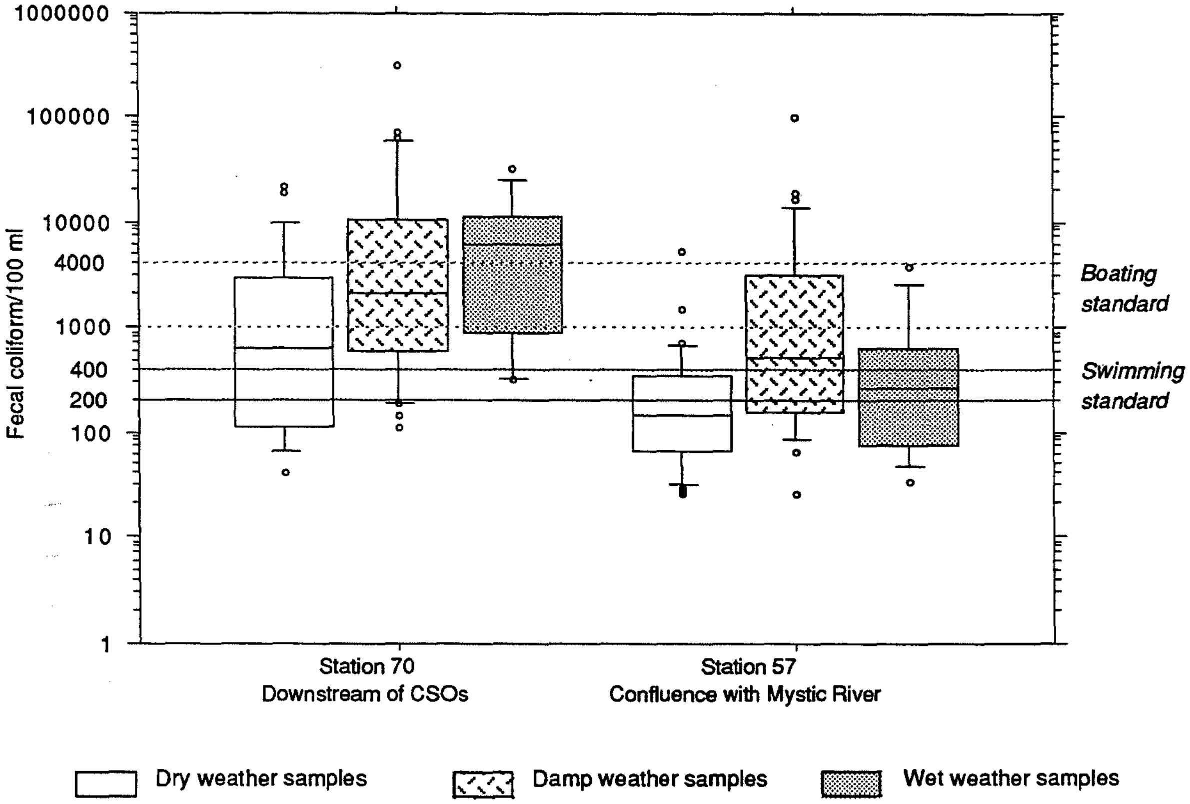
- ● poor quality or high risk
- ◍ fair quality or moderate risk
- ○ good quality or low/no risk
- ? insufficient data

SW=stormwater
N/A= not applicable
PAH=polycyclic aromatic hydrocarbons

Sources of information on present conditions

1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993-94
3 - Battelle, 1990a
4 - CH2M Hill, 1989
5 - Sommers, 1982
6 - Harbor Studies data
7 - MWRA, 1991

FIGURE 6-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - ALEWIFE BROOK



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
70	Dry	24	41	22201	744
70	Damp	31	114	313001	2918
70	Wet	10	326	33001	3308
57	Dry	30	26	5351	167
57	Damp	29	26	100001	752
57	Wet	9	34	3851	251
	TOTAL	133	26	313001	761

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 6-5. FECAL COLIFORM MONITORING DATA FOR ALEWIFE BROOK (1989-93)

6.6.2 Dissolved Oxygen

Surface dissolved oxygen in the Alewife Brook ranged from 2.4 to 13.2 mg/l, with a mean of 7.5 mg/l, in daytime sampling for the routine receiving water monitoring between 1989 and 1993 (MWRA 1991, Rex 1993, unpublished MWRA Harbor Studies data). Dissolved oxygen data at selected sites from the first five years of MWRA CSO receiving water monitoring are shown in Figure 6-6.

6.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

Some parts of the Alewife Brook are littered with trash in the water and on the banks (Sommers, 1982), while the common occurrence of sewage related floatables in the water and on overhanging branches has been documented by MWRA CSO receiving water monitoring staff. There are large items of trash, such as shopping carts and discarded appliances; these may have been reduced in number since 1985 (AMC, 1990) but still are present in large numbers and can make the brook entrance unnavigable. Alewife Brook is very turbid; it is not possible to see the bottom even where it is only two feet deep.

6.6.4 Oil and Grease

Sampling conducted for the 1990 MWRA CSO Facilities Plan (CH2M Hill 1989) included one station at the mouth of the Alewife Brook, where it empties into the Mystic River. Oil and grease measurements at this station ranged from 1 to 5 mg/l.

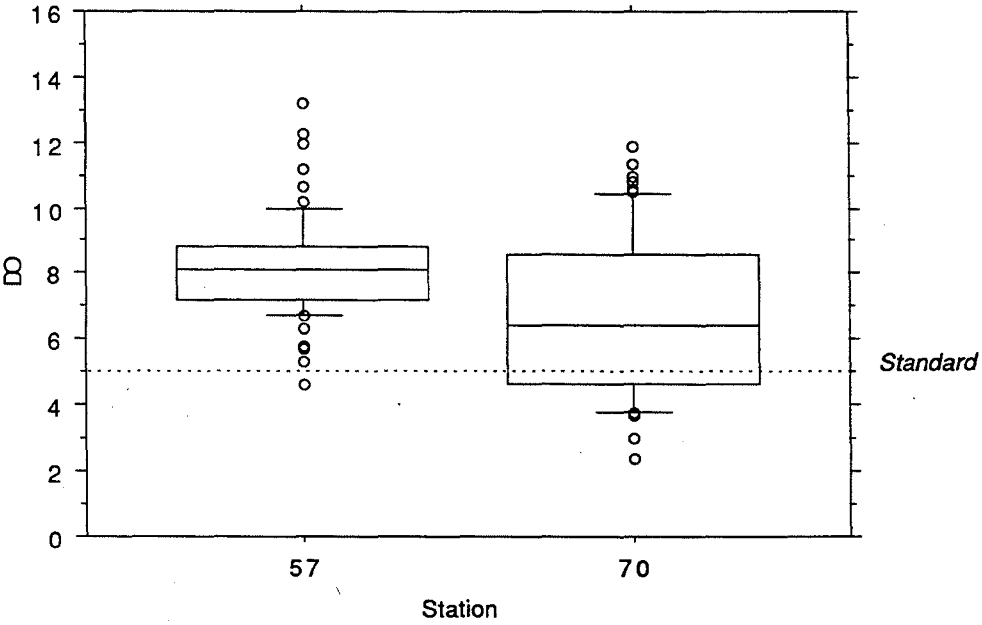
6.6.5 Bottom Pollutants or Alterations

Although channelized, the Alewife Brook has mostly a natural bottom. We are not aware of any information available on bottom conditions. A pilot study of CSO effects on sediment contamination conducted for MWRA included stations in the Mystic River at and near the confluence with Alewife Brook (see Chapter 7).

We are aware of no information on the benthic ecology of the Alewife Brook.

6.6.6 Nutrients

Nutrient samples were collected in 1988 at one station at the mouth of the Alewife Brook (CH2M Hill 1989). The results are given in Table 7-2 of this report. Based on guidance for estimating the nutrient status of lakes (MassDEP, 1992) the Alewife Brook appears to be of poor quality in terms of nutrients.



Station	No. of Samples	Concentration (mg/l)		
		Mean	Minimum	Maximum
57	65	8.2	4.6	13.2
70	65	6.7	2.4	11.9
TOTAL	130	7.5	2.4	13.2

FIGURE 6-6. DISSOLVED OXYGEN CONCENTRATIONS IN ALEWIFE BROOK - SURFACE SAMPLES (1989-93)

6.6.7 Toxic Pollutants and Toxicity

Selected toxic contaminants were analyzed in the 1988 sampling conducted for the 1990 MWRA CSO Facilities Plan (CH2M Hill, 1989). Results for the Mystic/Alewife confluence station indicate some potential violations of EPA acute criteria; see Chapter 7 for more detail.

6.6.8 Temperature

Surface temperature in the Alewife Brook did not exceed the state standard of 83°F (28.3°C) in any of the routine receiving water monitoring between 1989 and 1992 (MWRA 1991, Rex 1993, unpublished MWRA Harbor Studies data).

6.6.9 pH

In the 1988 sampling for the MWRA CSO Facilities Plan, pH at the Mystic/Alewife confluence varied from 6.6 to 8.0; thus, all eleven samples fell within the state standards (CH2M Hill, 1989).

6.7 USE ATTAINMENT

6.7.1 Existing Water Quality and Affected Uses

The water quality problems and affected uses in this segment are summarized on Figure 6-7. Class B uses are generally not supported in the Alewife Brook. The most serious problems are high bacteria counts and aesthetic degradation by trash and sewage-related floatables. All of these are problems in dry as well as wet weather.

MassDEP (1993a) identifies organic enrichment, nutrients, suspended solids, and pathogens as causes of water quality problems in the brook. Sources of these contaminants are urban runoff/storm sewers, CSOs, and in-place contaminants.

6.7.2 Baseline ("Future Planned") Water Quality and Affected Uses

Future planned conditions have somewhat less CSO flow than existing conditions. Possible dry weather inflows may keep bacteria levels high even in dry weather, and stormwater will continue to cause elevated bacteria levels during storms.

Table 6-1 summarizes bacterial impacts in the Alewife Brook segment. In the one-year storm, CSOs are relatively more important than stormwater; however, either CSO or stormwater loads

Figure 6-7. Beneficial uses affected by water quality in Alewife Brook

Class B

Water Quality Assessment

MWRA CSO/System Master Plan

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					ok ?	?			
Aquatic Life	C	ok	ok	ok	ok	C	C		?		ok		C		
Primary Contact Rec.								C				ok		C	
Secondary Contact Rec.								C						C	
Aesthetics									C	ok	ok		C	C	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity

Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.

BIP: Balanced Indigenous Population

(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

alone would cause non-attainment of the primary and secondary contact recreation standards in this very large storm. CSO alone would likely violate the swimming standard in the three-month storm, but the boating standard might be met if CSOs were the only source.

Table 6-2 summarizes the level of use this segment and the factors affecting attainment or nonattainment of the uses.

TABLE 6-1. IMPACTS OF FECAL COLIFORM FROM CSOs AND STORMWATER ON ALEWIFE BROOK

	Current		3 month storm			1 year storm		
Alewife Brook	Dry	Wet	CSO	SW	Both	CSO	SW	Both
Primary	***	***	***	***	***	***	***	***
Secondary	***	***	?	***	***	***	***	***

Key: CSO = CSO alone
SW = Stormwater alone
Both = CSO and stormwater
OK = Attains bacteria standard for class
*** = Violates bacteria standard for class
? = Partial attainment

TABLE 6-2. USE ATTAINMENT FACTORS - ALEWIFE BROOK

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	None	3	Stormwater, CSO
Secondary Contact Recreation	Low	3	Stormwater, CSO
Aquatic Life	High	2(?)	Stormwater, CSO
Fish Consumption	Low	(?)	(?)
Aesthetics	Moderate	3	CSO, Litter/dumping, Stormwater

* Preliminary determination, may be corrected through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 7
UPPER MYSTIC RIVER

7.1 DEFINITION OF RECEIVING WATER SEGMENT

The upper Mystic River segment includes the Mystic River between the southern end of Mystic Lakes down to the Amelia Earhart Dam (Figure 7-1). The Mystic River forms part of the border between Arlington and Medford and between Somerville and Medford. Tributaries to the Mystic River include the Mill Brook, which enters just below the Lower Mystic Lake; the Alewife Brook, which flows in a little further downstream, and the Malden River, which enters just above the dam. This report focuses on the CSO receiving water portion of the Mystic River, i.e. between the Mystic River/Alewife Brook confluence and the Amelia Earhart Dam.

7.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The upper Mystic River is a Class B-Fishable/Swimmable water. The Class B Malden River also discharges into the Mystic River within this reach. Water uses of this section of the Mystic River are varied, encompassing powerboating, canoeing, and fishing. Several yacht clubs are located along this stretch of the river and some of the homes adjacent to the river upstream in Medford have small piers. Public launching areas are available within this section as well. Although sailboat use is limited in some sections due to fixed bridges, instruction in small sailboats has historically been available. The Upper Mystic River is an anadromous fish run (alewives). There is no commercial shipping activity upstream of the Earhart Dam. There is, however, flatwater canoeing on the Mystic River and in the lower section of Alewife Brook. There are three marina and yacht clubs between the Mystic River/Malden River confluence and Malden Center and one just upstream of the dam.

Land uses adjacent to the river include a large area on the north side of the river under the control of the MDC known as the Mystic River Reservation (Figure 7-2). This area is extensively used for recreation including walking, biking, and birdwatching. Land uses abutting the Reservation include heavily developed residential and commercial areas. The Malden River area is used primarily for industrial and office park land uses. Other developed park and playground facilities exist in both Somerville and Medford. The overall area is a significant transportation corridor with several major roads and rail corridors crossing or running along the river.

Immediately upstream of Alewife Confluence, the river is bordered by broad grassy parkways. Beyond the parklands is residential land use. Between the Alewife Brook Pump Station and Route 93, there is parkland on the left hand of the river bordered by a parkway. Residential land use is behind the parkway and on the other side of the river. There is some commercial activity near its confluence with Alewife Brook. As the river passes behind Medford Square, the channel walls are lined with stone. Between Route 93 and the Earhart Dam, on the left hand

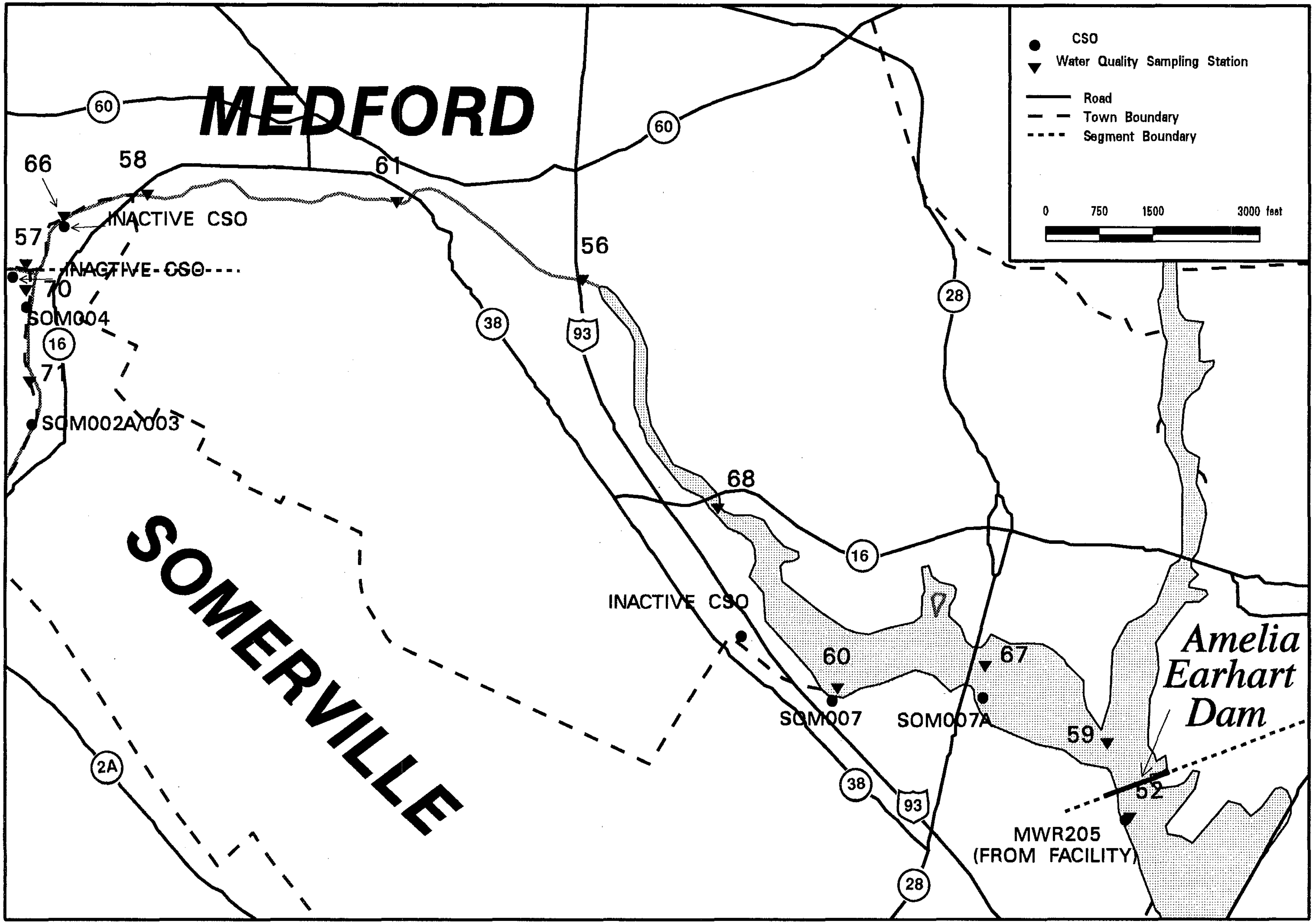


FIGURE 7-1. UPPER MYSTIC RIVER

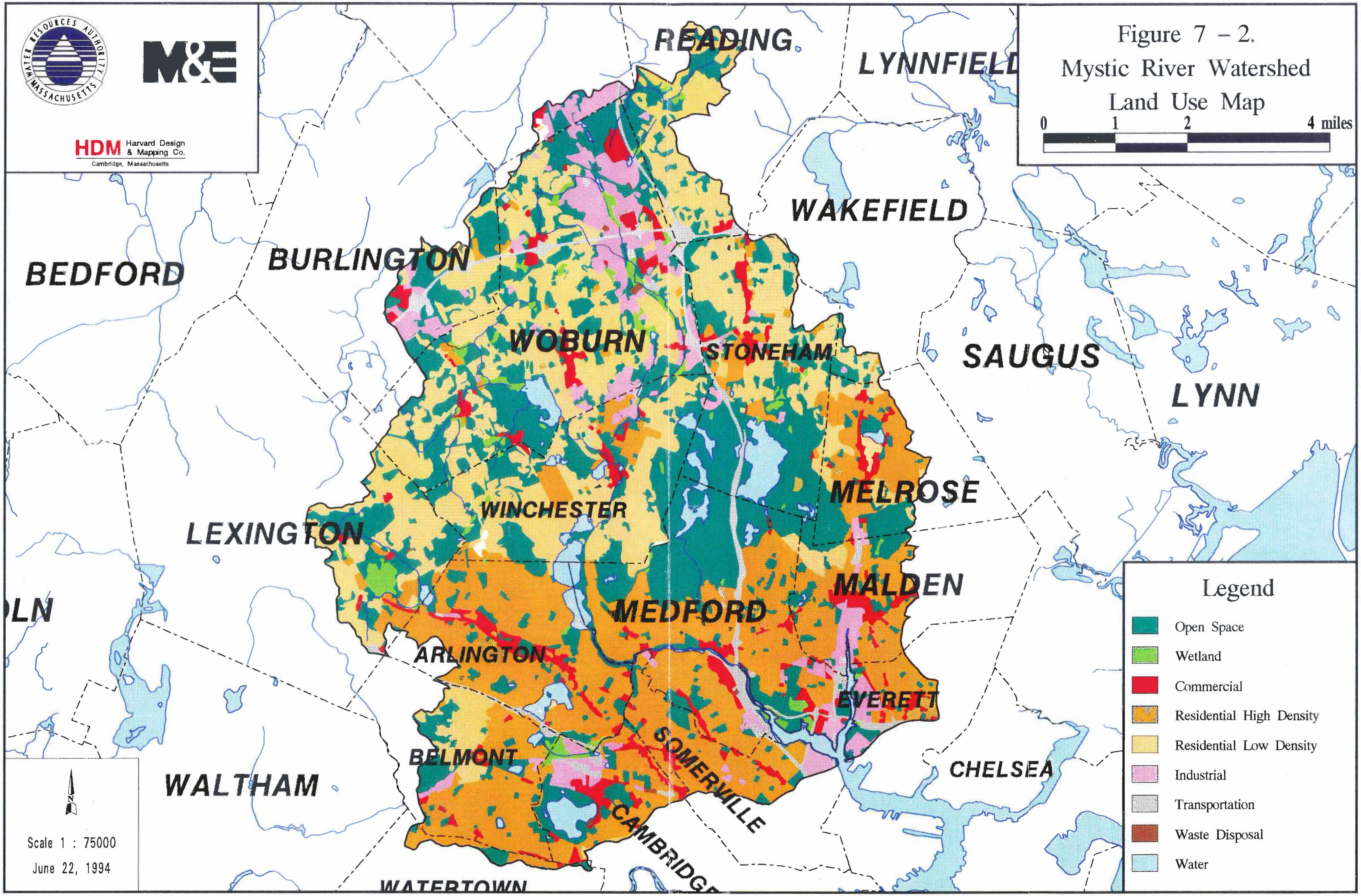


Figure 7 – 2.
Mystic River Watershed
Land Use Map

Scale 1 : 75000
June 22, 1994

WATER RESOURCES AUTHORITY MASSACHUSETTS
M&E
HDM Harvard Design & Mapping Co.
Cambridge, Massachusetts

side of the river until Route 28, there is a wide area of parkland; on the right bank there is a narrow strip of park. Downstream of Route 28, there is industrial activity on the river banks. There are bikeways on both sides which continue downstream of Route 28.

7.3 DESCRIPTION OF WATERSHED

7.3.1 Location

The Mystic River Watershed is located north of Boston, and includes the Mystic Lakes, the Aberjona River, Alewife Brook and the Malden River as well as the Mystic River (Figure 7-2). The total drainage area is 171 km^2. The eleven towns with a portion of their land in the watershed are listed below (WRC 1991, p. 10). The Mystic River itself flows from the outlet of the Mystic Lakes to Boston Harbor.

Arlington
Belmont
Burlington
Chelsea
Everett
Malden
Medford
Melrose
Somerville
Stoneham
Winchester
Winthrop
Woburn

7.3.2 Topography and Soils

The Mystic River generally flows through a flat region from its headwaters of the Aberjona River to Boston Harbor. In parts of the watershed, there are some hilly regions with elevations as high as 300 feet above sea level.

Downstream of the confluence with Alewife Brook, the Mystic River watershed is "Urban Land" or "Udorthents" (USDA, 1991). "Urban Land" consists of soil that has been altered or obscured by structures such as buildings or parking lots. "Udorthents" are previous tidal marshes or swamps that have been filled. Upstream of the confluence, major soil types include "Urban Land", "Canton", "Charlton", "Merrimac A", and "Paxton". Urban Land and Udorthents have varied characteristics; Canton, Charlton, Merrimac A, and Paxton soils have moderate erosion potentials (K = 0.24) and pH less than 6.0.

7.3.3 Dams, highways, and other man-made features

Several major roadways pass through the watershed. Route 93 passes through the upper and lower portions of the Mystic River. The Mystic Valley Parkway follows the west side of the Mystic River downstream below the Mystic River/Alewife Brook confluence. The Revere Beach Parkway cuts across the watershed near the Amelia Earhart Dam.

There is a dam on the Aberjona River in downtown Winchester and one at the mouth of the Mystic River (Amelia Earhart Dam). The Earhart Dam is used to control the level of the river during flood situations. It is equipped with pumps so that it can pump out water during high tides. It is also equipped with locks for boat passage.

7.3.4 Wetlands

There are extensive marshes on both sides of the river between the Fellsway (Rte 28) and the Mystic Valley Parkway (Rte 16) bridges. There are also wetlands and marshes at the mouth of the Malden River.

7.3.5 Watershed Towns, Upstream Land Use, and Upstream Pollution Sources

The watershed area upstream of the Alewife Brook and Mystic River confluence is generally residential with some pockets of industrial activity, particularly in Woburn. According to MassDEP (1993a), the Aberjona River is not supporting of its classification of B/WWF. Causes include ammonia, organic enrichment, and pathogens from municipal point sources, urban runoff and storm sewers. In addition, there may be toxic pollutants in the watershed and river from past industrial activities.

The Malden River has a thin marshland bordering the river on both sides. On the right side (going downstream), there is generally commercial and some industrial land use. On the other side is commercial and residential land use with some playgrounds. The left hand side of the confluence with the Mystic River is marshland.

According to MassWRC (1991), there are five industrial dischargers in the watershed, one each on the Mystic River, Aberjona River, Mill Brook, Fresh Pond Brook, and Halls Brook.

7.4 SOURCES OF POLLUTION

7.4.1 General

The upper Mystic River is polluted by the Alewife Brook, CSOs, stormwater, and industrial pollution. Estimated flows and loads of stormwater and CSOs (future planned), and from the upstream end of the segment, including Alewife Brook, are shown in Figures 7-3 and 7-4. Three month storm CSO flows and loads are not expected to change between existing and "future planned" conditions in this segment.

7.4.2 Stormwater discharges

The fairly even spatial distribution of indicator bacteria during wet weather, with areas far from or upstream of CSOs having similar counts to those near CSOs, indicates that sources other than combined sewage, such as contaminated stormwater could be contributing to the bacterial contamination of the upper Mystic River. For example, illegal connections are suspected in the Meeting House Brook drain area.

This portion of the watershed is highly urbanized with high density housing and commercial activities, and heavy industrial and transportation use. There are storm drains from both land and highway in the area. However, with available data, a relationship between land use and stormwater quality in the CSO study area cannot be defined (Metcalf & Eddy, 1994b).

7.4.3 CSO discharges

The CSOs[1] in the upper Mystic River segment lie at the downstream end, near the Amelia Earhart Dam. One of these, SOM007A, is an upstream overflow for the Somerville Marginal CSO facility, which discharges treated combined sewage downstream of the dam through MWR205 (see Chapter 8). None of the other CSOs in the upper Mystic River segment are treated.

One of the upper Mystic River CSOs (SOM007) was monitored during 1992 and did not overflow during the monitoring period (MWRA, 1993). SOM007A was indirectly monitored at the Somerville Marginal CSO facility. Maintenance inspections conducted in 1992 identified a crack in the crown of the conduit at SOM007A.

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[1] SOM005, near the mouth of the Alewife Brook, is believed to be inactive.

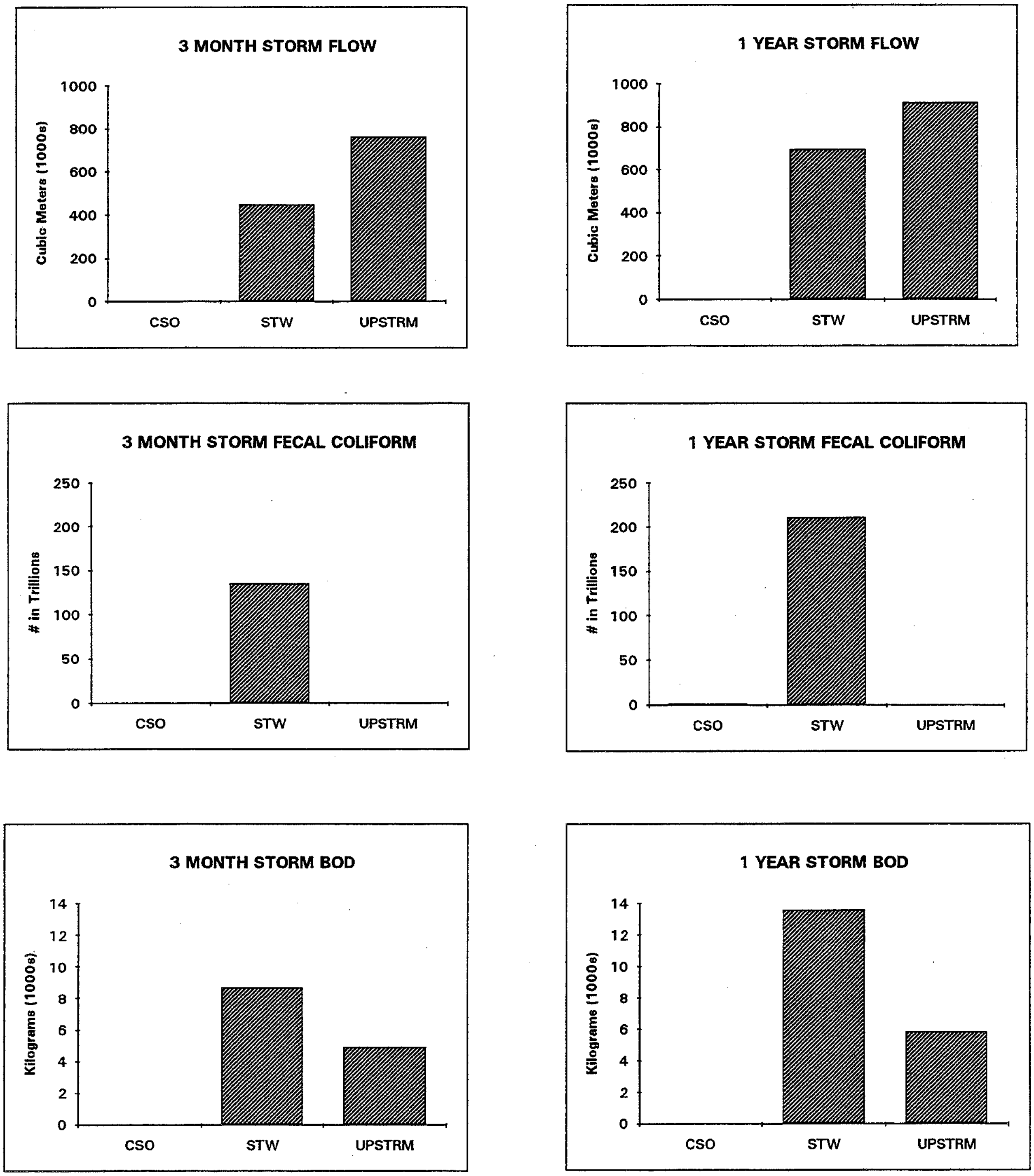


FIGURE 7-3. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENT - UPPER MYSTIC RIVER

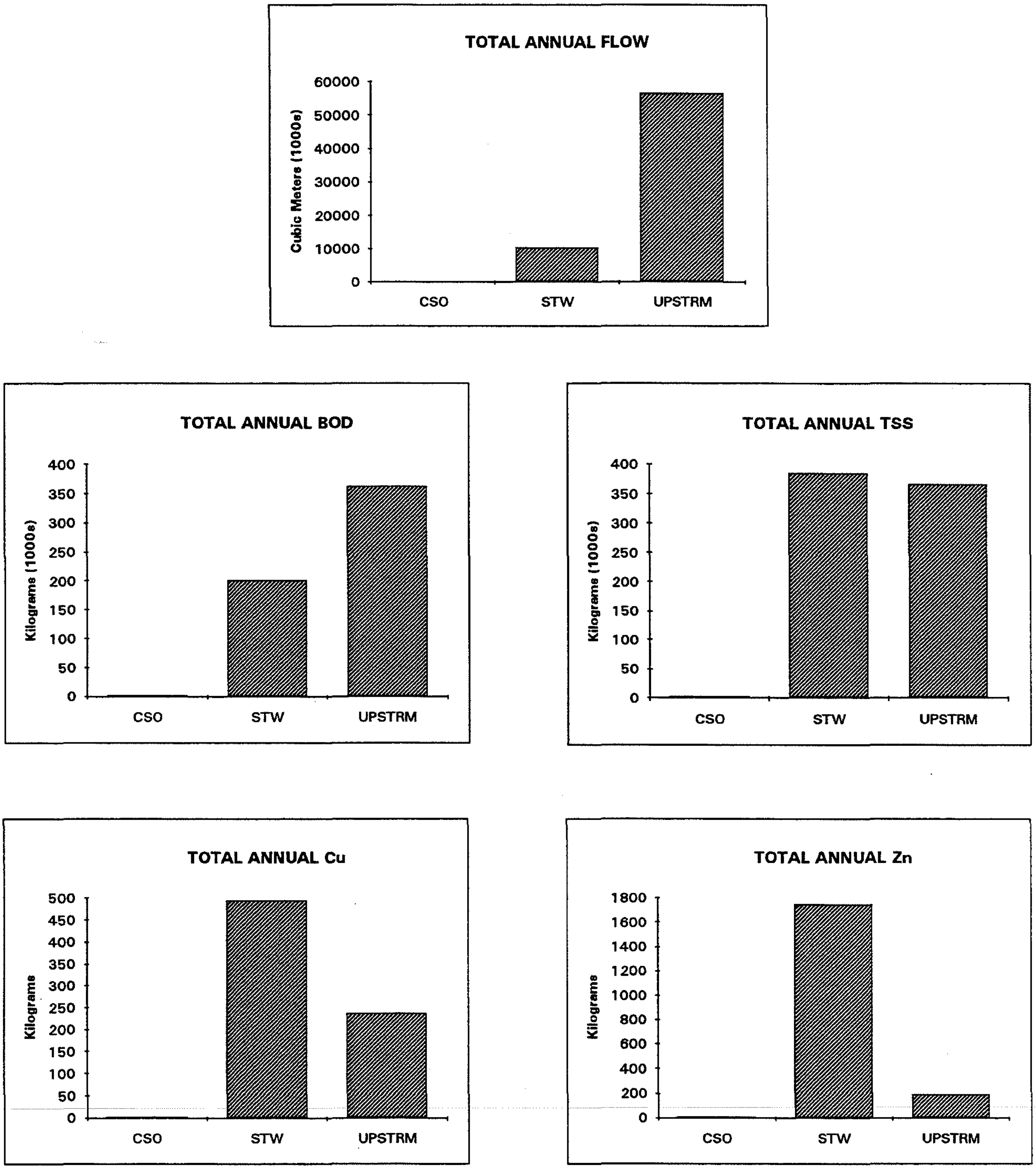


FIGURE 7-4. FUTURE PLANNED ANNUAL FLOWS AND LOADS - UPPER MYSTIC RIVER
(a) FLOWS, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

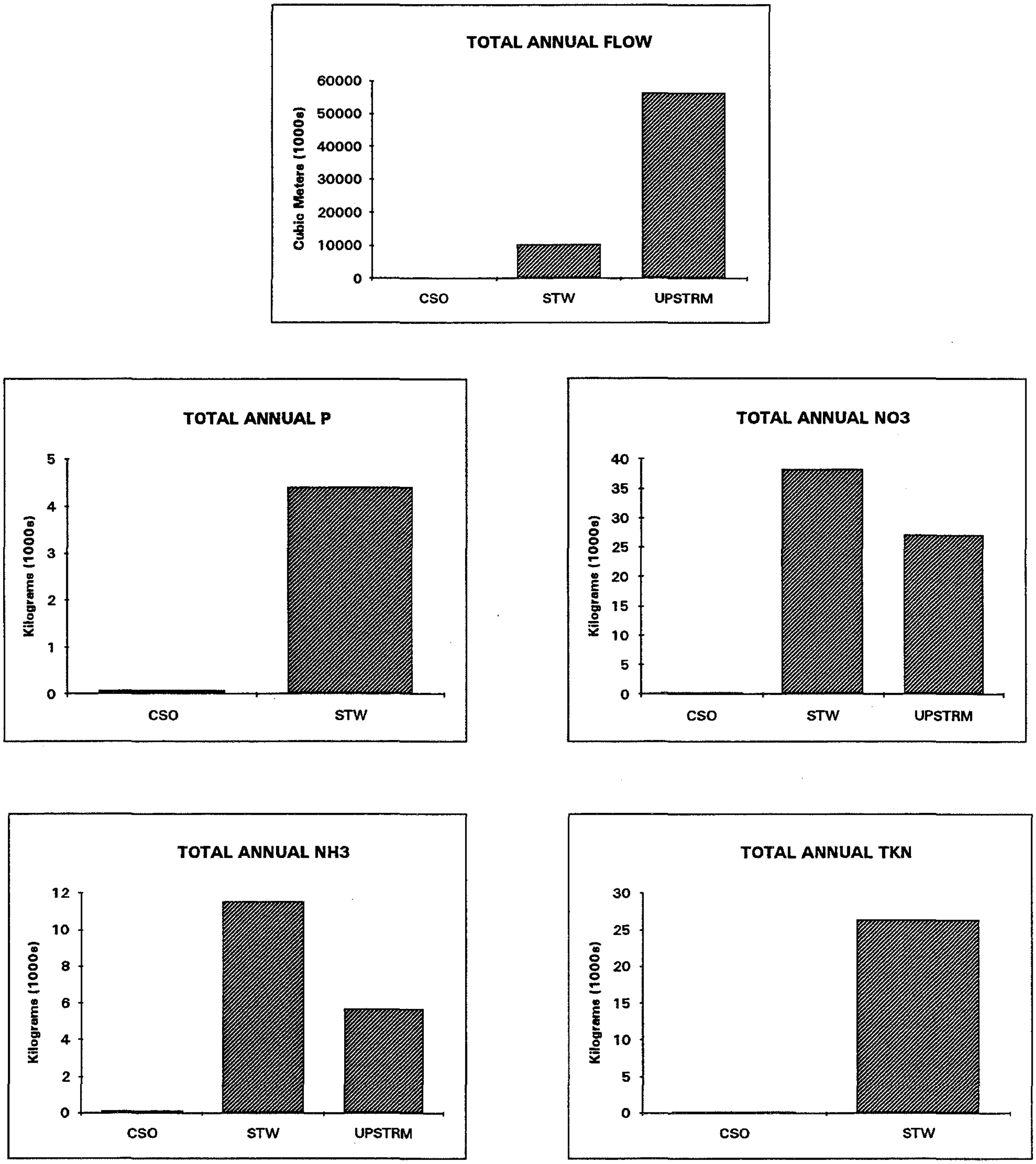


FIGURE 7-4. FUTURE PLANNED ANNUAL FLOWS AND LOADS - UPPER MYSTIC RIVER
(b) FLOWS, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

7.4.4 Upstream inputs

The Alewife Brook adversely affects the quality of the Mystic River (Rex, 1993). Also, bacterial counts upstream of all CSOs, and upstream of the Alewife Brook, are elevated during wet weather.

7.5 HYDRODYNAMICS

Major tributaries include the Aberjona River from the north, Mill Brook from the west, Alewife Brook from the west, and the Malden River from the north. There are several other streams and ponds tributary to the Aberjona River.

The only continuous U.S.G.S. streamflow gage is "Aberjona at Winchester" (62.5 square kilometers). Given the record of 1940 to the present, mean monthly flows vary from 0.25 m^3/s in August to 1.86 m^3/s in March. The average flow is 0.81 m^3/s.

The river is moderately narrow and swift in the uppermost portion, widening and slowing toward the dam. At the Amelia Earhart Dam, the average flow is approximately 2.1 m^3/s (calculated by adjusting the gaged flow for the drainage downstream of the gage, as in Alber and Chan 1994).

Like the Charles River, the Mystic River expands as it approaches the Amelia Earhart Dam. Thus, in the downstream section where most of the CSOs are located, the flow is quite sluggish and mixing is expected to be similar to that in the Charles River Basin.

7.6 EXISTING RECEIVING WATER QUALITY

According to MassDEP (1993a), the reach of the Mystic River upstream of the dam is non-supporting of Class B because of pathogens, metals, and nutrients. Sources include CSOs, stormwater runoff and upstream flow. There may also be toxic pollutants from past industrial activity in the groundwater of upstream and adjacent locations. Existing water quality conditions are summarized on Figure 7-5.

7.6.1 Bacterial contamination

Most of the upper Mystic River segment met or almost met the Class B standard during monitoring periods in 1990 and 1991 (Rex, 1993). During wet weather, however, bacterial counts tend to be slightly elevated throughout this segment (Rex, 1993). Counts are generally higher upstream than downstream. Fecal coliform monitoring data from the first five years of MWRA CSO receiving water monitoring are shown in Figure 7-6.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,5,6)	◍	◍	◍	meets or almost meets class SB std. downstream	boating	◍	upstream, CSOs, SW, Alewife Brook
	Dissolved Oxygen (1,6)	◍	◍	◍	some very low daytime counts	aquatic life fishing	◍	
Aesthetics	Solids and Floatables (2)	◍	◍	◍	floatables near Alewife Br; trash along river	passive recreation aquatic life	◍	CSOs vandals
	Color and Turbidity (2)	○	○	○		extensive passive recreation		
	Odor (2)	●	●	●	sewage odor often detected	extensive passive recreation		sewer overflows?
	Oil and grease (1,4)	○	○	○		extensive passive recreation	○	
	Bottom pollutants or alterations (3)	N/A	N/A	◍	elevatedPAH downstream of CSOs vs. upstream	aquatic life	◍	SW, upstream, CSOs
	Nutrients (4) (algal blooms)	●	●	●	a few very high nitrate meas.	passive recreation aquatic life	◍	
	Toxic Pollutants (4)			◍	some violations of metals chronic and acute	aquatic life	◍	SW, upstream, CSOs
	Temperature (6)	○	○	○		aquatic life	○	
	pH (4)			◍	some high measurements	aquatic life	◍	

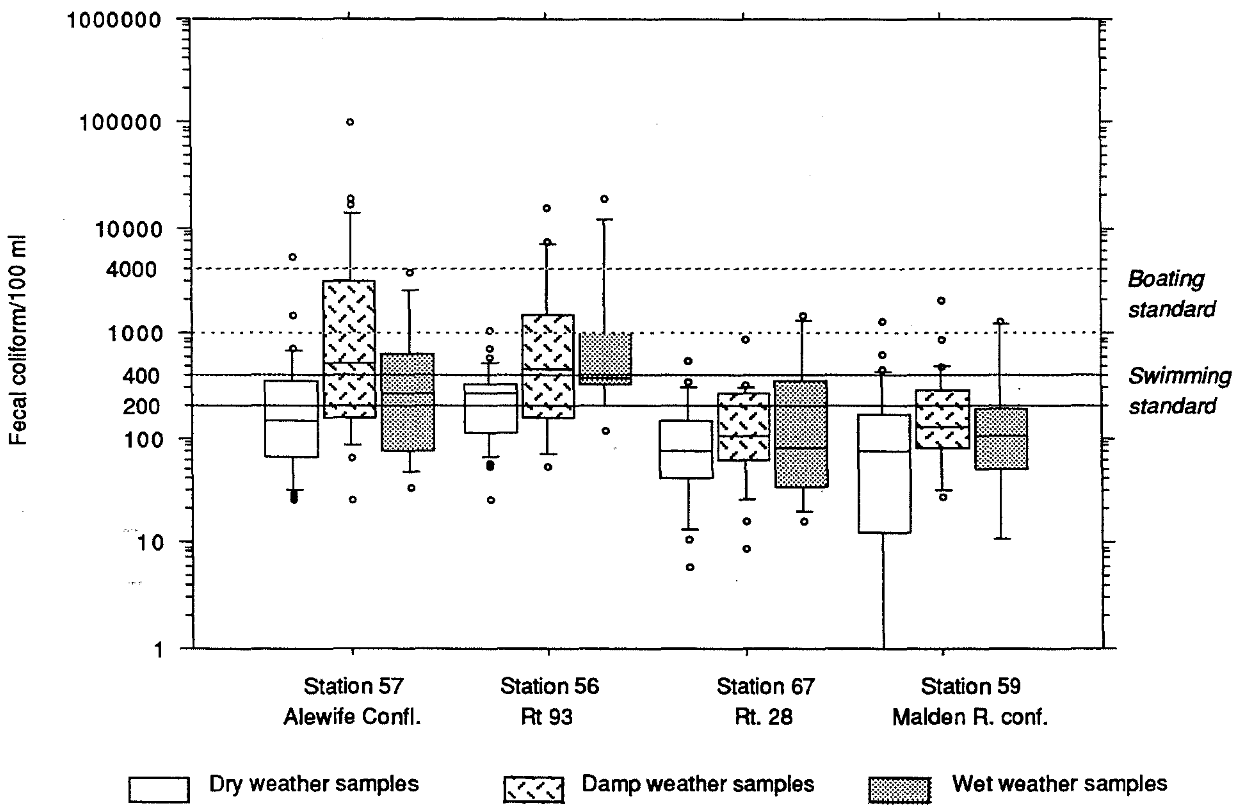
Key:

●	poor quality or high risk
◍	fair quality or moderate risk
○	good quality or low/no risk
?	insufficient data

SW=stormwater
N/A= not applicable
PAH=polycyclic aromatic hydrocarbons

Sources of information on present conditions
1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993-94
3 - Battelle, 1990a
4 - CH2M Hill, 1989
5 - MWRA, 1991
6 - Harbor Studies data

FIGURE 7-5. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - UPPER MYSTIC RIVER



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
57	Dry	30	26	5351	167
57	Damp	29	26	100001	752
57	Wet	9	34	3851	251
56	Dry	30	26	1086	210
56	Damp	24	54	15651	563
56	Wet	9	126	20001	694
67	Dry	32	1	551	68
67	Damp	31	9	906	105
67	Wet	12	16	1501	111
59	Dry	28	1	1306	43
59	Damp	28	1	2101	115
59	Wet	10	1	1341	89
	TOTAL	272	1	100001	163

* Number of Counts per 100 ml
Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".
Damp weather samples were collected when three-day rain was between 0.0" and 0.5".
Wet weather samples were collected when three-day rain >0.5".

FIGURE 7-6. FECAL COLIFORM MONITORING DATA FOR UPPER MYSTIC RIVER (1989-93)

7.6.2 Dissolved oxygen

Surface daytime dissolved oxygen in the freshwater segment of the Mystic River ranged from 0.7 to 19.7 mg/l, with a mean of 9.7 mg/l, in routine receiving water monitoring between 1989 and 1992 (MWRA 1991, Rex 1993, unpublished MWRA Harbor Studies data). Dissolved oxygen monitoring data at selected stations from the first five years of MWRA CSO receiving water monitoring are shown in Figure 7-7.

7.6.3 Aesthetics - solids and floatables; odor; color and turbidity

Sewage-related floatables and slicks have been observed by MWRA monitoring staff near the Mystic River/Alewife Brook confluence. Shopping carts and other trash are present all along the Mystic River, both along the banks and in the middle of the river. In addition, strong sewer odor is often detected at several areas along the upper Mystic River at the Medford Square exit off Route 16, near Purity off Route 16 and near SOM006 by the Route 16 overpass at the Meadow Glen Mall.

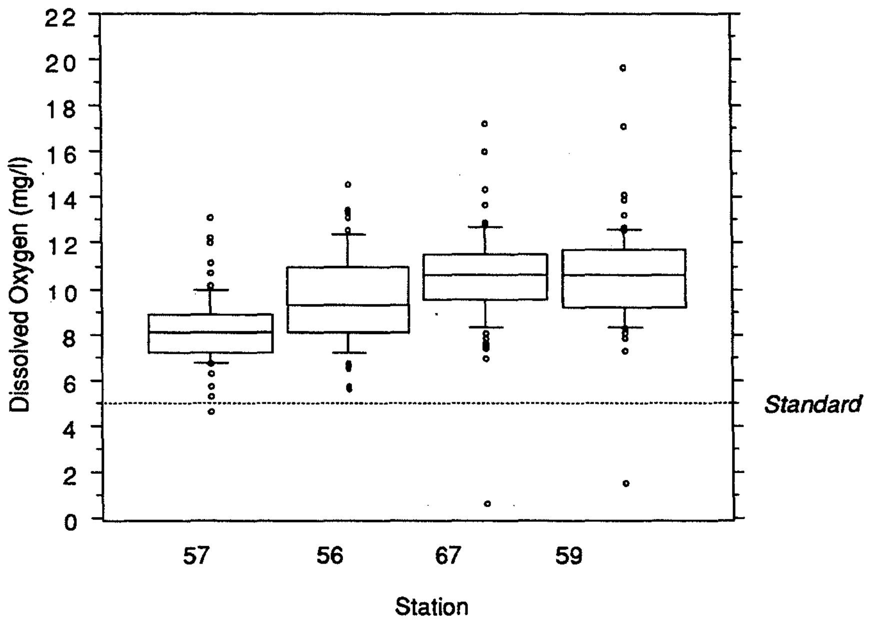
7.6.4 Oil and grease

The sampling conducted in 1988 for the 1990 MWRA CSO Facilities Plan (CH2M Hill 1989) included one station at the Alewife Brook/Mystic River confluence, one in the Malden River, and one just upstream of the Amelia Earhart Dam. All oil and grease measurements at these station were 5 mg/l or lower.

7.6.5 Bottom pollutants or Alterations

Information on sediment contamination of the upper Mystic River is limited. A pilot study of sediment quality conducted for MWRA included stations immediately upstream and downstream of the Mystic River/Alewife Brook confluence (Battelle 1990a). The investigators determined that PAH levels in sediments downstream of CSO inputs were elevated compared to upstream sediments, by approximately a factor of three (Table 7-1). Metals concentrations, in contrast, did not vary among the sampling areas. Comparison of these measurements to dredged material disposal criteria indicates that the contaminant levels include highly elevated ("Class III") concentrations of lead and zinc and elevated ("Class II") concentrations of chromium and copper. The measured values of $tPAH_6$, lead, and zinc in these samples were higher than Long and Morgan's (1990) ER-M level at which they suggest biological effects are likely; chromium and copper fall below the ER-M but above the more conservative ER-L effects threshold.

We are aware of no information on the benthic ecology of the freshwater portion of the Mystic River.



Station	No. of Samples	Concentration (mg/l)			
		Mean	Median	Minimum	Maximum
57	65	8.2	8.1	4.6	13.2
56	63	9.6	9.3	5.6	14.6
67	72	10.5	10.6	0.7	17.3
59	66	10.6	10.6	1.5	19.7
TOTAL	266	9.7	9.6	0.7	19.7

FIGURE 7-7. DISSOLVED OXYGEN CONCENTRATIONS IN UPPER MYSTIC RIVER (1989-93)

TABLE 7-1. SUMMARY OF UPPER MYSTIC SURFICIAL SEDIMENT CONTAMINATION MEASUREMENTS (BATTELLE 1990a)

	$tPAH_6$	Cd	Cr	Cu	Mn	Pb	Zn
Mean of Upstream Site	17.18	3.3	112	121	741	353	1004
Mean of Downstream Site	47.63	4.9	124	296	278	430	694

Note: All measurements are in ug/g; $tPAH_6$ is the sum of six commonly measured PAHs: fluoranthene, pyrene, chrysene, benz(a)anthracene, phenanthrene, and benzo(a)pyrene.

7.6.6 Nutrients

In the sampling conducted for MWRA in 1988, (CH2M Hill 1989) nutrients were analyzed in samples from the three stations in the upper Mystic River lakes. The results are given in Table 7-2. Based on guidance for estimating the nutrient status of lakes (MassDEP 1992), the upper Mystic River appears to be of poor quality because of elevated levels of nutrients.

TABLE 7-2. RANGES OF NUTRIENT CONCENTRATIONS IN UPPER MYSTIC RIVER

Location Station	Mystic/Alewife SS7	Malden R. SS5	A. Earhart Dam SS6
Orthophosphate (mg/l)	0.1-0.3	0.0-0.1	0.0-0.1
Total P (mg/l)	0.1-0.3	0.1-0.1	0.1-0.1
TKN (mg/l)	1.0-2.3	0.2-1.1	0.5-0.8
NH_3 (mg/l)	0.4-1.2	0.1-0.2	0.1-0.3
NO_3 (mg/l)	0.5-39.0	0.0-38.0	0.0-3.2

Source: CH2M Hill, 1989.

7.6.7 Toxic pollutants and toxicity

Selected toxic contaminants were analyzed in the 1988 sampling (CH2M Hill 1989). Comparison of the medians of the data for the three stations in the upper Mystic River segment to EPA chronic and acute criteria indicate the following:

- the chronic criterion for mercury appears to be violated at all three stations;
- the chronic and acute criteria for cadmium appear to be violated at all three stations;
- the chronic and acute criteria for copper, and the chronic criterion for zinc, appear to be violated at the Alewife Brook/Mystic River confluence station.

7.6.8 Temperature

Surface temperature in the upper Mystic River did not exceed the state Class B standard of 83°F (28.3°C) in any of the routine receiving water monitoring between 1989 and 1992 (MWRA 1991, Rex 1993, unpublished MWRA Harbor Studies data).

7.6.9 pH

In 1988 sampling conducted for the MWRA CSO Facilities Plan, pH at the three upper Mystic River stations ranged from 6.5 to 9.2, with the higher values measured in the Malden River and just upstream of the Amelia Earhart Dam (CH2M Hill, 1989). If real, this elevated pH could possibly be due to industrial discharges in the Malden River.

7.7 USE ATTAINMENT

7.7.1 Watershed Context

The Mystic River watershed is less highly developed than the lower part of the Charles watershed. There are pollutant inputs into the Aberjona River and other upstream tributaries, but it is not clear that these have an effect downstream of the Mystic Lakes.

The Mystic River CSO receiving water segment is affected by combined sewage inputs into the Alewife Brook. Neither of the tributaries to this segment, the Alewife Brook or the Malden River, support Class B uses. Mass. DEP (1993a) lists organic enrichment, suspended solids, and pathogens as problems in the Malden River.

7.7.2 Existing Water Quality and Affected Uses

The reach of the Mystic River from the outlet of Lower Mystic Lake to the Amelia Earhart Dam is non-supporting of Class B uses, according to Mass DEP (1993a); causes of non-attainment include pathogens, metals, and nutrients from CSOs and urban storm sewers. Our analysis indicates that floatables and odor cause aesthetic problems. Although dissolved oxygen is generally not a problem, there have been some very low daytime measurements.

While most of the CSOs in the upstream end of this segment are no longer active, high bacteria counts are still measured in wet and dry weather. These may be due to the Alewife Brook and/or to possible sewer surcharges along the Mystic River. The CSO discharges at the downstream end are very small and infrequent.

This segment is heavily used for boating and the secondary contact recreation bacterial standard is generally met. Water quality problems and affected uses in this segment are summarized on Figure 7-8.

7.7.3 Baseline ("Future Planned") Water Quality and Affected Uses

Since CSO discharges are not expected to change significantly between existing and "future planned" conditions, baseline water quality is expected to be the same as existing. Table 7-3 summarizes bacterial impacts in the upper Mystic River segment. Presently, the secondary contact recreation standard is met under dry and wet conditions, and we expect that this will continue to be true except possibly for large storms. Since the CSOs to this segment are not predicted to overflow in the design storms, the swimming standard would be met if CSOs were the only source.

Table 7-4 summarizes the level of used of this segment and the factors affecting attainment or non-attainment of the uses.

Figure 7-8. Beneficial uses affected by water quality in Upper Mystic River

Class B

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					ok?	?			
Aquatic Life	▨ ?	ok	▨ ?	ok	ok	▨ C	▨ C		ok		ok		▨ C		
Primary Contact Rec.								▨ C			ok	?		▨ W	
Secondary Contact Rec.								ok							
Aesthetics									ok	ok	ok	▨ C	▨ C	▨ W	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:

ok	Attained for Criteria
▨	Proven or Probable Non-Attainment
W	Wet Weather Non-Attainment
C	Wet and Dry Weather Non-Attainment

TABLE 7-3. IMPACTS OF FECAL COLIFORM FROM CSOs AND STORMWATER ON UPPER MYSTIC RIVER

	Current		3 month storm			1 year storm		
Upper Mystic River	Dry	Wet	CSO	SW	Both	CSO	SW	Both
Primary	***	***	OK	***	***	OK	***	***
Secondary	OK	OK	OK	?	?	OK	?	?

Key: CSO = CSO alone
SW = Stormwater alone
Both = CSO and stormwater
OK = Attains bacteria standard for class
*** = Violates bacteria standard for class
? = Partial attainment

TABLE 7-4. USE ATTAINMENT FACTORS - UPPER MYSTIC

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attain
Primary Contact Recreation	Low	3	Stormwater, CSO, Upstream/Alewife
Secondary Contact Recreation	Moderate-High	1	
Aquatic Life	High	2	Stormwater, CSO
Fish Consumption	Low	(?)	
Aesthetics	Moderate	2	Stormwater, CSO, Vandals, Odor at siphons

* Preliminary determination; may be corrected through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 8
MYSTIC RIVER/CHELSEA CREEK CONFLUENCE

8.1 DEFINITION OF RECEIVING WATER SEGMENT

This part of Boston Harbor includes the marine portion of the Mystic River, below the Amelia Earhart Dam, and the Chelsea Creek (or Chelsea River), a tidal estuary with a small freshwater segment at its head. The area is surrounded by East Boston, Chelsea, Everett, and Charlestown (see Figure 8-1). It extends to a line between the Mystic Wharf in Charlestown to the mouth of the Chelsea Creek in East Boston.

8.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The lower Mystic River is Class SB-Fishable/Swimmable plus restricted shellfishing, however, no shellfish resources are currently identified in this section. This area also includes Chelsea Creek which is also designated Class SB.

Where there is public access to wharves and bridges along the waterfront, fishing is popular, especially during seasonal runs of migratory predators and anadromous fish. Recreational fishing from small boats is also common, although commercial ship traffic sometimes restricts recreational fishing to the channel sides. Besides the anadromous alewives, this reach of the river is used by catadromous eels (which spawn at sea). Most of the waterfront area is dominated by maritime-industrial uses; in fact, much of this area falls into either the Mystic River or Chelsea Creek Designated Deep Port Area. A large percentage of the shipping activity within the Inner Harbor occurs in these areas.

The Moran Container Terminal is on the south side of the Mystic River above the Tobin Bridge. Opposite the terminal is a scrap metal loading facility. The Chelsea River has several tank farms on its banks; at least one has mid-channel off-loading facilities. There is also a minerals unloading and storage area on the north side of Chelsea River. The Boston Edison Power Plant is located along the Everett shore.

Other uses of the waters at the Mystic River/Chelsea Creek Confluence include shipping and barge businesses serving the "tank farms" and other industrial activities. The Chelsea waterfront is primarily industrial land with some smaller vacant parcels. Behind these activities is dense urban housing. The former Naval Hospital site in Chelsea has also been redeveloped as a residential community on the waterfront. The Tobin Bridge passes over the Mystic River and the McClellan Highway is on the east bank of the Chelsea Creek. Land use for the Boston harbor drainage area, including the Mystic River/Chelsea Creek confluence, is presented in Figure 8-2.

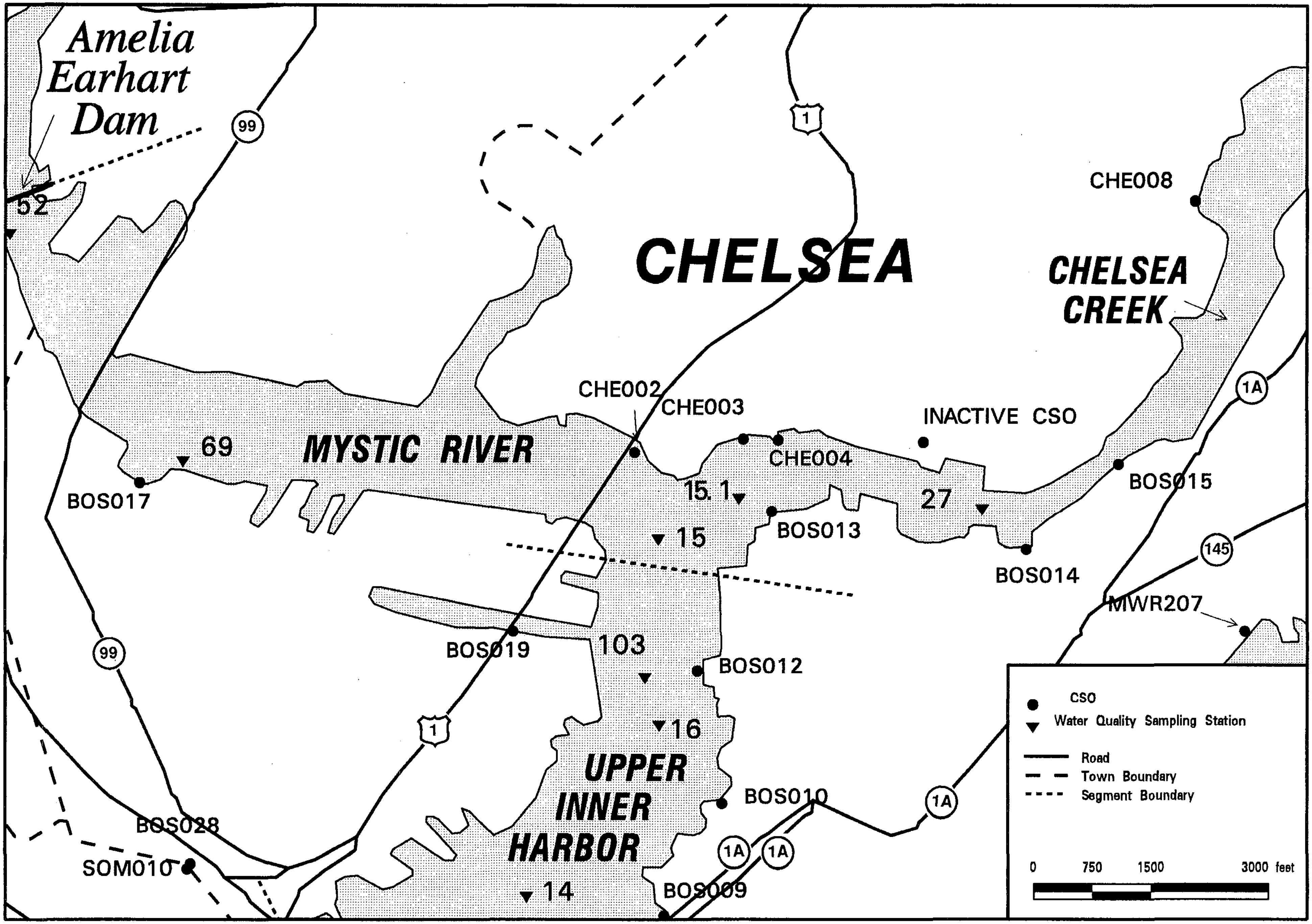


FIGURE 8-1. MYSTIC RIVER/CHELSEA CREEK CONFLUENCE

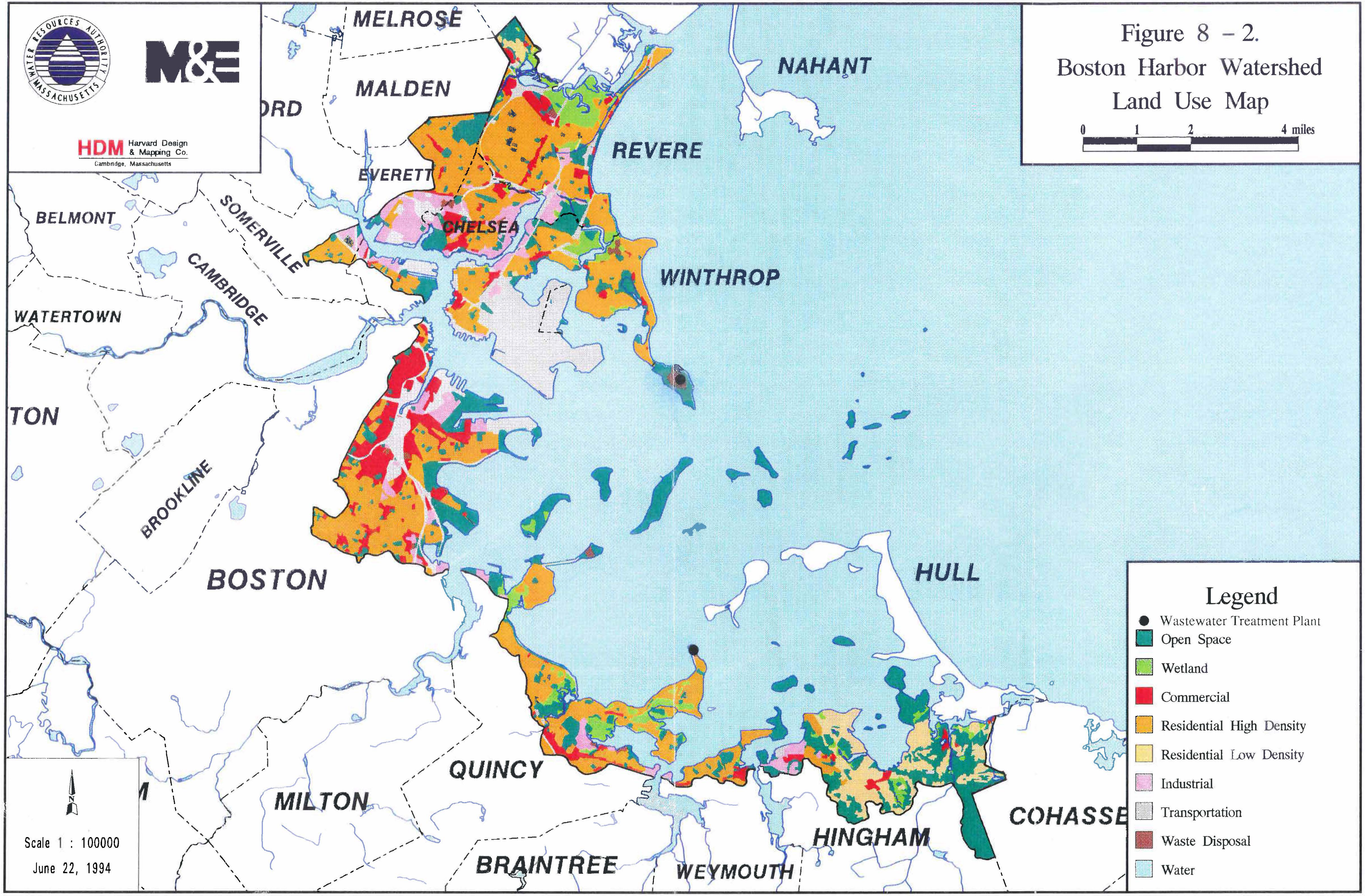


Figure 8 – 2.
Boston Harbor Watershed
Land Use Map

8.3 DESCRIPTION OF WATERSHED

8.3.1 Location

The drainage area of the Mystic River/Chelsea Creek Confluence receiving water segment is located in eastern Massachusetts. Communities partially in the drainage include Boston, Chelsea, Revere, and Everett. Chelsea Creek includes the creek and Mill Creek between Chelsea and Revere. The Mystic River drainage includes the lower section of the Mystic River and Island End River.

8.3.2 Topography and Soils

Chelsea Creek drains from the northeast to the southwest. The Mystic River drainage is from the west to the east. With the exception of the northeastern part of the Chelsea Creek and the northern part of the Mystic River drainage, the drainage is surrounded by several small hills (drumlins) with elevations as high as 150 feet mean sea level. The other parts of the drainage area are flat.

Most of the areas on or near the river banks are urban, paved land. Behind them, where there is some residential development, there is "Newport" type soil (USDA, 1989, 1991). This soil has a moderate erosion potential ($K = 0.28$).

8.3.3 Dams, Highways, and Other Man-Made Features

The Amelia Earhart Dam is located on the west end of the drainage area. It is used to control the level of the Mystic River during flood situations. It is equipped with pumps so that it can pump out water during high tides. It is also equipped with locks for boat passage.

Major highways pass through the drainage area. Routes 99 and 1 (Tobin Bridge) cross the Mystic River. Route 1A (McClellan Highway) is on the east bank of the Chelsea Creek. Revere Beach Parkway is on the north side of Mill Creek.

8.3.4 Upstream Towns, Land Use, and Upstream Pollution Sources

Table 8-1 shows the number of disposal sites that have either been confirmed or are to be investigated in cities in the watershed. Disposal sites in the watershed could potentially contribute toxic contaminants to the receiving water segment via discharge to streams or groundwater.

TABLE 8-1. CONFIRMED OR TO BE INVESTIGATED DISPOSAL SITES, MYSTIC RIVER/CHELSEA CREEK CONFLUENCE

	Number
Boston	507
Chelsea	35
Everett	40
Revere	36

Source: Mass DEP, 1993b.

8.4 SOURCES OF POLLUTION

8.4.1 General

The Mystic River/Chelsea Creek confluence segment receives pollutants from CSOs, shipping, stormwater, industrial wastewater and cooling water. Estimated flows and loads of stormwater, CSOs (future planned), and upstream sources are shown in Figures 8-3 and 8-4. Three-month storm CSO flows and loads is expected to decrease 47% between existing and future planned conditions.

8.4.2 Stormwater discharges

Stormwater discharges exist in most of the area surrounding this receiving water segment with the exception of a portion of Chelsea which has combined sewers (Metcalf & Eddy, 1994b). There have been no detailed studies of stormwater quality in this receiving water segment. This area is highly urbanized with high density housing and commercial activities, and heavy industrial use. However, using available data, a relationship between land use and stormwater quality in the CSO study area has not been identified (Metcalf & Eddy 1994b).

Dry weather screening conducted by BWSC (BWSC 1991, 1993) identified one storm drain (29J212) with oil, debris and possible sewage discharging into the lower Mystic River, and two storm drains containing oil and debris emptying into the Chelsea Creek.

8.4.3 CSO discharges

There are CSOs along both banks of the Chelsea Creek and along the south bank of the Mystic River. Except for the Somerville Marginal CSO (MWR205), none of the CSOs in the Mystic River/Chelsea Creek confluence segment are treated.

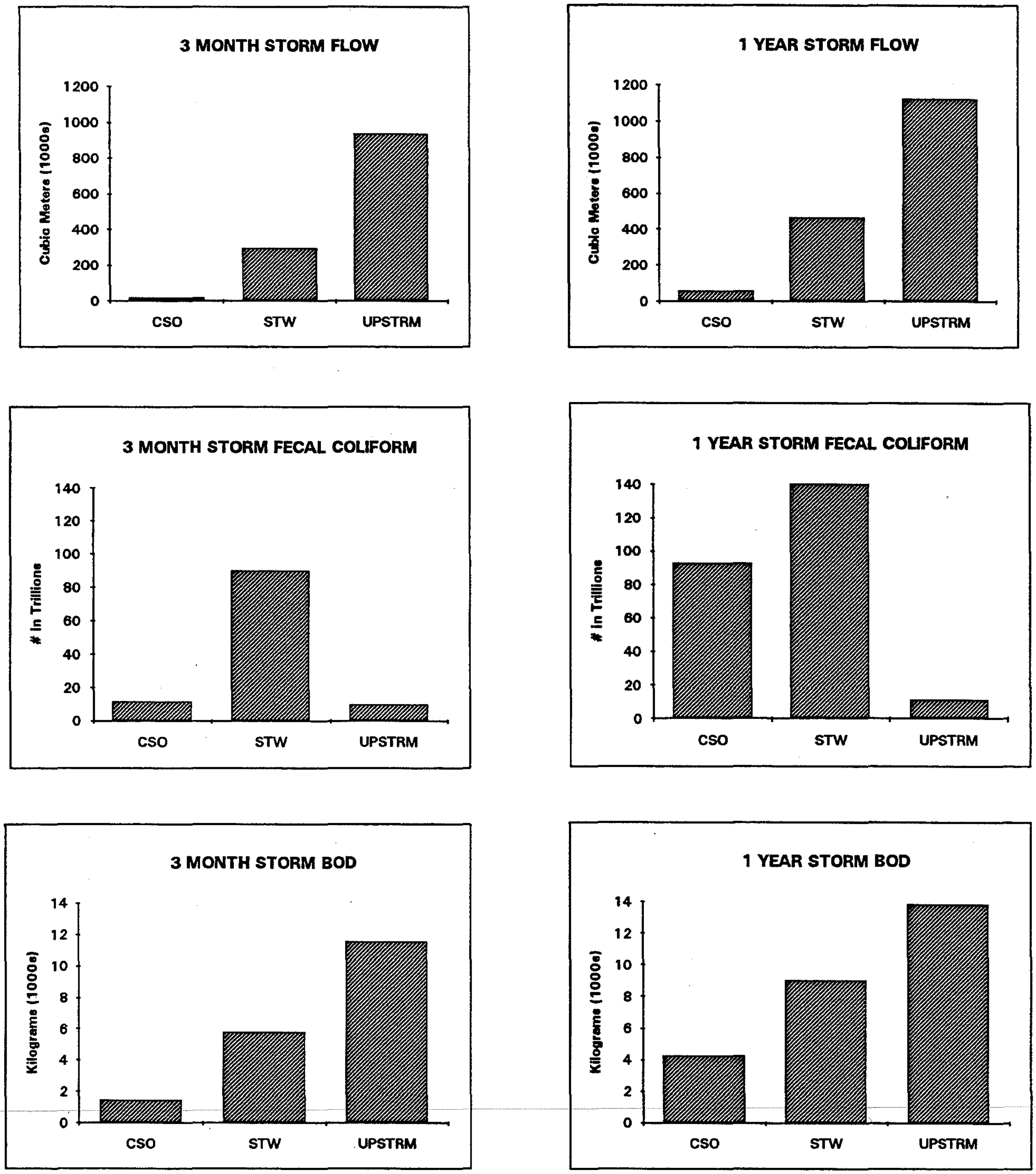


FIGURE 8-3. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - MYSTIC RIVER/CHELSEA CREEK CONFLUENCE

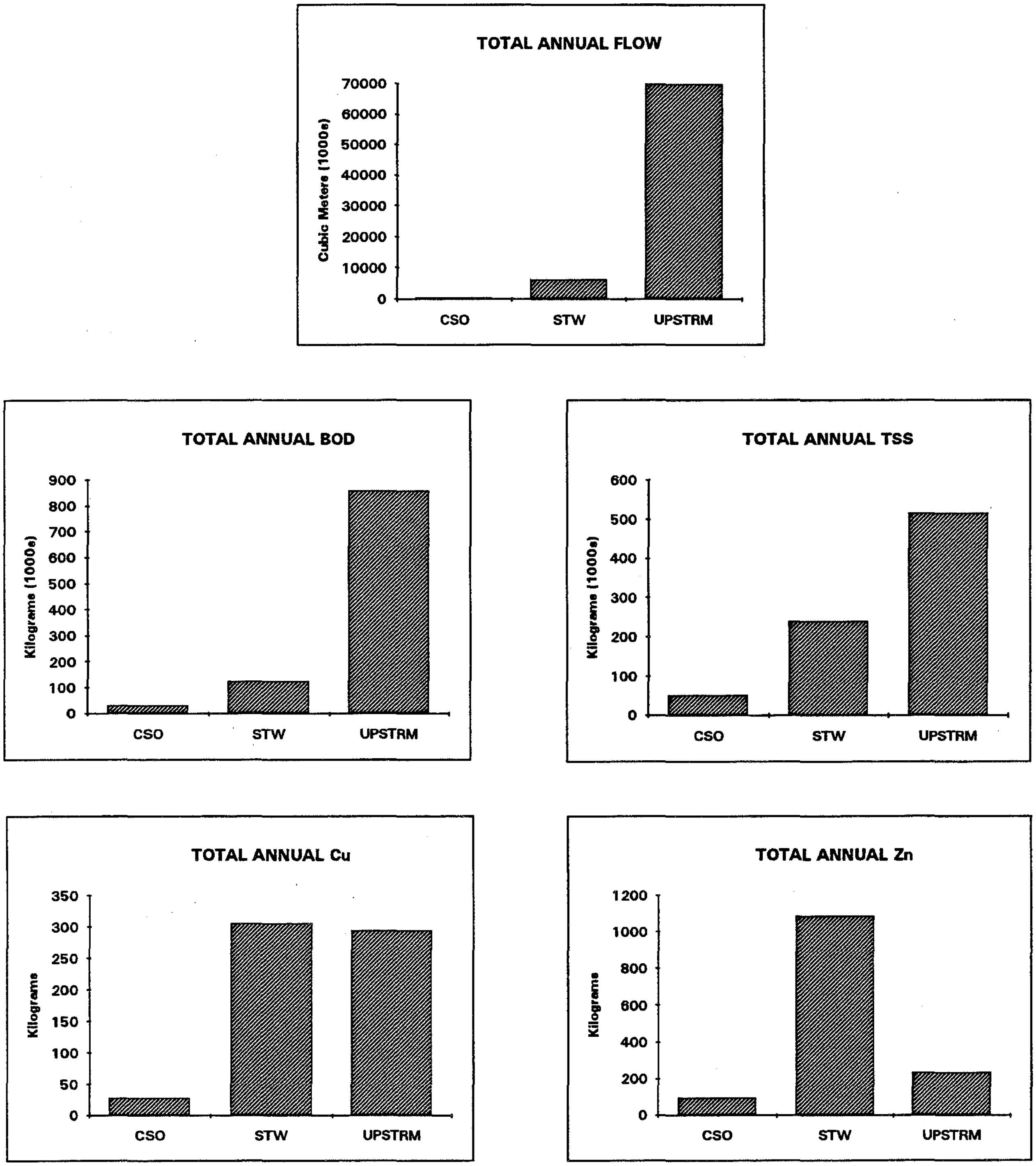


FIGURE 8-4. FUTURE PLANNED ANNUAL FLOWS AND LOADS - MYSTIC RIVER/CHELSEA CREEK CONFLUENCE (a) FLOWS, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

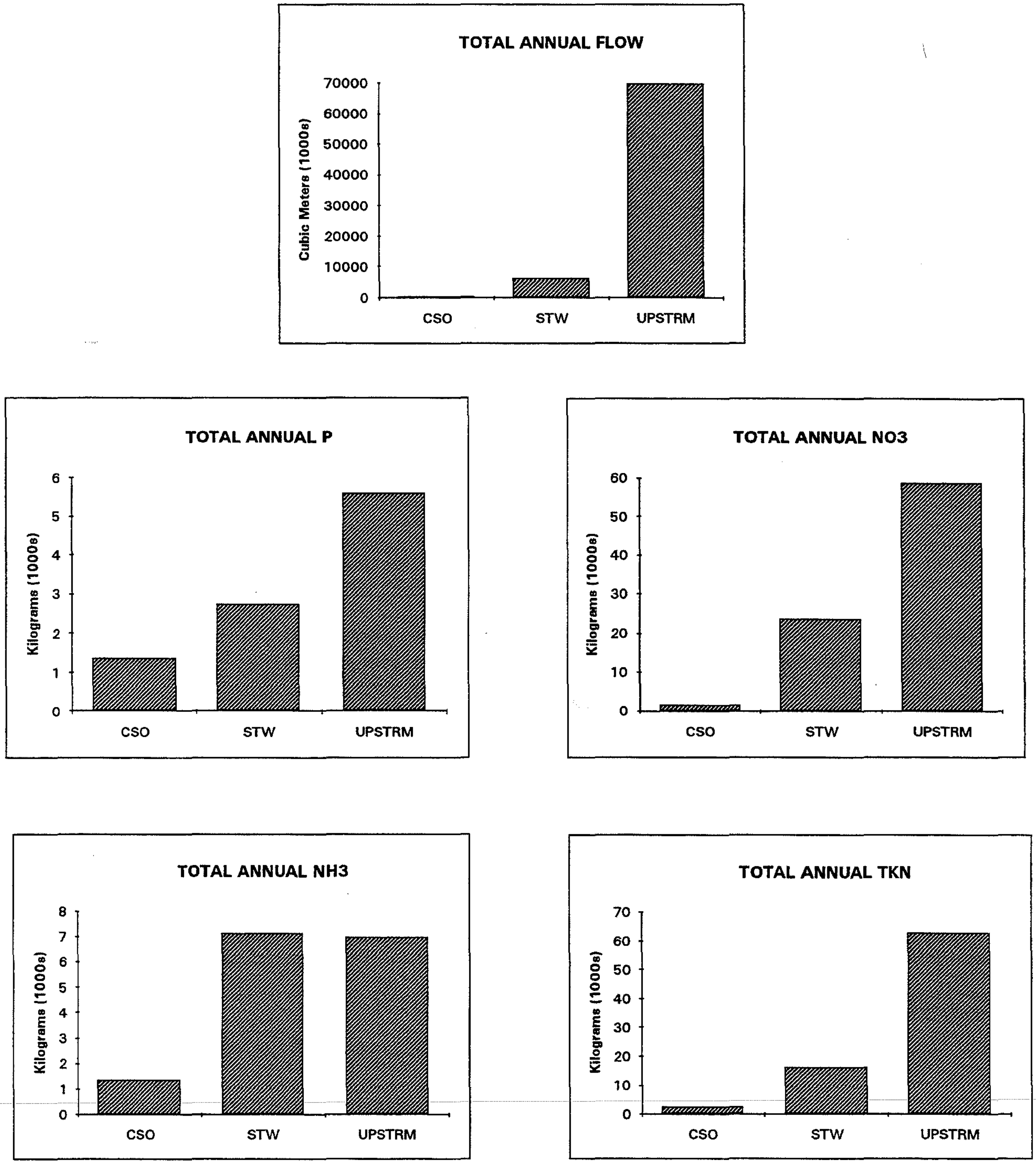


FIGURE 8-4. FUTURE PLANNED ANNUAL FLOWS AND LOADS - MYSTIC RIVER/CHELSEA CREEK CONFLUENCE (b) FLOWS, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

The Somerville Marginal Pretreatment Facility screens and effectively disinfects combined sewage (MWRA, 1993a; Bigornia-Vitale and Sullivan, 1993). It normally discharges below the Amelia Earhart Dam (through MWR205), but at high tide, it can also discharge upstream of the dam at SOM007A (see Chapter 7). The facility provides CSO treatment for a large area of Somerville. Increased pumping capacity has not affected Somerville Marginal, but start-up of the Charlestown Pumping Station and System Optimization Plans implementation may affect operations (MWRA 1993a). Formerly, there have been problems with dry weather overflows (MWRA 1993a). Also, an illegal discharge below the facility was recently identified (P. Carbone, MWRA, pers. comm. to A. Rex 1993).

Of the CSOs monitored in 1992, the Somerville Marginal facility and BOS017 both overflow after about 0.1" of rain (MWRA, 1993a); one other CSO occurs after about 0.15" of rain, two more overflow with 0.25" of rain, and a sixth overflows with about 0.4" of rain (MWRA 1993a).

One CSO (CHE002) was observed to have a leaky tide gate in 1992 inspections (MWRA 1993a), and two Chelsea CSOs were in poor physical condition. Several CSOs had accumulated debris and sediment, in one case causing a serious blockage. This CSO, along with some others, has since been cleaned.

8.4.4 Industrial Discharges

The Chelsea Creek portion is a very active oil terminal area; runoff and oil transfer activities and storage tanks are a likely source of petroleum-derived pollutants. In the lower Mystic River portion, uncontrolled direct runoff from scrap heaps and industrial sites is a potential source of pollution. Boston Edison has a small wastewater treatment plant that discharges 0.18 m^3/s just below the Amelia Earhart Dam. The annual loads of total suspended solids, copper, and zinc from the Edison discharge are about 2.4 tonnes, 62.3 kg and 25.8 kg, respectively (Alber and Chan, 1994). Monsanto is permitted to discharge up to 0.3 mgd of process water to the Mystic River, which is monitored for oil and grease, several metals and priority pollutants, cyanide, phenols, chloride, carbonaceous oxygen demand, and toxicity. NPDES-permitted stormwater discharges to the Mystic River include Amstar sugar in Charlestown, Bethlehem Steel, Allied Concrete on the Island End River, Atlantic Richfield's Revere Terminal and Exxon in Everett. Industrial stormwater discharges to the Chelsea River include Mobil Oil, Northeast Petroleum (Revere), Gibbs Oil Company (Chelsea), and Belcher New England. Glyptol, Inc. in Chelsea discharges non-contact cooling water and monitors for temperature oil and grease and carbonaceous oxygen demand (K. Colhane, and S. Halterman, MassDEP, pers. comm. to W. Leo, 1994).

8.4.5 Interceptor Wet Weather Overflows

There are two interceptor wet weather overflows in the drainage area; one in Chelsea at Second Street and Carter Street and one in Somerville at Medford Street and Somerville Avenue. Both can discharge flow into receiving waters through storm drains.

8.4.6 Upstream Inputs

Although there are pollution problems upstream (MassDEP, 1993a), the upper portion of the Mystic River does not appear to adversely affect the water quality of this lower segment. Water quality immediately upstream of the dam is better than that just downstream (it generally meets Class B standards), while the water quality of the lower portion does not meet either bacterial or dissolved oxygen requirements of 200/100 ml and 5 mg/l, respectively, for Class SB waters. The part of the upper Mystic River most affected by CSOs is at the Alewife Brook/Mystic River confluence, and the effect on water quality is dissipated by the time the water reaches the Amelia Earhart Dam.

Results of a dye release experiment conducted by MIT suggest that this receiving water segment is also affected by the Charles River and Upper Inner Harbor on the flood tide (Adams *et al.* 1993).

8.5 HYDRODYNAMICS

8.5.1 Near Field Mixing

Based upon the flow of the Aberjona River in Winchester, the mean flow at the mouth of the Mystic River is approximately 2.5 m^3/s (Alber and Chan 1994), while the low flow can be as little as 0.1 m^3/s (Metcalf & Eddy, 1994c). Flow in the river is regulated by the Amelia Earhart Dam. All drainage in the area, up to at least Mill Creek in Chelsea, is tidally influenced. This receiving water segment is always weakly stratified in salinity. The Chelsea River is mostly tidal, with a small freshwater discharge at the headwaters. The maximum tidal current in this segment is approximately 0.3 m/s (Eldridge, 1992). The major CSO is the Somerville Marginal facility which can represent a substantial portion of the freshwater input (e.g., during the August 17-18, 1992 storm, a discharge volume of 3.6 million gallons was measured, which represents an average flow of 0.6 m^3/s over six hours). However, receiving water salinity measurements indicate that tidal flushing provides substantial dilution (a factor of 10 or more) immediately downstream of the discharge.

The remaining CSOs in the reach are relatively small. Estimates made for a typical CSO event (discharge from CHE004 during the storm of August 17-18, 1992) suggest that dilutions of about

11, 33, and 90 are obtained at distances of 30, 100, and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994).

8.5.2 Farfield Mixing and Flushing

Fecal coliform distributions in the Mystic River/Chelsea Creek confluence area were modeled using the two-dimensional water quality model TEA/ELA (see Appendix A). Coliform counts rise quickly after the storm -- indicating that the sources are nearby rather than remote -- and gradually diminish back to background over five or six days. The Mystic River and Chelsea Creek appear to have similar flushing characteristics.

8.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized in Figure 8-5.

8.6.1 Bacterial contamination

The area near the Somerville Marginal CSO is one of the two areas of the Inner Harbor most affected by CSO discharge (Rex 1993; the other is Fort Point Channel, see Chapter 10). The water quality in this segment does not meet the bacterial standard of 200/100 ml. Fecal coliform data from the first five years of MWRA CSO receiving water monitoring are shown in Figures 8-6 and 8-7.

8.6.2 Dissolved Oxygen

Dissolved oxygen data from the first five years of MWRA CSO receiving water monitoring are shown in Figure 8-8. The dissolved oxygen (DO) levels below the Amelia Earhart Dam are among the lowest in the Inner Harbor (Rex 1993).

8.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

During wet weather, sewage-related floatables (toilet paper, condoms, etc.) are evident near Somerville Marginal and in the Mystic River, especially near the Mystic River/Alewife Brook confluence.

On several occasions (especially in 1990 and 1991), a large combined sewage plume was seen emanating from Somerville Marginal CSO with seagulls feeding in the plume. During these episodes, there were strong sewage or sewage/chlorine odors at that location.

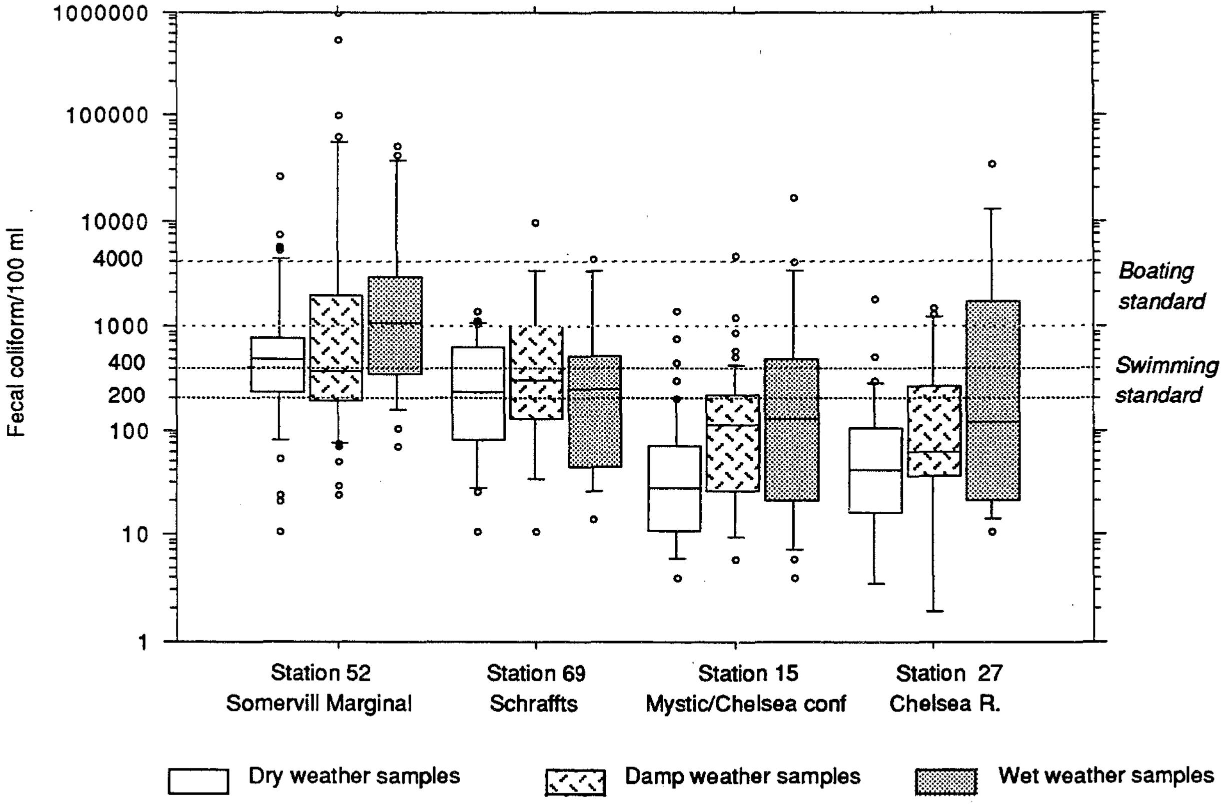
		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	●	●	●	always violates std. apparent dry sources		●	CSOs; SW?
	Dissolved Oxygen (1,6)	●	●	●	near SM (just below dam) levels are among lowest in Inner Harbor	aquatic life fishing	●	CSOs (esp. SM); restricted flushing?
Aesthetics	Solids and Floatables (1,2)	○	●	◍	sewage-related and other floatables near SM and in both rivers	aquatic life	◍	CSOs, SW
	Color and Turbidity (1,2)	◍	●	●	plumes			CSOs
	Odor (2)	○	●	◍	sewage or sewage + chlorine			SM CSO
	Oil and grease (1,8)	○	●	●	slicks			CSOs, ships
	Bottom pollutants or alterations (3,10,11)	N/A	N/A	●	extremely degraded, seasonally azooic anoxia, sed. toxicity	aquatic life	●	possibly CSOs for metals; anoxia physical
	Nutrients (5,9) (algal blooms)			◍	meso-eutrophic	aquatic life	◍	SW, upstream
	Toxic Pollutants (4)			◍	no WET from CSO Cl tox. from SM	aquatic life fishing	◍	upstream, shipping, SW, CSOs
	Temperature (6)	○	○	○		aquatic life	○	cooling water
	pH (N/A)							

Key:
● poor quality or high risk
◍ fair quality or moderate risk
○ good quality or low/no risk
? insufficient data

SM = Somerville Marginal CSO facility
SW=stormwater
N/A= not applicable
WET=whole effluent toxicity

Sources of information on present conditions
1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993-94
3 - Battelle, 1990a
4 - Wallace et al. 1987
5 - Unpublished New England Aquarium data
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989
9 - ENSR, 1993
10-US Army Corps 1990, 1993; and Normandea Associates, 1993
11-MacDonald, 1991

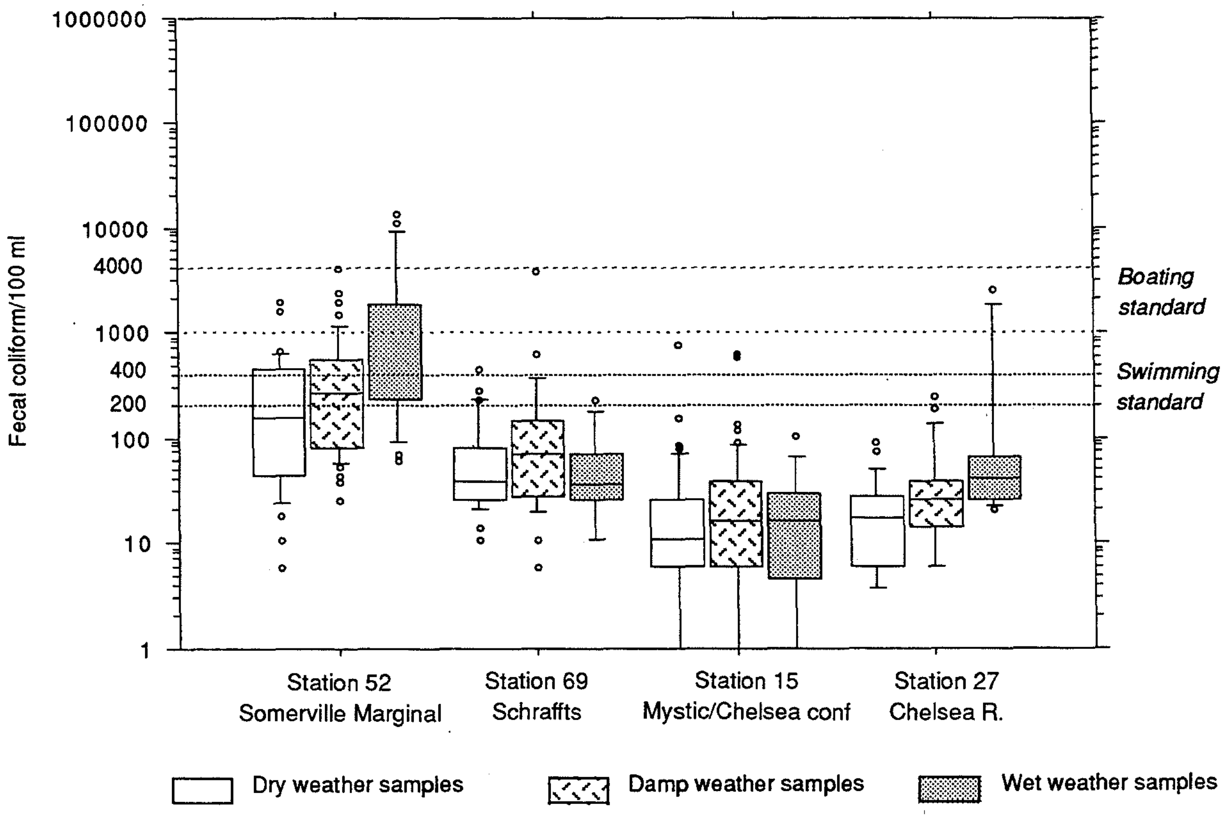
FIGURE 8-5. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - MYSTIC RIVER/CHELSEA CREEK CONFLUENCE



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
52	Dry	44	11	27751	480
52	Damp	47	24	1000001	793
52	Wet	19	71	53501	1417
69	Dry	29	1	1401	185
69	Damp	24	1	10101	287
69	Wet	11	14	4551	219
15	Dry	56	1	1426	28
15	Damp	62	1	4901	72
15	Wet	20	4	17501	129
27	Dry	30	1	1826	36
27	Damp	27	1	1576	65
27	Wet	12	11	36501	186
	TOTAL	381	1	1000001	147

* Number of Counts per 100 ml

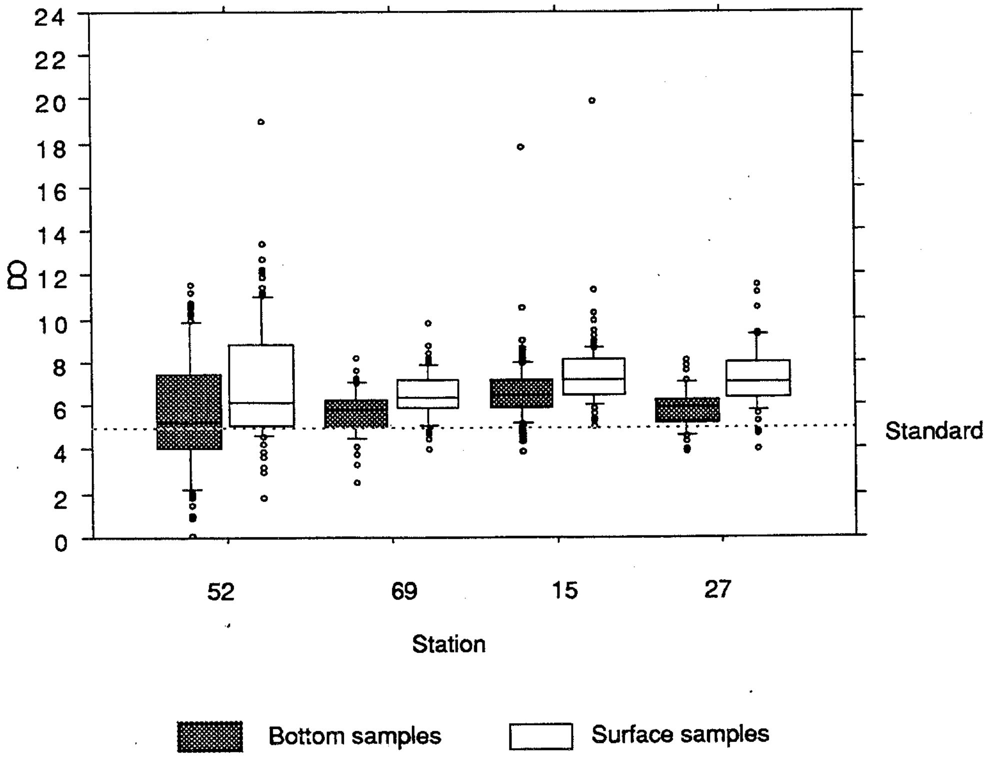
FIGURE 8-6. FECAL COLIFORM MONITORING DATA FOR THE MYSTIC RIVER/CHELSEA CREEK CONFLUENCE - SURFACE SAMPLES (1989-93)



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
52	Dry	42	6	2001	142
52	Damp	45	26	4276	244
52	Wet	18	61	13626	610
69	Dry	26	11	449	50
69	Damp	24	6	3926	76
69	Wet	11	11	231	41
15	Dry	51	1	796	10
15	Damp	55	1	646	13
15	Wet	15	1	106	12
27	Dry	24	1	96	14
27	Damp	23	1	251	24
27	Wet	8	21	2681	64
	TOTAL	342	1	13626	43

* Number of Counts per 100 ml

FIGURE 8-7. FECAL COLIFORM MONITORING DATA FOR THE MYSTIC RIVER/CHELSEA CREEK CONFLUENCE - BOTTOM SAMPLES (1989-93)



Station	Sample Type	No. of Samples	Concentration (mg/l)			
			Mean	Median	Minimum	Maximum
52	Bottom	104	5.8	5.2	0.1	11.6
52	Surface	110	6.9	6.2	1.8	19.0
69	Bottom	62	5.6	5.8	2.5	8.2
69	Surface	63	6.5	6.4	4.1	9.8
15	Bottom	118	6.7	6.5	4.0	17.8
15	Surface	134	7.4	7.2	5.1	19.9
27	Bottom	55	5.8	5.9	3.9	8.1
27	Surface	69	7.3	7.1	4.1	11.6
	TOTAL	715	6.6	6.4	0.1	19.9

FIGURE 8-8. DISSOLVED OXYGEN CONCENTRATIONS IN THE MYSTIC RIVER/CHELSEA CREEK CONFLUENCE (1989-93)

Surface slicks of apparently CSO-derived material containing toilet paper, miscellaneous debris, and floating scum have also been noted in the Chelsea River on several occasions during MWRA CSO receiving water monitoring program sampling. In late summer 1989, after a moderate rain, such a slick was tracked to the immediate shoreline vicinity of a CSO in Chelsea (K. Keay, unpublished MWRA CSO receiving water monitoring data).

8.6.4 Oil and Grease

The data on oil and grease are limited; sampling conducted for MWRA in 1988 indicated that oil and grease concentrations were below 5 mg/l in the Chelsea Creek (CH2M Hill 1989).

8.6.5 Bottom pollutants or alterations

A great deal of information exists on the sediment quality of the Inner Harbor; this is described in more detail in Chapter 9.

A pilot study of sediment quality conducted for MWRA included two stations downstream of the Amelia Earhart Dam (Battelle, 1990a). The average pollutant concentrations from samples collected at both stations are presented in Table 8-2. By comparison to stations in the upper Mystic River, the investigators tentatively determined that CSOs have less effect on PAH contamination of the sediment below the dam than they do further upstream. It was also concluded that CSOs do not contribute to metals contamination of the river sediments (Battelle 1990). In these samples, lead, zinc, and $tPAH_6$ exceed the "ER-M" concentrations proposed by Long and Morgan (1990) as sediment contamination levels at which biological effects are likely; chromium and copper exceed the more conservative "ER-L" threshold for possible biological affects.

TABLE 8-2. SUMMARY OF LOWER MYSTIC SURFICIAL SEDIMENT CONTAMINATION MEASUREMENTS (BATTELLE, 1990a)

Parameter	$tPAH_6$	Cd	Cr	Cu	Mn	Pb	Zn
Concentration	27.59	3.9	124	296	278	430	694

Note: The average of samples from two stations below the Amelia Earhart Dam is given. All measurements are in $\mu g/g$; $tPAH_6$ is the sum of six commonly measured PAHs: phenanthrene, fluoranthene, pyrene, chrysene, benz(a)anthracene, and benzo(a)pyrene.

The Corps of Engineers (1993) measured sediment contamination in the Mystic River and Chelsea Creek in 1986 and 1993. Highly elevated ("Class III") concentrations of arsenic, lead, and zinc were measured in the Mystic River, while chromium, copper, mercury and nickel reached "Class II" concentrations. Chelsea Creek sediments had some samples with Class III concentrations of lead, and the sediments reached Class II levels for arsenic, chromium, mercury, nickel, and zinc.

Data on sediment quality collected in berthing areas in the lower Mystic River and Chelsea Creek (Normandeau 1993) include highly elevated (Class III) concentrations of arsenic, lead, and zinc, and elevated (Class II) concentrations of chromium, copper, and mercury in the Mystic River; in the Chelsea River, Class III concentrations of chromium, lead, and zinc, and Class II concentrations of arsenic, copper, and mercury were measured. Both total PAHs and total PCBs reached Class III concentrations at lower Mystic River and Chelsea Creek berth sites.

Sediments were also tested for toxicity (Normandeau, 1993; U.S. Army Corps of Engineers, 1993). Sediments in the main channel and in the berth areas showed toxicity to amphipods significantly greater than that of the control sediments. In bioassay tests, all berth sites showed good survival of worms and clams; the Corps of Engineers bioassay of main channel sediments showed some toxicity to clams in the Mystic River and Chelsea Creek sites.

The benthic biology of the lower Mystic River and Chelsea Creek was most recently studied in 1986 by the U.S. Army Corps of Engineers during an environmental assessment of the impacts of Harbor improvement dredging (Hubbard and Bellmer, 1989). Bottom communities in both rivers were extremely degraded, with sparse assemblages of few species. Sediments at some locations in these rivers are at least seasonally azoic (devoid of macrofaunal invertebrates) (Hubbard and Bellmer, 1989).

8.6.6 Nutrients

ENSR (1993) measured nutrient and chlorophyll concentrations at the Mystic River/Chelsea Creek Confluence on a single date in 1993. The most recent year in which the area was monitored regularly was 1991 (unpublished New England Aquarium data). The range of nutrient concentrations in 1991 are presented in Table 8-3, the single 1993 measurements is included for comparison. The mean 1991 total phosphorus concentrations in this portion of the harbor correspond to the "healthy" classification of the EPA's guidelines on Use Attainability (EPA, undated). However, the annual range encompasses measurements in both the "healthy" and "fair" categories. The 1993 data (one sample collected in March) place the area in the "fair" category.

The annual mean total P concentrations in this area have declined since 1987. Mean annual concentrations prior to 1987 ranged from 0.14 to 0.22 mg/l (fair to poor). Since 1987, mean concentrations ranged from 0.06 to 0.09 mg/l (healthy to fair). Dissolved inorganic nitrogen

TABLE 8-3. MYSTIC RIVER/CHELSEA CREEK CONFLUENCE NUTRIENT AND CHLOROPHYLL MEASUREMENTS

	Dissolved Inorganic Nitrogen (mg/l)		Total Phosphorus (mg/l)		Chl a (μg/l)	
	1991	1993	1991	1993	1991	1993
min	0.12		0.04		0.01	
max	0.36		0.08		9.33	
mean	0.23	0.25	0.06	0.13	2.77	0.95

Sources: New England Aquarium (unpublished data); ENSR, 1993.

data are only available since 1987 and there is no obvious trend in mean concentrations (Lavery, et al., in prep.).

The 1991 chlorophyll concentrations in the confluence area ranged from 0.11 to 9.33 μg/l with an annual mean of 2.77 μg/l. The single 1993 measurement of chlorophyll *a* was 0.95 μg/l. No trend in mean chlorophyll concentrations is evident over the period 1987 to 1991, with annual means ranging from 1.43 μg/l in 1989 to 8.46 μg/l in 1990. According to Wetzel's (1983) classification of estuaries, the 1991 chlorophyll concentrations place the Mystic River/Chelsea Creek Confluence in the mesotrophic-eutrophic category.

8.6.7 Toxic Pollutants and Toxicity

Water quality in the harbor generally meets water quality standards for toxic contaminants; a possible exception is copper, which may exceed the EPA water quality criterion in the Inner Harbor (Wallace *et al.* 1987, Rex 1989). More recent Inner Harbor samples by UMass/Boston (Wallace, et al., 1993) do not show any metals acute criteria exceedances.

8.6.8 Temperature

In the 1989-1992 MWRA CSO receiving water monitoring program data set, the temperature in the lower Mystic River/Chelsea Creek Confluence never exceeded the Class SB standard of 85°F; the maximum temperature recorded in surface water was 23.6 C (74.5°F).

8.7 USE ATTAINMENT

8.7.1 Watershed Context

The heavily urban and industrial land characteristics of the drainage impact the present water quality of the confluence area. The entire drainage area does not support one or more designated uses. A review of the causes and sources of non-attainment of Class SB in the lower Mystic River shows that stormwater runoff and combined sewer overflow are the major sources of pollution (MassDEP, 1993a). The pollutants include organic enrichment resulting in low DO, pathogens, and ammonia. Sediments in the receiving water segments contain high levels of toxic metals, PAHs and PCBs.

Chelsea Creek is also nonsupporting of Class SB (MassDEP, 1993a). Types of pollutants and sources present along the Chelsea Creek are similar to the lower Mystic River except that oil and grease are also present in the creek.

8.7.2 Existing Water Quality and Affected Uses

Figure 8-9 shows how water quality problems in the lower Mystic River and the Chelsea Creek affect uses. In this segment, bacteria affects the use of the river for primary contact recreation (swimming) in wet weather throughout the segment and in both wet and dry weather near the Somerville Marginal outfall MWR205. The secondary contact recreation standard is met, but larger storms can cause violations, especially near MWR205.

Bottom water frequently have dissolved oxygen below the state standard, particularly near MWR205. The Mystic River/Chelsea Creek confluence segment also has aesthetic problems with sewage-related and other floatables, and odors near large CSOs. Because of the restricted flushing and high pollutant load, sediments and bottom-dwelling organisms in this segment are severely affected.

8.7.3 Baseline ("Future Planned") Water Quality and Affected Uses

CSO loads of pollutants are not expected to decrease between existing and baseline ("future planned") conditions, as SOPs and Intermediate Projects are completed and system pumping capacity continues to increase. In addition, elimination of the illegal discharge into the Somerville Marginal outfall will reduce bacteria counts near MWR205. However, for many of the water quality problems in this segment, pollutant loads from stormwater appear to dominate the totals. If these loads are assumed to remain unchanged under baseline conditons, we estimate that beneficial uses will continue to be affected. In general, baseline water quality will be slightly better than existing water quality.

Figure 8-9. Beneficial uses affected by water quality in the Mystic River /Chelsea Creek Confluence

Class SB

Water Quality Assessment
MWRA CSO/System Master Plan

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.											?	?			
Aquatic Life	▨ C, s	ok		▨ W, s	▨ W, s	▨ C	▨ C		?		?		▨ ?		
Primary Contact Rec.								▨ C	▨ W	?	▨ W	▨ W, s		▨ W	
Secondary Contact Rec.								▨ W							
Aesthetics									▨ W	?	▨ W		ok	▨ W	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:

ok	Attained for Criteria
▨	Proven or Probable Non-Attainment
W	Wet Weather Non-Attainment
C	Wet and Dry Weather Non-Attainment
s	Somerville Marginal CSO Treatment Facility

In this segment, the model predicts that fecal coliform counts exceed the swimming standard for about 1½ days after the three-month storm now; under future planned conditions, the length of time will be slightly less. For the three-month storm, the high bacteria counts are due primarily to non-CSO sources; in the one-year storm, both CSO and non-CSO sources contribute to violations of the swimming standard that last about one to 1½ days. With all sources, the boating standard is also violated for several hours after the one-year storm. Chelsea Creek bacteria counts are just slightly higher than Mystic River counts; this appears to confirm that the water quality of the Mystic River upstream of the Amelia Earhart Dam does not adversely affect the water quality downstream.

Table 8-4 summarizes bacterial impacts in the Mystic River/Chelsea Creek confluence segment. "Non-CSO" includes upstream inputs as well as stormwater.

Table 8-5 summarizes the level of use of this segment and the factors affecting attainment or non-attainment of the uses.

TABLE 8-4. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN THE MYSTIC RIVER AND CHELSEA BROOK

Resource Area	Current Conditions		3-Month Storm Event				1-Year Storm Event		
	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Mystic R. Chelsea Cr. Confluence									
Swimming[a]	Violates	Violates							
Boating[b]	OK	Violates							
Restricted Shellfishing[c]	Violates	Violates							
Mystic River									
Swimming[a]			35	28	0	23	38	18	34
Boating[b]			0	0	0	0	5	0	0
Chelsea Creek									
Swimming[a]			32	28	1	20	35	22	29
Boating[b]			1	0	0	0	10	2	0

Note:

(a) Swimming (hours fecal coliform count > 200/100 ml)
(b) Boating (hours fecal coliform count > 1000/100 ml)
(c) Restricted shellfishing limit (fecal coliform count < 88/100 ml)

TABLE 8-5. USE ATTAINMENT FACTORS - MYSTIC/CHELSEA

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	None	3	Upstream sources, Stormwater, CSO
Secondary Contact Recreation	Moderate	3	Upstream sources, Stormwater, CSO
Aquatic Life	Moderate	2(?)	Upstream sources, Stormwater, CSO
Fish Consumption	Low (?)	(?)	
Aesthetics	Low	2-3	Upstream sources, Stormwater, CSO

* Preliminary determination; may be corrected through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 9
UPPER INNER HARBOR

9.1 DEFINITION OF RECEIVING WATER SEGMENT

The upper part of the Inner Harbor lies between downtown Boston, Charlestown, and East Boston. It includes the Charles River below the new Charles River Dam, the Mystic River below its confluence with Chelsea Creek, and the area between downtown Boston and East Boston (Figure 9-1). This area includes ten combined sewer overflows. The harbor is channelized and deep here; freshwater from the two rivers mixes with seawater in this salt-stratified region.

9.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The Inner Harbor is designated as Class SB - Fishable/Swimmable plus restricted shellfishing (MassDEP, 1990). At this time, the only shellfish resource identified within this upper portion of the Inner Harbor is one "prohibited" bed at the mouth of Chelsea Creek (Rex *et al.* 1992).

The upper Inner Harbor includes the main shipping channels (inbound/outbound) used by large freighters and tankers for deliveries to the industrial, energy and shipping facilities located along the waterfront. This includes a container facility in Charlestown and tank farms in the Chelsea Creek. Other water uses include the major public ferries located at Long and Rowes Wharves which serve commuters, people seeking recreational tours of the Harbor and vacationers headed for Cape Cod, Martha's Vineyard and Nantucket. The Coast Guard base is also located in this area of the Harbor. Other boating uses in the upper Inner Harbor include marinas and mooring areas associated with mixed use developments. Sailing is also taught within the Inner Harbor.

Fishing off the harbor side of the new Charles River Dam and many other wharves and bridges is popular, as it is throughout much of the Inner Harbor where public access to the waterfront is provided. Recreational fishing from small boats is also common, although commercial ship traffic sometimes restricts this activity to channel sides. Fishing is especially intense during seasonal runs of migratory predators such as striped bass and bluefish, and during runs of anadromous fish such as rainbow smelt. In general, the Inner Harbor is not a major target area of the once-thriving recreational flounder fishery in Boston Harbor. Some commercial lobstering takes place in the upper Inner Harbor, especially in the early spring. A major offloading facility and pound for the commercial lobster fishery is located in the upper Inner Harbor, next to the Coast Guard Base. Such facilities use local waters for flow-through holding tanks.

Over-wintering harbor seals have been observed near the Charlestown Navy Yard. On the land side, the area varies from maritime industrial uses in Charlestown and East Boston, where there is a federally designated port area, to under-utilized piers along a portion of the East Boston waterfront. Much of the downtown Boston area and a portion of the Charlestown Navy Yard

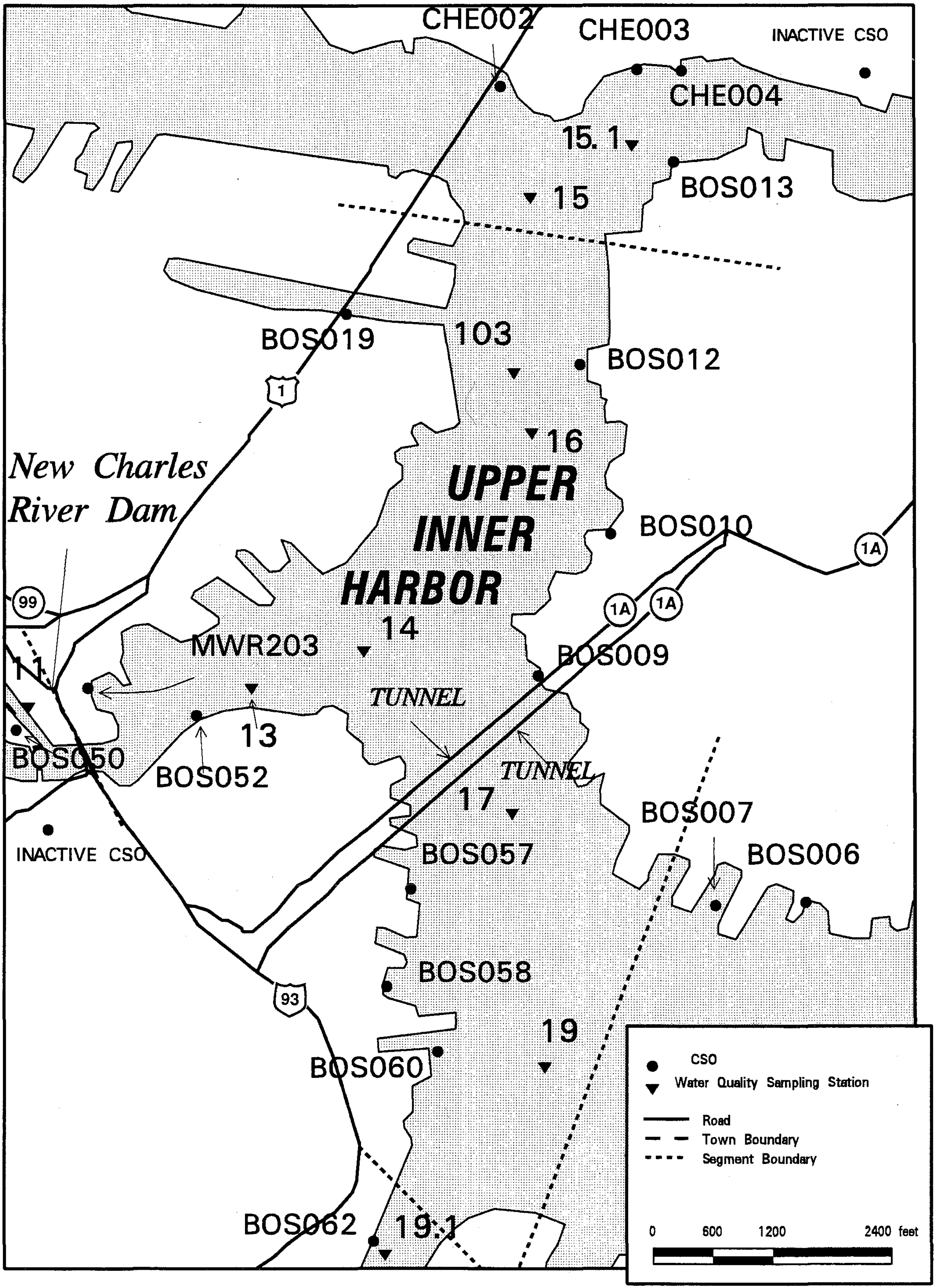


FIGURE 9-1. UPPER INNER HARBOR

is dominated by mixed use developments of residential, office and commercial space. On the land side of Atlantic Avenue is the elevated Southeast Expressway, high density apartment and commercial activity (the North End), and office buildings and Fanueil Hall Market Place. Public recreational opportunities include the North End Park, the Christopher Columbus Waterfront Park and LoPresti Park in East Boston. Cultural attractions include the New England Aquarium on the downtown waterfront and the U.S.S. Constitution Museum and ship within the National Park section of the Charlestown Navy Yard. Land use for the Boston Harbor drainage area, including Upper Inner Harbor, was presented in Figure 8-2.

9.3 CHARACTERIZATION OF WATERSHED

9.3.1 Location

The upper Inner Harbor receives drainage from Charlestown, downtown Boston/North End, and East Boston. There are no streams draining into the area. Fort Point Channel, described in Chapter 12, also discharges into the Upper Inner Harbor segment.

9.3.2 Topography and Soils

The area is mostly flat; hills include Bunker Hill, Breeds Hill, and Beacon Hill. Some of the coastline is fill. Most of the areas on or near the coastline are urban and paved.

9.3.3 Dams, highways, and other man-made features

The shoreline of the area is bordered by busy Atlantic Avenue and Commercial Street; nearby is the elevated Southeast Expressway.

9.4 SOURCES OF POLLUTION

9.4.1 General

The largest pollutant sources to the upper Inner Harbor sub-area are combined sewer overflows, stormwater, and upstream sources (the Charles and Mystic Rivers). There are no industrial or cooling water discharges directly into the upper Inner Harbor. There is extensive boating activity on the upper Inner Harbor; power boats and marinas are a potential source of pollutants such as oil, grease, and bacteria. NPDES-permitted discharges to this segment include stormwater discharges from the U.S. Coast Guard Support Center, Rowes Wharf, and storm drains from 20 Custom House Street (S. Halterman, MassDEP, pers. comm., 1994).

Estimated flows and loads of CSOs (future planned) and stormwater are shown in Figures 9-2 and 9-3. Three-month storm CSO discharges are not expected to change appreciably between existing and "future planned" conditions although the amount of untreated combined sewage are predicted to be reduced by 45%.

9.4.2 Stormwater Discharges

Except for Charlestown, most of the surrounding area has combined sewers. There are no detailed stormwater quality data for receiving water segment. This area is highly urbanized with high density housing and commercial activities, and heavy industrial use. There are probably storm drains from both land and highways into receiving waters. However, with available data, a correlation has not been found between land use and stormwater quality in the CSO study area (Metcalf & Eddy, 1994b).

BWSC dry weather screening (BWSC 1991, 1993) identified only one stormwater drain with oil and debris, (however several storm drains in this area were not included in the sampling.

9.4.3 CSO Discharges

Except for flow from the Prison Point CSO treatment facility, CSO discharges into the upper Inner Harbor are untreated. Of the CSOs monitored during 1992, four overflowed after about 0.15" of rain, and Prison Point overflowed after about 0.25" of rain (MWRA, 1993a, Table 6). Two CSOs had tidal inflow, while one (BOS052) did not activate in 1992. CSO inspections (MWRA, 1993a) showed tide gate problems at one location and buildup of scum, sediment, and debris at others; it is not known whether these problems have been corrected.

In 1992 CSO quality sampling, flow from BOS012 in East Boston had substantially higher counts of fecal coliform than other CSOs sampled during the same storms in other parts of the harbor (MWRA, 1993a), although the differences were not statistically significant. The nutrient concentrations from this CSO were also higher, while the concentrations of TSS, BOD, Zn, and Cu were comparable.

The Prison Point (Charles River Estuary) CSO Facility pumps up to 5 mgd to Deer Island; in wet weather, it provides screening, skimming, settling and chlorination to up to 323 mgd more, and provides detention of 1.29 million gallons (MWRA, 1993a). The treatment removes some BOD and TSS and usually is effective at disinfection (Bigornia-Vitale and Sullivan, 1992). The facility receives combined sewage from Boston, Cambridge, and Somerville, and appears to effectively relieve CSOs further upstream so that they don't overflow into the Charles River Basin (MWRA, 1993a). Increases in pumping capacity have had only minor effect on CSO flows, although future improvements are expected to reduce discharge from Prison Point. The Prison Point facility discharges through a multipost diffuser at the base of the new Charles River Dam.

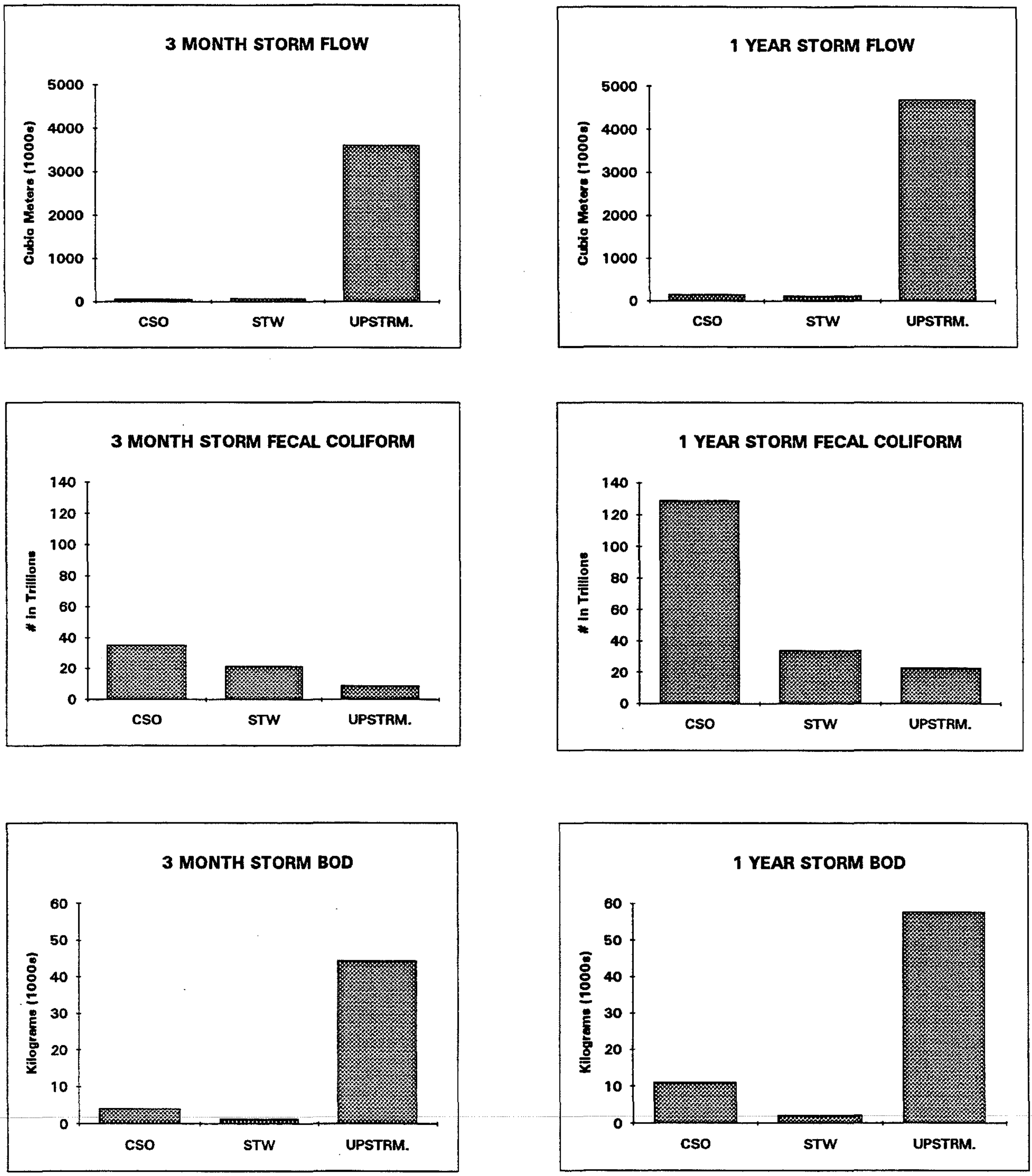


FIGURE 9-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - UPPER INNER HARBOR

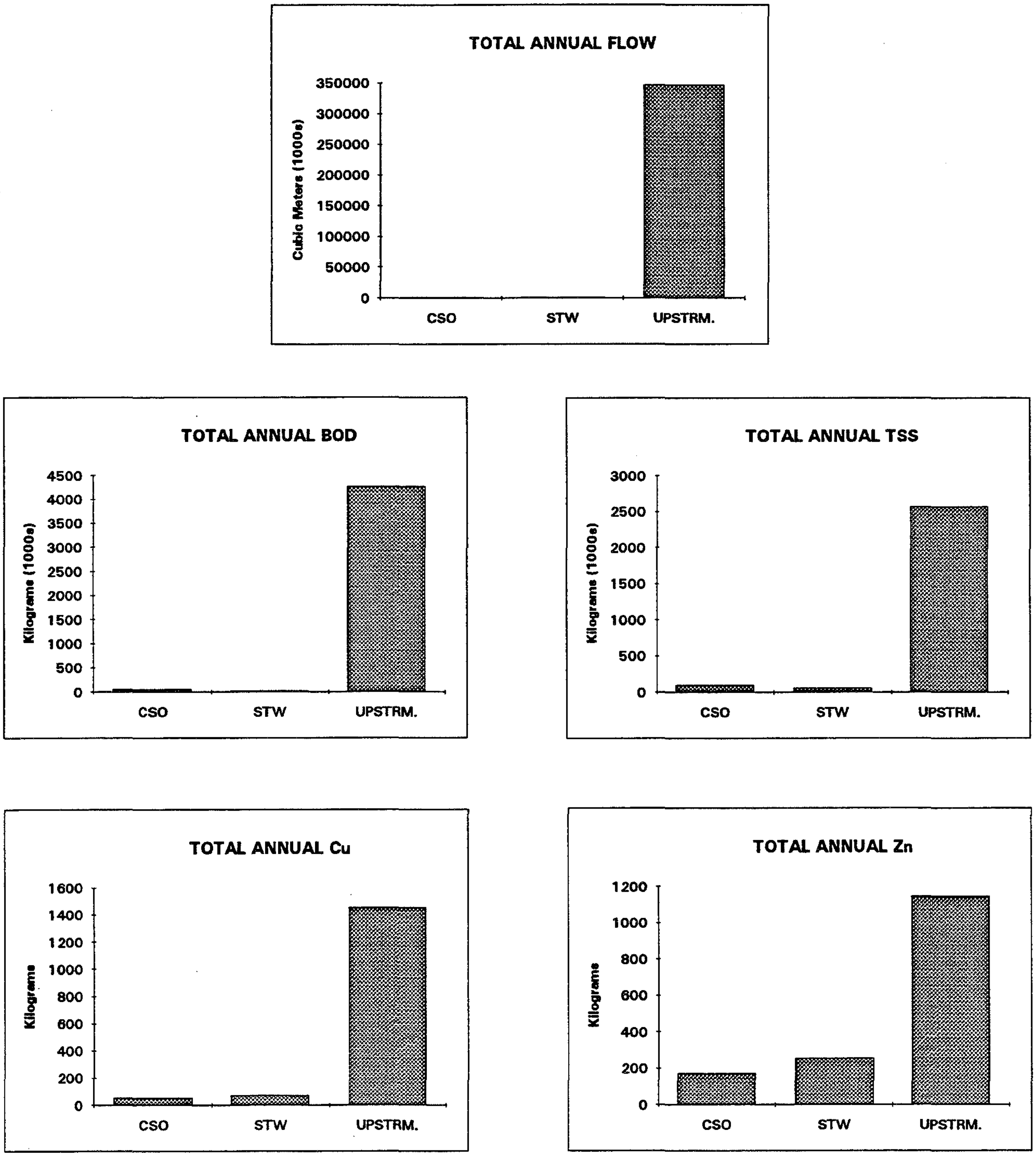


FIGURE 9-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS UPPER INNER HARBOR
(a) FLOWS, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

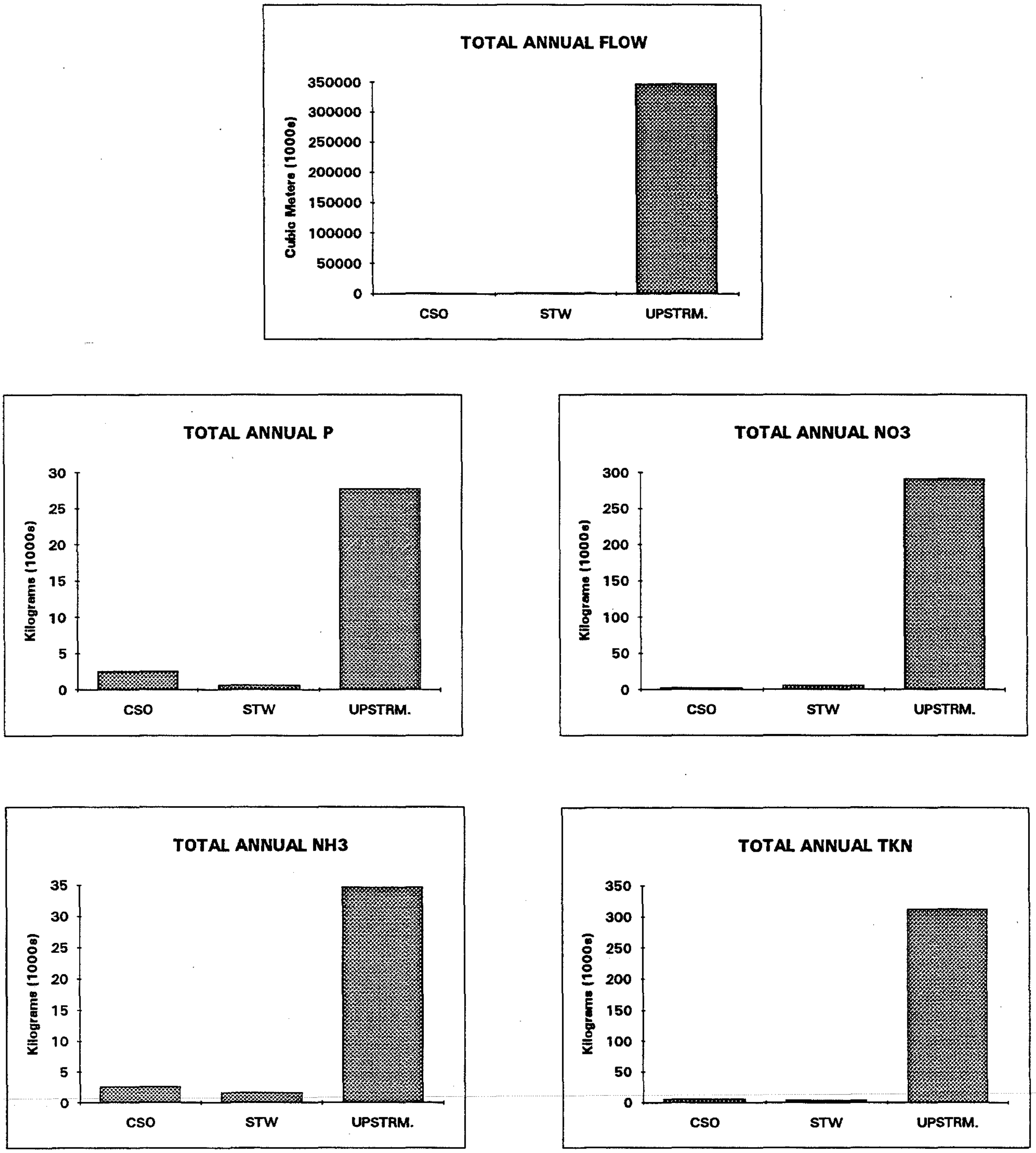


FIGURE 9-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - UPPER INNER HARBOR (b) FLOWS, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

9.4.4 Upstream inputs

The effect of the Charles River on Inner Harbor water quality was examined by MIT researchers with a dye study in 1992 (Adams *et al.*, 1993). This study indicated that nearly all bacteria from the Charles River would die or sink before reaching the mouth of the Inner Harbor. The effect on the upper Inner Harbor is probably large, the effect on the lower Inner Harbor small, and the effect on the Outer Harbor from the Charles River negligible.

9.5 HYDRODYNAMICS

9.5.1 Nearfield Mixing

Upper Inner Harbor is tidal with a range of approximately ten feet. It is seasonally weakly stratified. The largest CSO in this segment is Prison Point, which discharges downstream from the Charles River Dam. Despite its large flow, salinity measurements indicate that good mixing occurs before the effluent reaches the main stem of the Inner Harbor. Within the main shipping channel, mixing is mainly by tidal currents which reach a maximum of about 0.4 m/s (Eldridge, 1992), keeping the plumes from the Prison Point discharge and the other CSOs near the shore during periods of flood and ebb. The dilution of the smaller CSOs in the lower Inner Harbor should be similar to dilution of the Prison Point discharge.

Estimates of far field mixing can be obtained from Inner Harbor tracer studies. Using freshwater as a tracer, Bumpus *et al.* (1953) estimated Inner Harbor flushing times ranging from 1.8 to 10 days, depending primarily on freshwater inflow. An Inner Harbor dye study conducted in July 1992 yielded a flushing time for Charles River water of 3.5 to 4 days (Adams *et al.*, 1993), which agrees with Bumpus for the summertime freshwater flow of about 4 m^3/s. Based on Adams' results, the harbor-wide dilution of Charles River water would be about 60. The harbor-wide dilution of contaminants from other sources would be inversely proportional to the flow of the source relative to the flow of the Charles River.

9.5.2 Farfield Mixing and Flushing

Receiving water modeling results are shown in Appendix A. In the upper Inner Harbor segment, fecal coliform counts rise slightly more gradually after a storm than in the Mystic/Chelsea confluence segment; this probably indicates that multiple sources affect this segment, including indirect inputs of wet weather loads via the Charles River and Fort Point Channel. The counts return to background gradually, at about the same rate as in the Mystic/Chelsea confluence segment.

9.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized in Figure 9-4.

9.6.1 Bacterial contamination

Fecal coliform bacteria levels in the upper Inner Harbor do not meet swimming standards of 200/-100 ml. In dry weather, bacteria levels meet standards on average except in the immediate vicinity of CSOs (Rex, 1993; Rex *et al.*, 1992). After heavy rain (greater than one inch), the swimming standard is violated for two to four days (Rex *et al.*, 1992) and the less stringent secondary contact (boating) standard of 1000/100 ml for fecal coliform is also violated (Rex, 1993; Rex *et al.*, 1992). Surface bacteria counts are higher than bottom water counts, and ebb tide counts are higher than flood tide counts (Rex, 1993). These trends indicate a shoreline freshwater source of bacteria such as combined overflow. Fecal coliform data for the first five years of MWRA CSO receiving water monitoring are shown in Figures 9-5 and 9-6.

9.6.2 Dissolved Oxygen

Dissolved oxygen levels in surface water generally meet the water quality standard during wet and dry weather (Rex, 1993). However, depressions of dissolved oxygen are seen near large CSOs during wet weather. Also, Hurricane Bob in 1991 caused depressions of dissolved oxygen, possibly by resuspending oxygen-demanding sediments (Rex, 1993).

In bottom waters, daytime dissolved oxygen levels frequently violate the standard of 5 mg/l and occasionally fall below 2 mg/l (Rex *et al.*, 1992). Early-morning samples show very low dissolved oxygen concentrations in bottom waters (Alber *et al.*, 1993). Dissolved oxygen data (daytime measurements at selected stations) for the first five years of MWRA CSO receiving water monitoring (1989-1993) are shown in Figure 9-7.

9.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

CSOs contribute to occasional odor problems in the Inner Harbor at low tide (MWRA, 1990, Vol 1 p. 4B-12). Floatables and trash are often seen in the vicinity of the Charles River Dam. Some of the debris appears to be coming from sources upstream of the dam, since MWRA monitoring staff have observed the debris passing through the locks. In 1991, a survey of BOS058 and BOS057 showed that on several occasions, both CSOs had discharged, leaving a plume of oil and grease and particulates. Seagulls were observed to be feeding in the plume. Floatable debris (logs, tires, pieces of piers) is found throughout the harbor especially after storms.

		Dry Conditions	**Wet Conditions**	**Overall Quality**	**Comments**	**Existing uses affected**	**Health/ eco-system risk**	**Pollutant Sources**
	Bacteria (1,6,7)	◍	●	●	during dry weather standards are not met near CSOs	boating; swimming?	●	CSOs; SW?, boats?
	Dissolved Oxygen (1,6)	◍	●	●	surface DO depressed near CSOs (wet); bottom DO often low esp. at dawn; RSOD	aquatic life fishing, lobstering lobster # intake	●	CSOs, SOD restricted flushing
Aesthetics	Solids and Floatables (1,2)	◍	●	◍	CSO plume	passive recreation aquatic life?	◍	CSOs, SW, Charles R?
	Color and Turbidity (1,2)	◍	●	◍	CSO plume	passive recreation		CSOs (BOS057,58)
	Odor (2,8)	○	◍	◍	low tide	passive recreation		CSOs
	Oil and grease (1,2,8)	◍	●	●	slicks from boats and CSOs	passive recreation	◍	ships, boats, CSO
	Bottom pollutants or alterations (10,11)	N/A	N/A	●	contam. levels highest of any area in harbor. extremely degraded, seasonally azooic	aquatic life	●	CSOs, rivers, sludge? anoxia physical and due to OC
	Nutrients (4,5,9,13) (algal blooms)			●	eutrophic	aquatic life	●	CSOs; other?
	Toxic Pollutants (3,4,12)	◍	●	●	bioaccum. worse than at DI. Cl tox. from PP	aquatic life fishing, lobstering lobster # intake	●	rivers; CSO, SW?
	Temperature (6)	○	○	○		aquatic life	○	
	pH (N/A)							

Key:

● poor quality or high risk

◍ fair quality or moderate risk

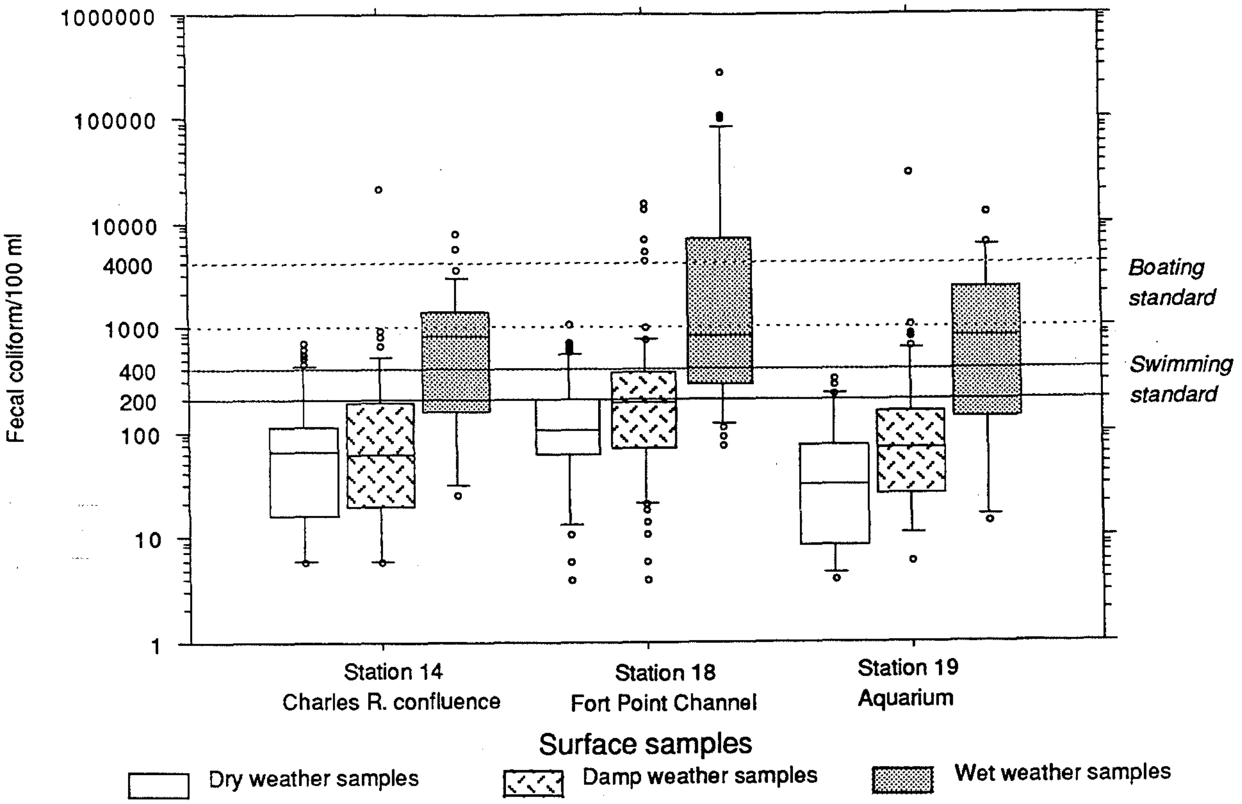
○ good quality or low/no risk

? insufficient data

PP = Prison Point CSO facility
SW=stormwater
OC= organic carbon
N/A= not applicable
SOD = sediment oxygen demand

Sources of information on present conditions
1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993-94
3 - Wallace et al 1987
4 - MWRA, 1993a (Interim CSO Report)
5 - Robinson, et al. 1990
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989
9 - ENSR, 1993
10-Corps of Engineers 1990, 1993;
Normandeau Associates 1993;
Hubbard and Bellmer 1986; Hubbard 1987
11-MacDonald, 1991
12-Downey et al., 199
13-Unpublished New England Aquarium data

FIGURE 9-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - UPPER INNER HARBOR

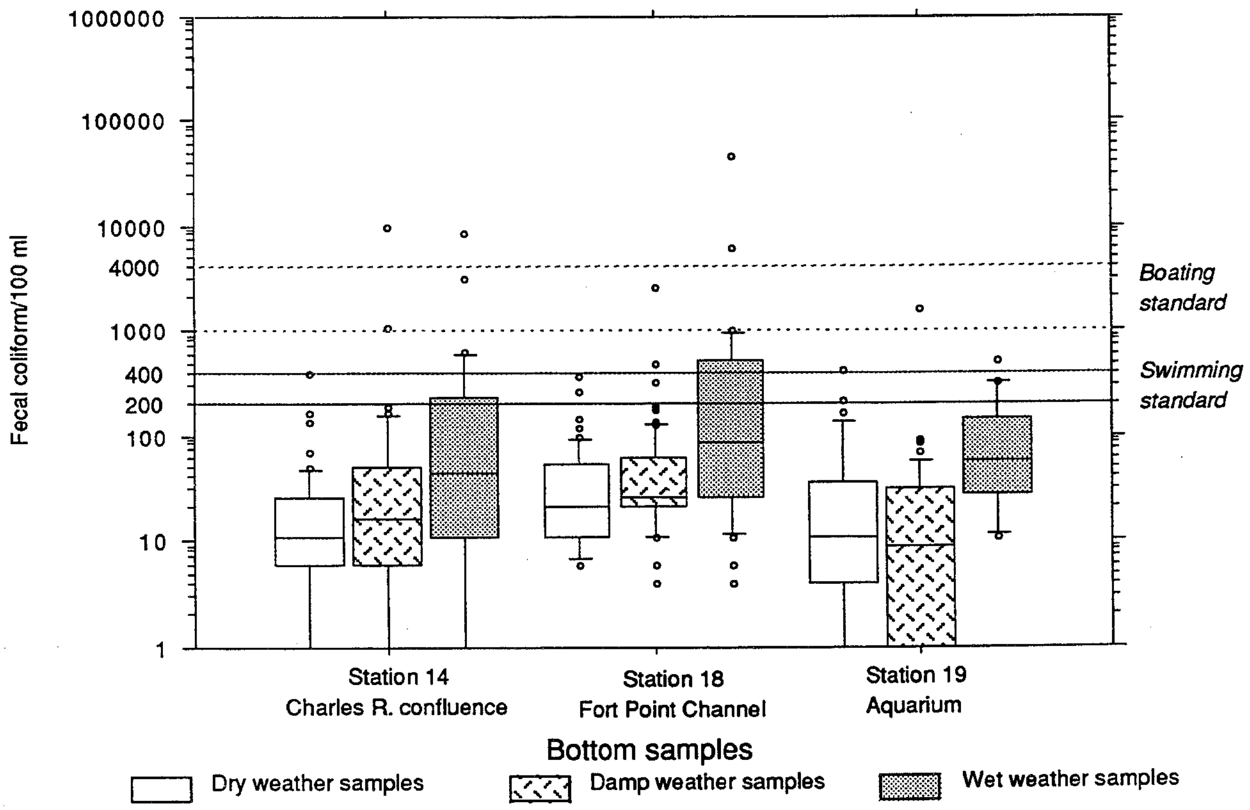


Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
14	Dry	46	1	749	45
14	Damp	53	1	22301	59
14	Wet	31	1	7976	399
18	Dry	50	4	1080	94
18	Damp	76	4	16026	179
18	Wet	30	79	281001	1662
19	Dry	28	1	329	26
19	Damp	46	1	31401	69
19	Wet	17	1	12701	427
	TOTAL	377	1	281001	122

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".
Damp weather samples were collected when three-day rain was between 0.0" and 0.5".
Wet weather samples were collected when three-day rain >0.5".

FIGURE 9-5. FECAL COLIFORM MONITORING DATA FOR UPPER INNER HARBOR AND FORT POINT CHANNEL - SURFACE SAMPLES (1989-93)



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
14	Dry	47	1	409	12
14	Damp	52	1	10001	19
14	Wet	31	1	8801	42
18	Dry	48	1	381	22
18	Damp	72	4	2601	35
18	Wet	27	4	45251	123
19	Dry	28	1	441	11
19	Damp	44	1	1626	8
19	Wet	16	1	526	56
	TOTAL	365	1	45251	23

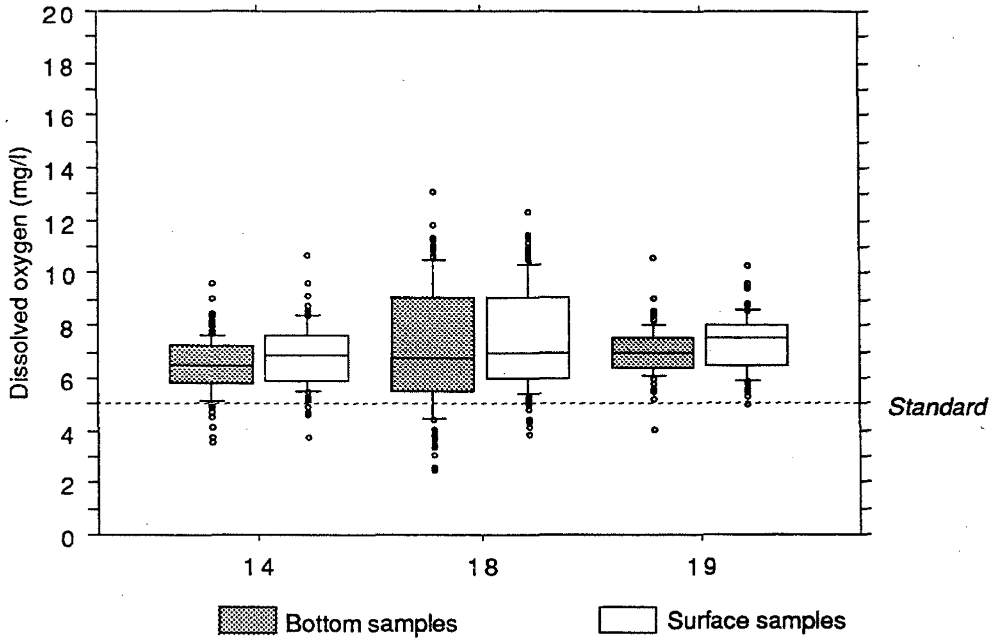
* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 9-6. FECAL COLIFORM MONITORING DATA FOR UPPER INNER HARBOR AND FORT POINT CHANNEL - BOTTOM SAMPLES (1989-93)



Station	Sample Type	No. of Samples	Concentration (mg/l) Mean	Median	Minimum	Maximum
14	Bottom	128	6.4	6.5	3.6	9.7
14	Surface	129	6.8	6.9	3.8	10.7
18	Bottom	139	7.2	6.8	2.5	13.1
18	Surface	152	7.5	7.0	3.9	12.4
19	Bottom	85	7.0	7.0	4.1	10.6
19	Surface	86	7.3	7.5	5.0	10.3
	TOTAL	719	7.1	6.9	2.5	13.1

FIGURE 9-7. DISSOLVED OXYGEN CONCENTRATIONS
IN UPPER INNER HARBOR AND FORT POINT CHANNEL (1989-93)

9.6.4 Oil and Grease

In addition, to the greasy plume described above, oil slicks are often observed in vicinity of Charles River Dam. Oil slicks from boats are often encountered in Harbor. In 1988, oil and grease concentrations were about 5 mg/l or less in the upper Inner Harbor (CH2M Hill, 1989).

9.6.5 Bottom Pollutants or Alterations

The information available on harbor sediment contamination has been reviewed by MacDonald, 1991; Cahill and Imbalzano, 1991; Hathaway *et al.*, 1992, and Buchholtz-ten Brink *et al.* 1993, among others. Inner Harbor sediments are the most contaminated of any area of the harbor[1], and are particularly high in polycyclic aromatic hydrocarbons (Shiaris and Jambard-Sweet, 1986). Minimum, maximum and median concentrations of some contaminants for the Inner Harbor as a whole are shown in Table 9-1. Some of these historical measurements fall in "Category III" (very elevated) of the Massachusetts dredging criteria for all the metals measured and for PCBs. The median concentrations of lead, zinc, chromium, and $tPAH_6$, and the maximum concentration of copper, cadmium and mercury and tPCB exceed the "ER-M" levels suggested by Long and Morgan (1990) as likely to cause biological effects.

Data on sediment quality in a berthing area in the upper Inner Harbor (at the mouth of the Mystic River) include very elevated ("Class III") concentrations of arsenic, lead, and zinc, and elevated ("Level II") concentrations of cadmium, chromium, copper, and mercury (Normandeau, 1993). Total PAHs reached Class III concentrations and total PCBs reached Class II levels. Sediments in the berth area showed toxicity to amphipods significantly greater than that of the control sediments. In bioassay tests, the berth sites showed good survival of worms and clams (Normandeau, 1993).

In summer, the sediment is anoxic or has a very shallow (< 1 cm) apparent redox potential discontinuity depth (SAIC 1990, 1992). Sediment toxicity testing shows that some Inner Harbor sediments are toxic to *Ampelisca*, an organism common in other parts of the harbor (U.S. Army Corps of Engineers 1990). Because of the lack of oxygen, the high loading of organic carbon, and the high levels of chemical contaminants, the Inner Harbor floor has a low abundance and diversity of benthic organisms (Leo *et al.* 1993, Kelly and Kropp 1992).

It is likely that the Inner Harbor sediments are affected not only by nearby sources (CSOs, rivers) but also by effluent and accumulated wastewater sludge that was formerly discharged at the harbor entrance (Stolzenbach *et al.*, 1993; Leo *et al.*, 1993).

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[1] There are very few data on riverbed contamination.

TABLE 9-1. SUMMARY OF INNER HARBOR SURFICIAL SEDIMENT CONTAMINATION MEASUREMENTS[a]

	$tPAH_6$[b]	tPCB[c]	Cd	Cr	Cu	Hg	Pb	Zn
median	17	0.35	4	220	200	1.5	217.5	310
minimum	0.0025	0.3	0	0.83	12	0.02	19	16.8
maximum	59	7	75	720	1650	68.8	1200	1500

Notes: All units are in $\mu g/g$

a. Metals data are from Hathaway *et al.* (1992), PAH data are from the review by MacDonald (1991).

b. $tPAH_6$ is the sum of six commonly measured PAHs: phenanthrene, fluoranthene, pyrene, chrysene, benz(a)anthracene, and benzo(a)pyrene.

c. tPCB is the sum of all PCB congeners measured.

9.6.6 Nutrients

Nutrient data for the upper Inner Harbor are available from several sources. ENSR measured dissolved inorganic nitrogen and chlorophyll at two sites on a single occasion in 1993. MWRA measured total phosphorus at one site on several occasions during 1993. The most recent year in which water quality was comprehensively and regularly monitored was 1991, by the New England Aquarium (unpublished data). The range of nutrients concentrations measured in 1991 and 1993 are presented in Table 9-2. Mean total phosphorus concentrations for 1991 and 1993 correspond to the "healthy" class of the EPA's guidelines on Use Attainability (EPA, undated). Like the Mystic River/Chelsea Creek confluence, however, the range of total phosphorus concentrations include values in the "fair" category.

The annual mean total phosphorus concentrations in this area have declined since 1987 (Lavery, et al. in prep). Mean annual concentrations prior to 1987 were in the range 0.14 to 0.19 mg/l ("fair"). Since 1987, mean concentrations have been in the range 0.06 - 0.08 mg/l ("healthy"). There is no obvious trend in mean dissolved inorganic nitrogen concentrations from 1987 to the present (Lavery et al., in prep.)

Chlorophyll concentrations in the upper Inner Harbor averaged 2.70 $\mu g/l$ in 1991. The 1993 data were all collected in summer (Aug.- Sept.) and are strongly influenced by a dense phytoplankton bloom. The mean 1993 chlorophyll concentration was 9.0 $\mu g/l$, with a peak concentration almost seven times that observed in 1991. On the basis of the 1991 mean chlorophyll concentrations, the upper Inner Harbor can be classified as mesotrophic-eutrophic according to Wetzel's (1983) classification. However, the 1993 data show that at times this region can be highly eutrophic.

TABLE 9-2. UPPER INNER HARBOR NUTRIENT AND CHLOROPHYLL MEASUREMENTS

	Dissolved Inorganic Nitrogen (mg/l)		Total Phosphorus (mg/l)		Chl a (μg/l)	
	1991	1993	1991	1993	1991	1993
minimum	0.13	0.29	0.05	0.04	0.01	0.29
maximum	0.40	0.36	0.10	0.13	7.46	41
mean	0.22	0.32	0.07	0.06	2.70	9.0

Note: 1993 total phosphorus and chlorophyll data from MWRA (Lavery, et al. in prep.) and 1993 dissolved inorganic nitrogen data from ENSR (1993). All 1991 data from New England Aquarium.

9.6.7 Toxic pollutants and toxicity

Water quality in the harbor generally meets applicable water quality standards and criteria for toxic contaminants; a possible exception is copper, which may exceed the EPA water quality criterion in the Inner Harbor (Wallace *et al.* 1987, Rex 1989). Rex (1989) notes that copper levels measured by Wallace *et al.* (1987) are higher in the Inner Harbor than those measured at the Deer Island discharge location (MWRA 1988). More recent samples (Wallace, et al., 1993) do not show any metals criteria violations.

Bioaccumulation study results indicate higher concentrations of toxic organic contaminants (PAHs, PCBs, DDTs) in tissues of mussels deployed in the upper Inner Harbor than at a station near the Deer Island discharge (Downey *et al.*, 1993). Combined sewage includes middle- and high-molecular-weight PAH compounds at higher concentrations than does effluent (Wade, 1993).

9.6.8 Temperature

In the MWRA CSO receiving water monitoring program 1989-92 data set, the temperature in the upper Inner Harbor never exceeded the class SB standard of 85°F; the maximum temperature recorded in surface water was 28.0 C (82.4°F).

9.7 USE ATTAINMENT

9.7.1 Watershed Content

The heavily urban, commercial, and industrial land characteristics of the drainage area adversely impact the present water quality of the coastline area. Boston Inner Harbor (area from Summer Tunnel to Castle Island) is not attaining Class SB status because of ammonia, total toxics, pathogens, and organic enrichment/DO because of urban runoff, CSOs, and in-place contaminants (Mass DEP, 1993a).

9.7.2 Existing Water Quality and Affected Uses

Figure 9-8 shows how water quality problems in the upper Inner Harbor affect uses. In this segment, fecal coliform counts exceed the standard for primary contact recreation (swimming) in wet weather. The secondary contact recreation standard is met in dry and "damp" weather, and is nearly met in wet weather.

Although daytime dissolved oxygen levels usually meet the state standard, low levels at dawn are characteristic of this segment and of other parts of the Inner Harbor. The upper Inner harbor segment has aesthetic problems caused by floatables and oil slicks, especially near the Charles River Dam. Sediments are contaminated and enriched with organic material, affecting bottom-dwelling organisms. There may be a problem with bioaccumulation of toxic contaminants.

9.7.3 Baseline ("Future Planned") Water Quality and Affected Uses

CSO loads of pollutants are expected to decrease between existing and baseline ("future planned") conditions; in particular, the amount of untreated CSO will probably decrease. Therefore, bacteria levels and violations of other water quality parameters are expected to decline.

In this segment, the model predicts that fecal coliform counts exceed the swimming standard for about 1½ days after the three-month storm now; under future planned conditions, the violation is predicted to persist for about one day. The boating standard is not predicted to be exceeded under future planned conditions except near Fort Point Channel after the 1-year storm. When only non-CSO sources to the harbor and rivers are included, the swimming standard is not violated in the model prediction, except for a few hours at the mouth of the Charles River.

Table 9-3 summarizes bacterial impacts in the upper Inner Harbor segment. "Non-CSO" includes upstream inputs and dry-weather loads as well as stormwater.

Figure 9-8. Beneficial uses affected by water quality in Upper Inner Harbor

Class SB

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			FCA for Lobster
Aquatic Life	▨ C	ok		▨ W pp	▨ W pp	▨ C	▨ C				?	▨ W	▨ C		
Primary Contact Rec.								▨ C	▨ W	?	▨ C	▨ W		▨ W	
Secondary Contact Rec.								▨ W							
Aesthetics									▨ W	?	▨ C	▨ W	?	▨ W	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:

ok	Attained for Criteria
▨	Proven or Probable Non-Attainment
W	Wet Weather Non-Attainment
C	Wet and Dry Weather Non-Attainment
cr	Charles River
pp	Prison Point

TABLE 9-3. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN UPPER INNER HARBOR

	Current Conditions		3-Month Storm Event				1-Year Storm Event		
Resource Area	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Mouth of Charles River (downstream of new dam)									
Swimming[a]	?	Violates	32	21	3	0	37	32	4
Boating[b]	OK	Violates	0	0	0	0	0	0	0

Note:

(a) Swimming (hours fecal coliform count > 200/100 ml)

(b) Boating (hours fecal coliform count > 1000/100 ml)

Table 9-4 summarizes the level of use of this segment and the factors affecting attainment or non-attainment of the uses.

TABLE 9-4. USE ATTAINMENT FACTORS - UPPER INNER HARBOR

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	Low	3	Untreated CSO, stormwater
Secondary Contact Recreation	Moderate-High	2	Untreated CSO, stormwater
Aquatic Life	Moderate	2	CSO, rivers, stormwater
Fish Consumption	Moderate	2(?)	Rivers, CSO, Stormwater
Aesthetics	Moderate-High	2	Rivers, CSO, stormwater

* To be determined through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 10
FORT POINT CHANNEL

10.1 DEFINITION OF RECEIVING WATER SEGMENT

Fort Point Channel (Figure 10-1) is a narrow, shallow embankment off the upper part of the Inner Harbor. It separates South Boston from the downtown area. The average depth of the channel is about 6 meters and its average width is about 150 meters, but a portion of the channel is much shallower and narrower. The CSO discharge that dominates this area is the BOS070 system.

10.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

Fort Point Channel is designated as Class SB - Fishable/Swimmable plus restricted shellfishing (MassDEP, 1990). At this time, there are no shellfish resources identified by Division of Marine Fisheries within the channel. Recreational fishing from the bridges and wharves lining the channel has been observed by MWRA monitoring staff.

The channel is currently used for both powerboat (including fishing vessels) and barge activities in accordance with related land-side uses. The water based uses within Fort Point Channel include the use of the area as a refuge for boats during extreme weather, although the construction of the fixed span bridge at the mouth of the channel will soon eliminate this use for larger vessels and for some sailboats.

Land-side uses include a mix of industrial facilities (including the Gillette Company), seafood handling facilities (which use channel water for maintaining lobsters), transportation corridor uses (South Station) and cultural uses (Tea Party Ship, Children's Museum). The Childrens' Museum is currently finalizing plans for a major addition to be constructed on a barge in the channel and which will include an urban ecology component. Other major uses include the large Post Office facility, an MBTA train maintenance facility (at the upstream end) and large parking areas. The upstream end is bordered by a major highway interchange. The channel itself is lined with granite, with five low bridges over it. Land use in the Boston Harbor drainage area including Fort Point Channel, was presented in Figure 8-2.

10.3 DESCRIPTION OF WATERSHED

10.3.1 Location

The Fort Point Channel receives drainage from a large area of Boston, including Roxbury, Dorchester, the South End, parts of South Boston, the Roxbury Conduit and Dorchester Brook.

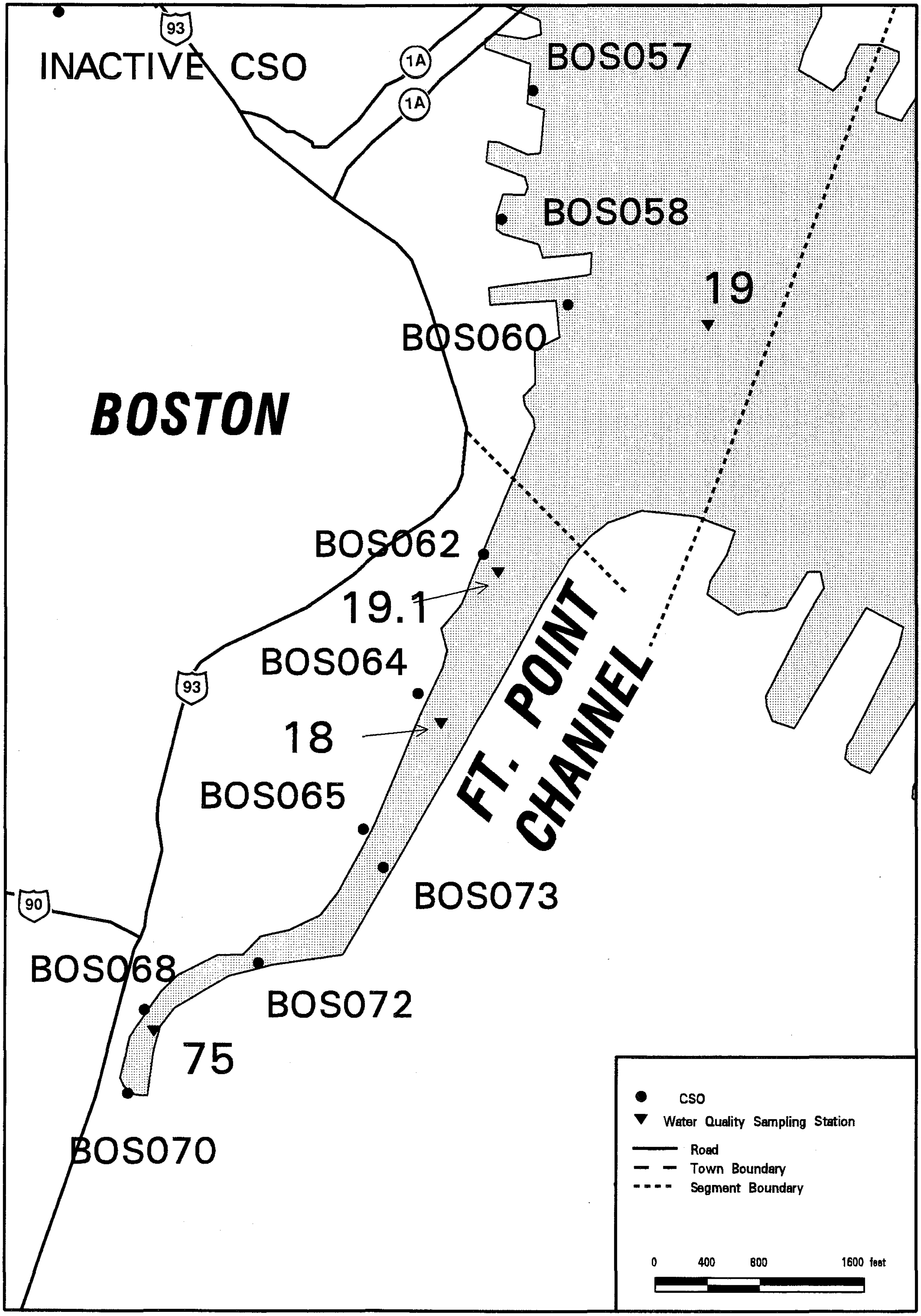


FIGURE 10-1. FORT POINT CHANNEL

10.3.2 Topography and Soils

The area is flat with no major hills. Much of the coastline is fill. Most of the areas on or near the coastline are urban, paved land.

10.3.3 Dams, highways, and other man-made features

The shoreline of the area is bordered by a busy highway, Interstate 93 or the Southeast Expressway. The construction of the Third Harbor Tunnel will affect Fort Point Channel significantly; the tunnel will underlie the channel and a portion of the seabed will be raised by a few meters. This will result in significantly restricted circulation in the area above the tunnel crossing.

10.4 SOURCES OF POLLUTION

10.4.1 General

Fort Point Channel receives a heavy load of pollutants from CSOs and stormwater. The channel receives a large fraction of the total MWRA system CSO flow, with BOS070 constituting the largest of the CSOs in the channel. In addition, there is a cooling water discharge owned by Gillette that flows into Fort Point Channel.

There is evidence that the sediments of Fort Point Channel tend to accumulate particles and associated pollutants from more remote sources (Stolzenbach *et al.* 1993, Leo *et al.* 1993).

Estimated flows and loads of CSOs (future planned) and stormwater are shown in Figures 10-2 and 10-3. Three month storm CSO flows and loads are expected to decrease by 27% between existing and "future planned" conditions.

10.4.2 Stormwater Discharges

The area surrounding Fort Point Channel has mostly combined sewers. It should be noted that the largest CSO (BOS070) has significant stormwater input below the regulators; the quality of this stormwater has not been examined by BWSC or MWRA.

There are no detailed studies of stormwater in the receiving water segment. In general, stormwater concentrations of fecal coliform bacteria, suspended solids, BOD, nutrients and metals are lower than concentrations in combined sewage. (Metcalf & Eddy, 1994a, 1994b).

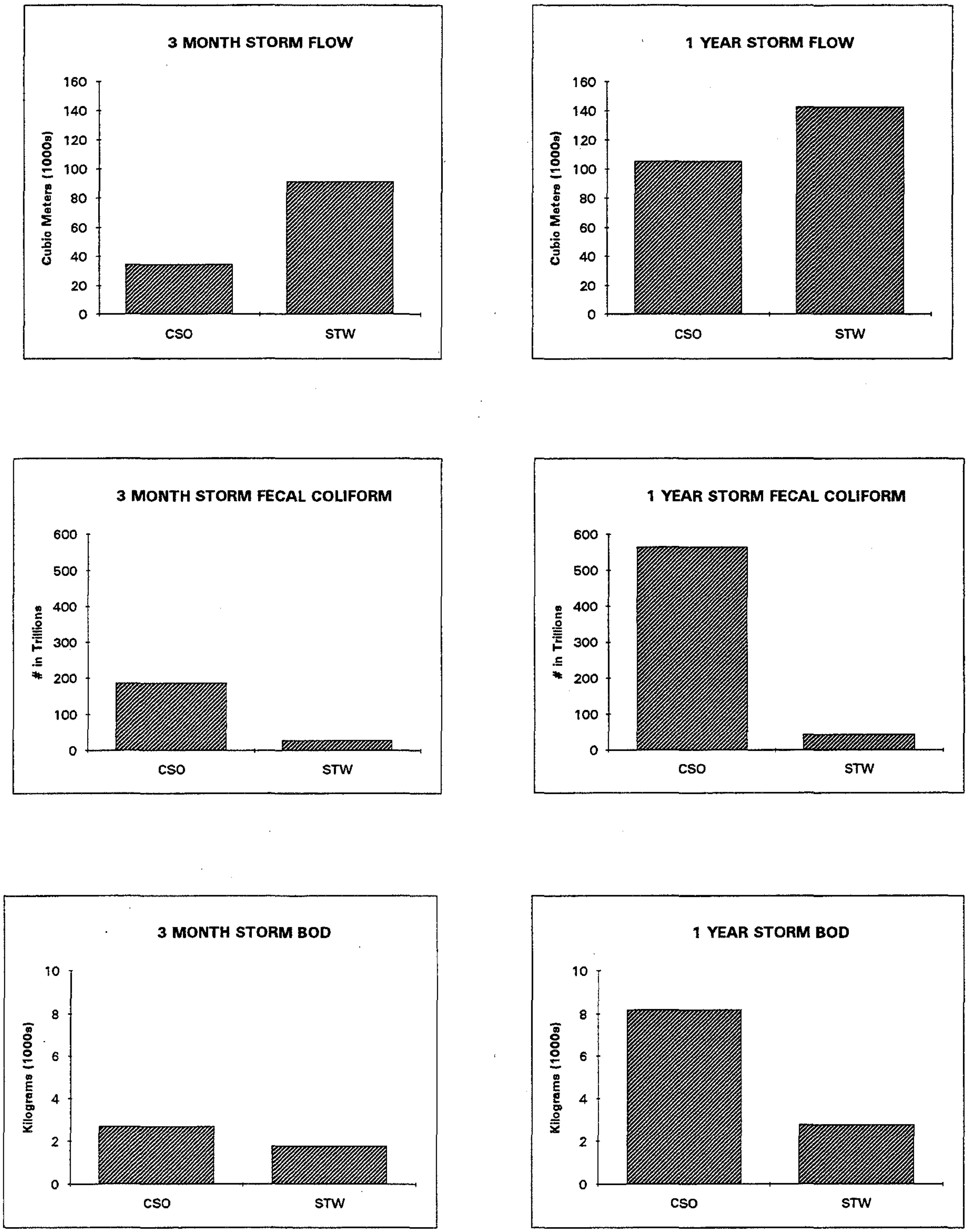


FIGURE 10-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - FORT POINT CHANNEL

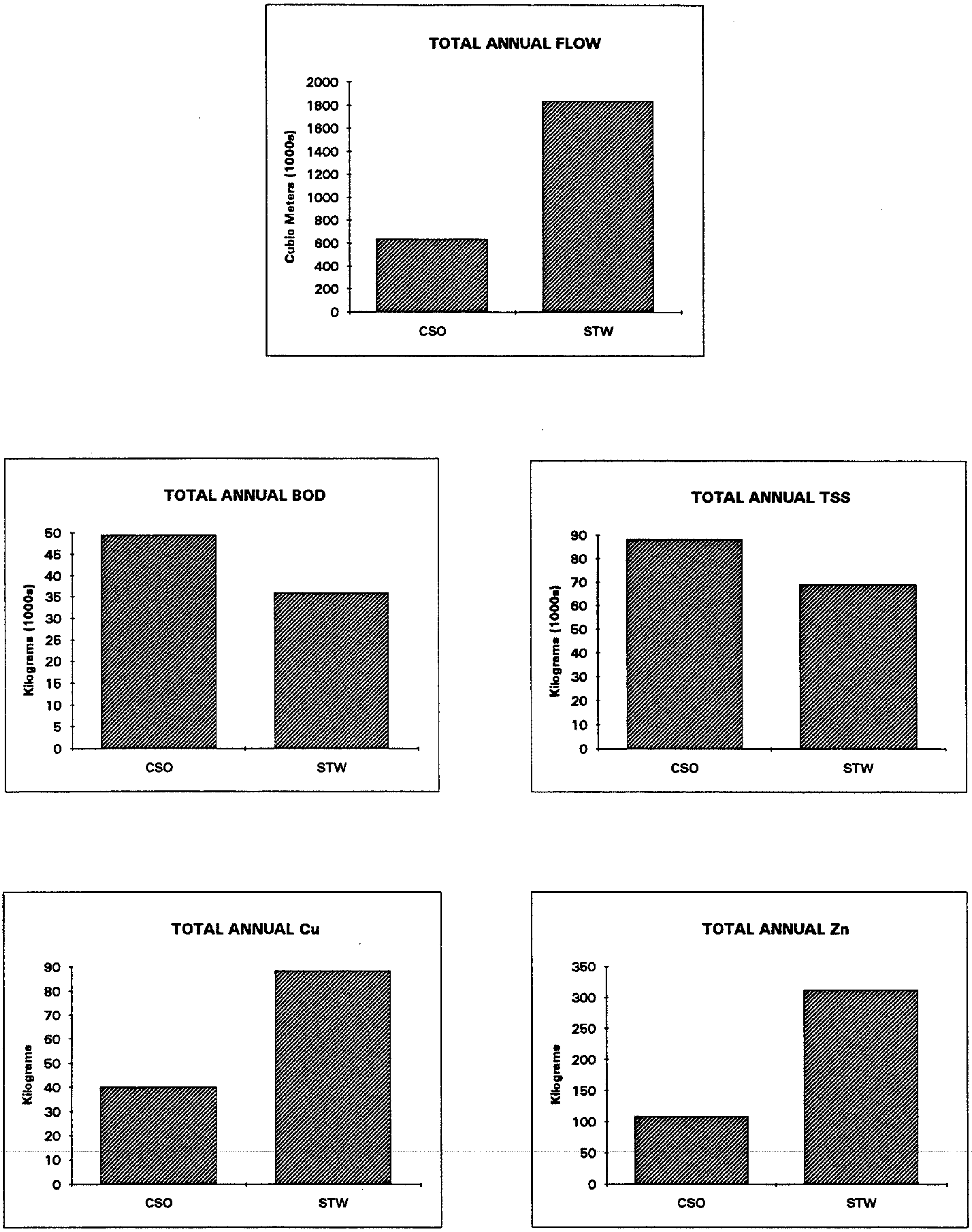


FIGURE 10-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - FORT POINT CHANNEL
(a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

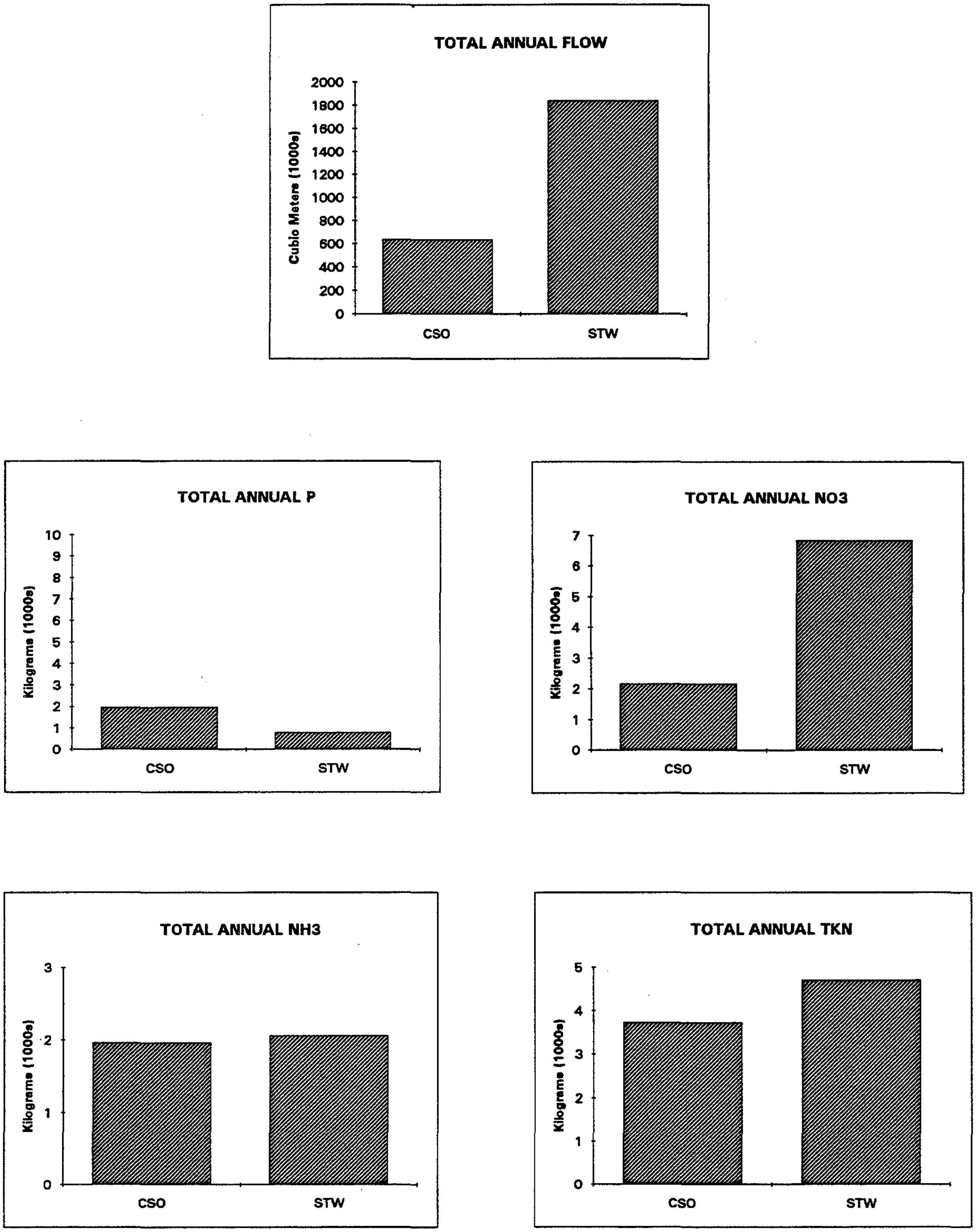


FIGURE 10-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - FORT POINT CHANNEL
(b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

BWSC dry weather screening of stormwater found one storm drain that had evidence of oil and debris during the first screening (BWSC 1991) but not during the second screening (BWSC 1993).

This area is highly urbanized with high density housing and commercial activities, and heavy industrial use. Given the available data, a correlation cannot be made between land use and stormwater quality in the CSO study area (Metcalf & Eddy, 1994b).

10.4.3 CSO discharges

None of the CSOs discharging into Fort Point Channel is treated. The large CSO at the head of the channel, BOS070, is the terminus of the Roxbury and Dorchester Brook Conduits that drains 1,800 acres of sanitary flow, 735 acres of storm flow and 930 acres of combined flow in Boston. It is the largest single untreated CSO in the system. Of the CSOs monitored in 1992, two (BOS070 and BOS062) overflowed with about 0.1" of rain, two overflowed with about 0.4" of rain, and one overflowed with about 0.8" of rain (MWRA 1993). One CSO did not overflow during the 1992 monitoring period. CSO inspections in 1992 (MWRA, 1993a) identified leaky tide gates and debris accumulation at BOS064 and BOS070, which have since been cleaned and repaired by BWSC.

The timing of the discharge and the action of the tide gates can cause the input of pollutants to be intermittent or continuous, large or small (Adams *et al.*, 1992).

10.5 HYDRODYNAMICS

10.5.1 Nearfield Mixing

The Fort Point Channel receiving water area is tidal with a range of approximately ten feet. It is stratified when there is freshwater inflow at the head (Adams et al., 1992). The major CSO in the channel is BOS070. Because the tide intrudes upstream of the culvert at BOS070, some mixing takes place underground. Salinity measurements suggest this initial mixing results in a dilution of about two while dilution in the middle of the channel exceeds 10 (Adams *et al.*, 1992).

10.5.2 Farfield Mixing

Additional information on mixing and flushing can be obtained from three dye studies of Fort Point Channel conducted by MIT (Adams *et al.* 1992) and two dye studies conducted by CH2M Hill (1990). The CH2M Hill dye studies were conducted in September 1989, prior to the correction of the dry weather overflow in 1990. During the MIT wet weather survey, and during the CH2M Hill wet and dry surveys, there was an approximately one million gallon per day dry weather flow of raw sewage entering the channel due to a blocked regulator. This freshwater inflow affected the hydrodynamics of the channel as well as the water quality (Adams *et al.* 1992).

The measured residence times in Fort Point channel varied between 1 and 2.5 days depending on the tidal height, timing of the tracer release, and the freshwater inflow from BOS070, the large CSO at the head of the channel (Adams *et al.* 1992). Flushing of the channel is governed mostly by the tide; it is affected by the range (spring *vs.* neap) with some influence by density currents driven by freshwater inflow at the channel head. In the absence of freshwater input, the theoretical residence time is 1.3 days, derived from the tidal prism method for an average tide.

It is estimated that 15% of the fecal coliform and *Enterococcus* would leave the channel and assuming intermediate flushing (Adams *et al.* 1992). The MIT researchers also released paint particles to study the settling of particles discharged into Fort Point Channel. Using intermediate settling and flushing rates, about 45% of the particles would leave the channel. Adams *et al.* (1992) conclude that CSO particles are probably retained more efficiently, as they settle more quickly. Also, Stolzenbach *et al.* (1993) have determined that Fort Point Channel acts as a "sediment trap" for particles from remote sources as well as those from Fort Point Channel CSOs.

Receiving water model results (see Appendix A) indicate that bacteria disappear from the channel at a slightly faster rate than other parts of the Inner Harbor. The levels are somewhat higher to begin with after a storm, and return to background levels in about six days after the three-month storm.

10.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions in Fort Point Channel are summarized in Figure 10-4.

10.6.1 Bacterial contamination

Fort Point Channel is one of the two areas of the Inner Harbor most affected by CSO discharge (Rex 1993; the other is near the Somerville Marginal CSO, see Chapter 8). The channel does not meet the swimming standard for fecal coliform of 200/100 ml; on average about 0.25" of rain over three days is all that is required to raise the fecal coliform count to over 200 colonies/100 ml (Rex, 1993). Fecal coliform data from the first five years of MWRA CSO receiving water monitoring are shown in Figure 10-5 and 10-6.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	●	●	●	only light rain raises bacteria counts above standard	boating	●	CSOs; SW
	Dissolved Oxygen (1,6)	●	●	●	among lowest in Inner Harbor both surface & bottom	aquatic life lobster # intake	●	CSOs
Aesthetics	Solids and Floatables (1)		●	●		passive recreation aquatic life	●	CSOs; SW?
	Color and Turbidity (1,2)	◍		◍	green plume near Broadway Bridge	passive recreation	N/A	industrial?
	Odor (2,8)	?	?	?		passive recreation	N/A	
	Oil and grease (1,2,8)	●	●	●	slicks near Summer St. Bridge	passive recreation	N/A	CSOs; SW
	Bottom pollutants or alterations (10,11)	N/A	N/A	●	extremely degraded, worst part of IH, at least seasonally azoic	aquatic life	●	CSOs, sludge; anoxia due to OC
	Nutrients (3,5,9) (algal blooms)			◍	oligotrophic (based on chlorophyll)	aquatic life	◍	CSOs; other?
	Toxic Pollutants (4)			●		aquatic life fishing, lobstering lobster # intake	●	CSO, SW?
	Temperature (6)	○	○	○		aquatic life	○	
	pH (N/A)							

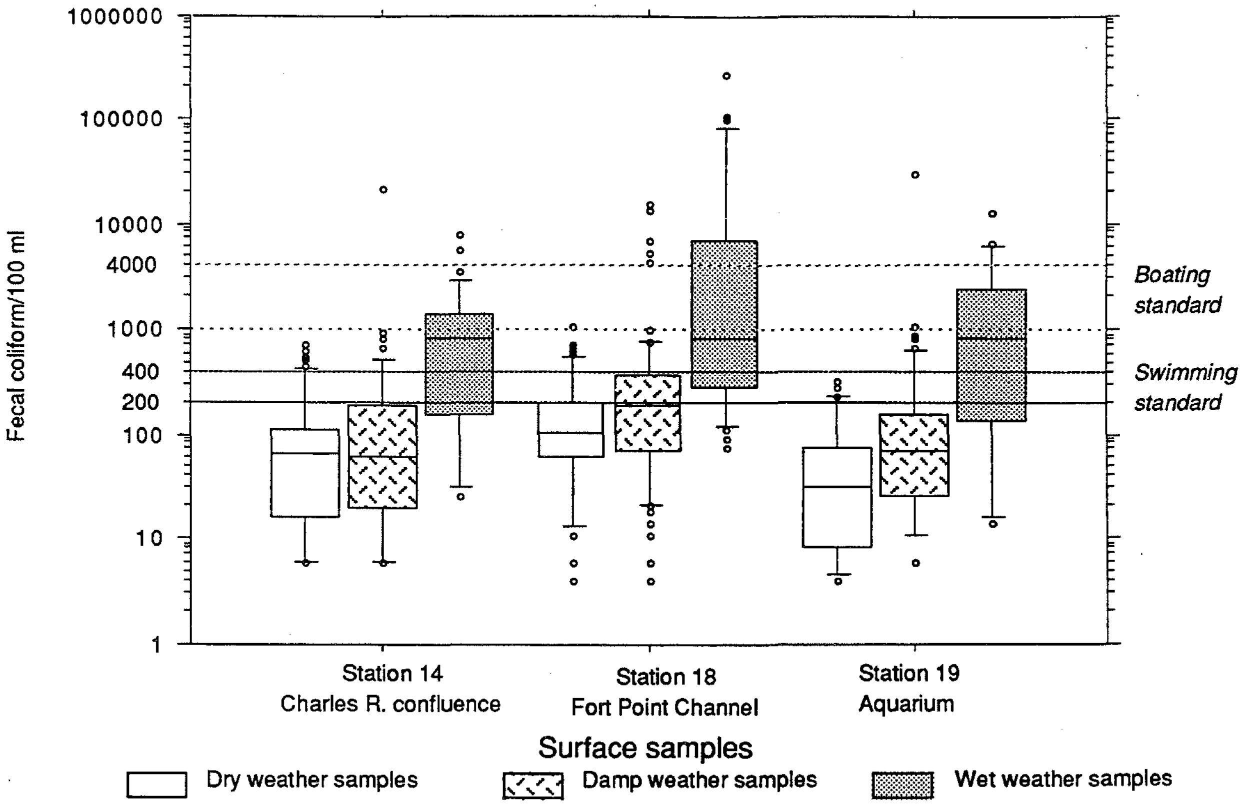
Key:
● poor quality or high risk
◍ fair quality or moderate risk
○ good quality or low/no risk
? insufficient data

SW=stormwater
OC= organic carbon
N/A= not applicable
PAH = Polycyclic aromatic hydrocarbons

Sources of information on present conditions

1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993
3 - Unpublished New England Aquarium data
4 - MWRA, 1993a (Interim CSO Report)
5 - Robinson, et al. 1990
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989
9 - ENSR, 1993
10-Corps of Engineers 1990, 1993; Normandeau Associates, Inc. 1993
11-MacDonald, 1991
12-Hubbard & Bellmer, 1989; Hubbard 1987

FIGURE 10-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - FORT POINT CHANNEL



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
14	Dry	46	1	749	45
14	Damp	53	1	22301	59
14	Wet	31	1	7976	399
18	Dry	50	4	1080	94
18	Damp	76	4	16026	179
18	Wet	30	79	281001	1662
19	Dry	28	1	329	26
19	Damp	46	1	31401	69
19	Wet	17	1	12701	427
	TOTAL	377	1	281001	122

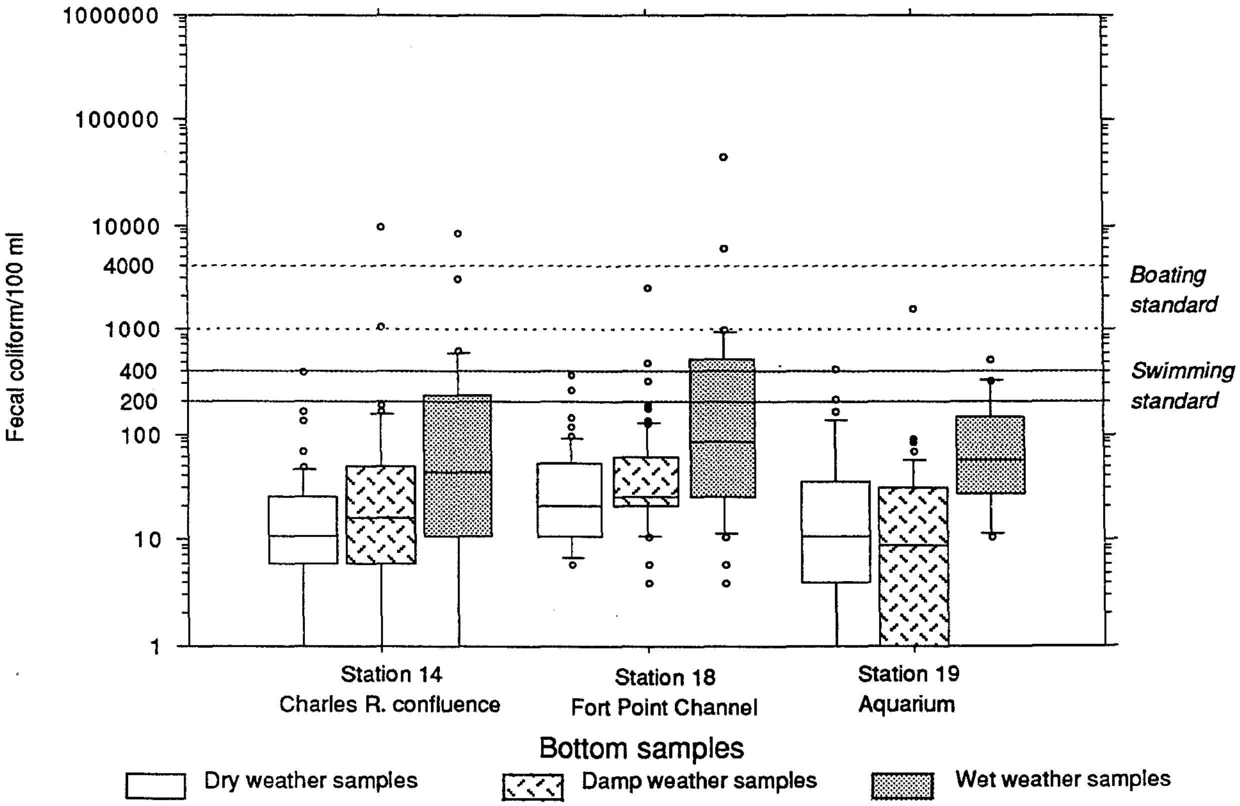
* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 10-5. FECAL COLIFORM MONITORING DATA FOR UPPER INNER HARBOR AND FORT POINT CHANNEL - SURFACE SAMPLES (1989-93)



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
14	Dry	47	1	409	12
14	Damp	52	1	10001	19
14	Wet	31	1	8801	42
18	Dry	48	1	381	22
18	Damp	72	4	2601	35
18	Wet	27	4	45251	123
19	Dry	28	1	441	11
19	Damp	44	1	1626	8
19	Wet	16	1	526	56
	TOTAL	365	1	45251	23

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 10-6. FECAL COLIFORM MONITORING DATA FOR UPPER INNER HARBOR AND FORT POINT CHANNEL - BOTTOM SAMPLES (1989-93)

10.6.2 Dissolved oxygen

The dissolved oxygen (DO) levels in Fort Point Channel are among the lowest in the Inner Harbor (Rex 1993). In the first four years of MWRA CSO receiving water monitoring, 1989-92, the minimum surface DO concentration was 1.9 mg/l and the minimum bottom DO concentration was 2.5 mg/l; the surface mean and bottom mean concentrations were both 5.8 mg/l. Dissolved oxygen data (Station 18) for the first five years of MWRA CSO receiving water monitoring are shown in Figure 10-7.

10.6.3 Aesthetics - solids and floatables; odor; color and turbidity

Large amounts of floatables and scum derived from stormwater and CSO discharges are commonly observed near the head of Fort Point Channel in the days following rain (K. Keay, pers. comm. 1993).

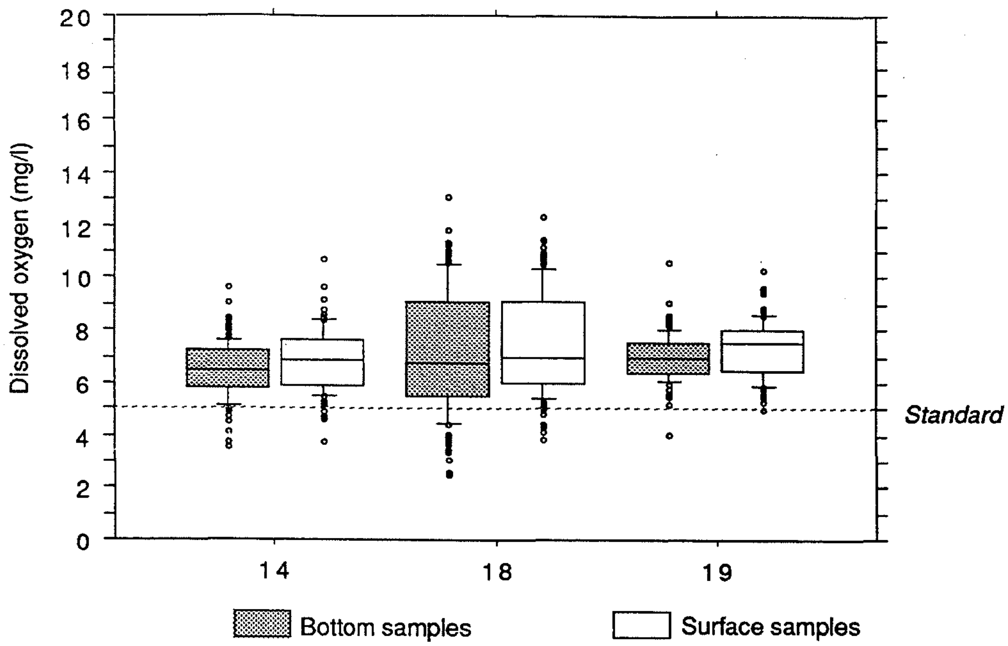
In addition, on several occasions during dry weather a bright green plume of uncertain origin has been observed in Fort Point Channel near the Broadway Street Bridge (L. Wong, pers. comm. 1993). One potential source of this green liquid is an outfall near the Broadway Street Bridge. This outfall has been observed to discharge on many occasions with each episode lasting less than one minute.

10.6.4 Oil and Grease

The data on oil and grease is limited; sampling by CH2M Hill in 1988 revealed oil and grease concentrations in Fort Point Channel (CH2M Hill 1989) ranging between 5 and 22 mg/l, with a mean concentration of 6 mg/l. Oil and grease slicks have been observed many times off the Summer Street Bridge by South Station.

10.6.5 Bottom pollutants or alterations

Very high concentrations of inorganic (Stolzenbach *et al.*, 1992) and organic (McGroddy, 1993) contaminants have been measured in Fort Point Channel sediments. Benthic communities in and near Fort Point Channel are extremely degraded, even in comparison to the generally degraded communities found in the Inner Harbor. Much of the channel is at least seasonally azoic, and radioisotope profiles indicate that bioturbation is negligible on both short and long time scales (Wong, 1992; E. Gallagher, UMass/Boston, unpublished data). Even at the mouth of Fort Point Channel, communities are degraded, with only a very few organisms restricted to the top few millimeters of sediment (Leo *et al.* 1993).



Station	Sample Type	No. of Samples	Concentration (mg/l)			
			Mean	Medium	Minimum*	Maximum*
14	Bottom	128	6.4	6.5	3.6	9.7
14	Surface	129	6.8	6.9	3.8	10.7
18	Bottom	139	7.2	6.8	2.5	13.1
18	Surface	152	7.5	7.0	3.9	12.4
19	Bottom	85	7.0	7.0	4.1	10.6
19	Surface	86	7.3	7.5	5.0	10.3
	TOTAL	719	7.1	6.9	2.5	13.1

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 10-7. DISSOLVED OXYGEN CONCENTRATIONS IN UPPER INNER HARBOR AND FORT POINT CHANNEL (1989-93)

10.6.6 Nutrients

ENSR (1993) measured nutrient and chlorophyll concentrations at two sites in the Fort Point Channel on a single date in 1993. The most recent year in which the area was monitored regularly was 1991 (New England Aquarium, unpublished data). The range of nutrient concentrations measured in 1991 and 1993 are presented in Table 10-1. The mean 1991 total phosphorus concentrations in this portion of the harbor correspond to the transition between Categories and "A" and "B-C" (healthy and fair, respectively) of the EPA's Use Attainability Guidelines (EPA, undated). The 1993 concentrations are considerably higher than the 1991 concentrations with the mean at the threshold concentration for "poor" classification (category "D"). The 1993 data are from a single date in March and are unlikely to be representative of the annual mean 1993 conditions. However, both the limited 1993 data and the more extensive 1991 data suggest that Fort Point Channel phosphorus concentrations are frequently bordering on, or within, the "Fair" to "Poor" categories. Dissolved inorganic nitrogen and total phosphorus data for Fort Point Channel are available since 1987 (New England Aquarium, unpublished data). There is no obvious trend in annual mean concentrations of either nutrient (Lavery et al., in prep.).

The 1991 mean chlorophyll *a* concentration was 2.08 μg/l. The mean concentration on the single day of sampling in 1993 was 1.5 μg/l. These concentrations place Fort Point Channel in the oligotrophic category. It should be noted that this classification (Wetzel, 1983) is based on chlorophyll only; another classification scheme that was based on nutrient concentrations could give a different result. No obvious trend is apparent in the chlorophyll data from 1987 to 1991, with annual means ranging from 5.49 to 26.73 μg/l (New England Aquarium, unpublished data; Lavery et al., in prep.).

10.6.7 Toxic Pollutants and Toxicity

Water quality in the harbor generally meets applicable water quality criteria for toxic contaminants; a possible exception is copper, which appears to exceed the EPA water quality criterion in the Inner Harbor (Wallace *et al.* 1987, Rex 1989).

10.6.8 Temperature

In the MWRA CSO receiving water monitoring program data set for 1989 to 1992, the temperature in Fort Point Channel never exceeded the class SB standard of 85°F; the maximum temperature recorded in surface water was 24.0 C (75.2°F).

TABLE 10-1. FORT POINT CHANNEL NUTRIENT MEASUREMENTS

	Dissolved Inorganic Nitrogen (mg/l)		Total Phosphorus (mg/l)		Chl a (µg/l)	
	1991	1993	1991	1993	1991	1993
minimum	0.08	0.28	0.04	0.10	0.01	0.50
maximum	0.35	0.45	0.13	0.32	7.46	1.90
mean	0.20	0.37	0.08	0.20	2.08	1.50

Sources: 1991 data from New England Aquarium (unpublished) and 1993 data from ENSR (1993).

10.7 USE ATTAINMENT

10.7.1 Existing water quality and affected uses

Figure 10-8 shows the effect of water quality on uses of Fort Point Channel. This area's designated uses are not supported. Bacteria levels exceed the swimming standard in dry weather as well as wet; the boating standard of 1000 fecal coliform/100 ml is met in dry and damp weather, but not after storms. Dissolved oxygen levels often fall below the standard near the bottom of the channel; aquatic life is affected as well by contaminated, enriched sediment, high nutrient levels, and oil and grease. Aesthetic uses are affected by oil slicks and by plumes from CSOs and other sources.

10.7.2 Baseline ("Future Planned") Water Quality and Affected Uses

Future planned conditions may be somewhat improved over existing conditions, as CSO flows to this segment are expected to decrease. Table 10-2 summarizes the status of bacterial impacts in Fort Point Channel now and under future planned conditions. In the three month storm, receiving water modeling predicts that the swimming standard of 200/100 ml will be violated for about one day at the channel mouth under future planned conditions, compared to 1½ days under present conditions. The boating standard (1000/100 ml) is predicted to be violated now for about half a day, but is predicted not to be violated under future planned conditions. Since CSOs are the major source of bacteria to this segment, the results for CSOs alone are similar to those for all sources combined; if CSOs were eliminated, the model predicts that the swimming standard would be met for the three-month and one-year design storms.

Figure 10-8. Beneficial uses affected by water quality in Fort Point Channel

Class SB

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			FCA for Lobster
Aquatic Life	▨ C	ok		ok	ok	▨ C	▨ C				▨ ?		▨ C		
Primary Contact Rec.								▨ C	▨ C		▨ C			▨ W	
Secondary Contact Rec.								▨ C						▨ W	
Aesthetics									?	▨ C	▨ C	?	▨ C	▨ W	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:	
ok	Attained for Criteria
▨	Proven or Probable Non-Attainment
W	Wet Weather Non-Attainment
C	Wet and Dry Weather Non-Attainment

Table 10-3 summarizes the level of use of this segment and the factors affecting attainment of the uses.

TABLE 10-2. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN FORT POINT CHANNEL

Resource Area	Current Conditions		3-Month Storm Event				1-Year Storm Event		
	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Mouth of Fort Point Channel									
Swimming[a]	Violates	Violates	40	29	28	0	40	37	0
Boating[b]	?	Violates	11	0	0	0	18	16	0

Note:
(a) Swimming (hours fecal coliform count > 200/100 ml)
(b) Boating (hours fecal coliform count > 1000/100 ml)

TABLE 10-3. USE ATTAINMENT FACTORS IN FORT POINT CHANNEL

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	None	3	CSO, Stormwater
Secondary Contact Recreation	Moderate	3	CSO, Stormwater
Aquatic Life	Low	2	Sediment, Stormwater, CSO
Fish Consumption	Low	2(?)	CSO, Stormwater
Aesthetics	Moderate	2	CSO, Stormwater

* Preliminary determination; may be corrected through public participation process
** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 11

LOWER INNER HARBOR

11.1 DEFINITION OF RECEIVING WATER SEGMENT

The lower part of the Inner Harbor lies between South Boston and East Boston (Logan Airport) (Figure 11-1). As the shipping channel for the Port of Boston, the lower Inner Harbor contains two shipping channels, one maintained to a minimum depth of 35 feet, the other to a minimum depth of 40 feet (Hubbard, 1987). The Third Harbor Tunnel, which will connect Interstate 90 to Logan Airport, is currently being constructed in the lower Inner Harbor. The U.S. Army Corps of Engineers and the Massachusetts Port Authority (Massport) have plans to dredge much of the 35 foot channel, the lower Mystic River, Chelsea Creek, and several berthing areas to a depth of 40 feet (Hubbard, 1987).

11.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USES

The Lower Inner Harbor is classified SB-fishable/swimmable plus restricted shellfishing. At this time, there are no identified shellfish resources within this area. The primary use of this portion of the Inner Harbor is for maritime industrial facilities, including the Boston Marine Industrial Park. The Fish Pier is also located along this section of the waterfront and serves as a landing area for offshore and local fisheries. Where there is public access to wharves and bridges along the waterfront, fishing is popular, especially during seasonal runs of migratory predators and anadromous fish. Recreational fishing from small boats is also common, although commercial ship traffic sometimes is restricted to the channel sides. Some commercial lobstering takes place in the lower Inner Harbor, especially in the early spring.

Land uses along the waterfront in South Boston support the maritime industrial and fish landing and processing uses. Much of the land is publically owned by Massport, the Boston Economic Development and Industrial Corporation, and by the City or Federal governments. One exception is the Fan Pier site, slated to be developed as the new Federal Courthouse facility. This development will include a component of public access for passive recreation. Construction of the Third Harbor Tunnel is taking place near Reserved Channel. On the East Boston side of the harbor, the land use is dominated by Logan International Airport. This land is being developed as a mix of air cargo, office and hotel facilities. In the area northwest of Logan Airport, the shore is lined with dilapidated piers, ship drydock and repair facilities. Behind the piers and repair facilities is multifamily housing in East Boston. Land use in the Boston Harbor drainage area, including lower Inner Harbor, was presented in Figure 8-2.

Snowy owls are seen at Logan Airport in some years.

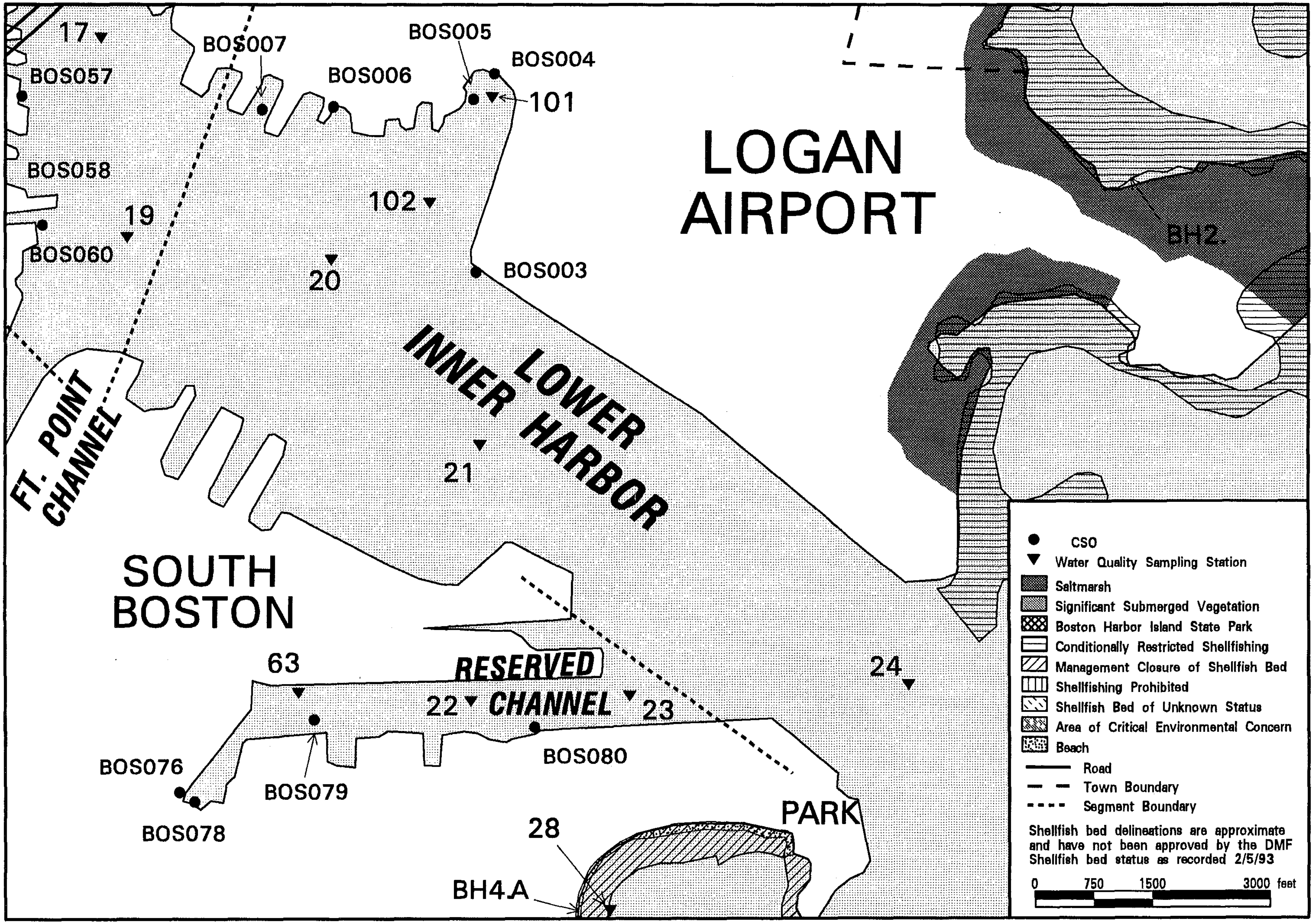


FIGURE 11-1. LOWER INNER HARBOR

11.3 CHARACTERIZATION OF WATERSHED

11.3.1 Location

This lower Inner Harbor segment receives drainage from South Boston, East Boston, and Logan Airport. There are no streams draining into the area.

11.3.2 Topography and Soils

The area is flat with no major hills. Nearly all of the coastline is fill. Most of the areas on or near the coastline are urban, paved land, although Castle Island at the mouth of the Inner Harbor includes parkland.

11.3.3 Dams, highways, and other man-made features

Logan International Airport borders the lower Inner Harbor on the northeast.

11.4 SOURCES OF POLLUTION

11.4.1 General

Combined sewer overflows and stormwater runoff are believed to be the main pollutant sources to the lower Inner Harbor receiving water segment. There are no industrial or cooling water discharges directly into the Inner Harbor. There is extensive commercial shipping and recreational boating activity on the lower Inner Harbor; commercial ships may discharge bilge, while power boats and marinas are a potential source of pollutants such as oil, grease and bacteria. There is evidence that bacteria discharged into President Roads (*i.e.* from disposal of Deer Island wastewater sludge that stopped discharging in 1991) were transported into the lower Inner Harbor in the bottom water (Rex, 1993, Keay *et al.*, 1993).

Estimated flows and loads of CSOs (future planned) and stormwater are shown in Figures 11-2 and 11-3. CSO flows and loads to this segment for the three-month storm are expected to decrease 38% between existing and "future planned" conditions.

11.4.2 Stormwater discharges

Stormwater runoff into this area of the harbor includes runoff from Logan Airport. Compared to non-airport stormwater, airport runoff during the spring, summer and autumn seasons is

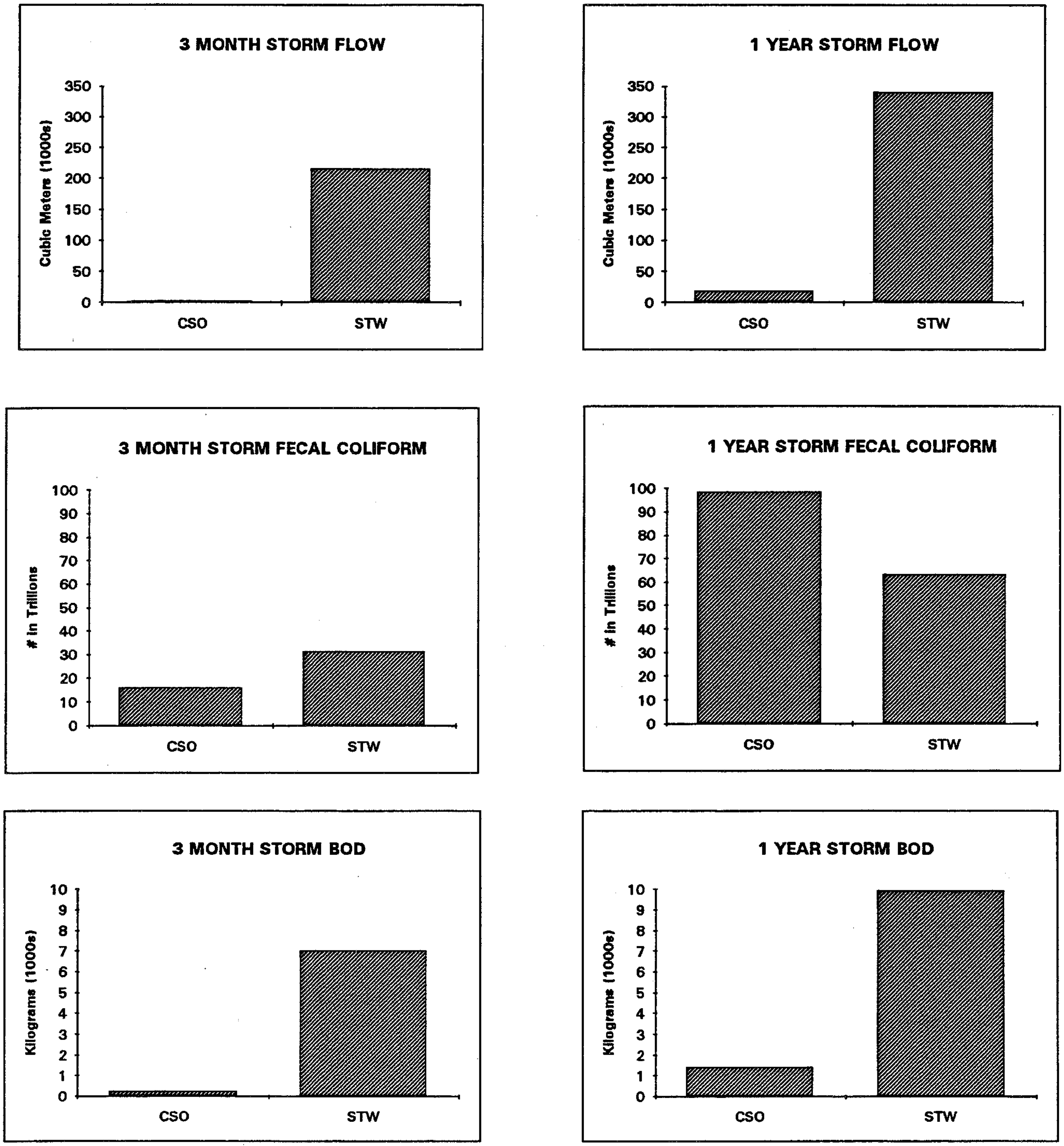


FIGURE 11-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - LOWER INNER HARBOR

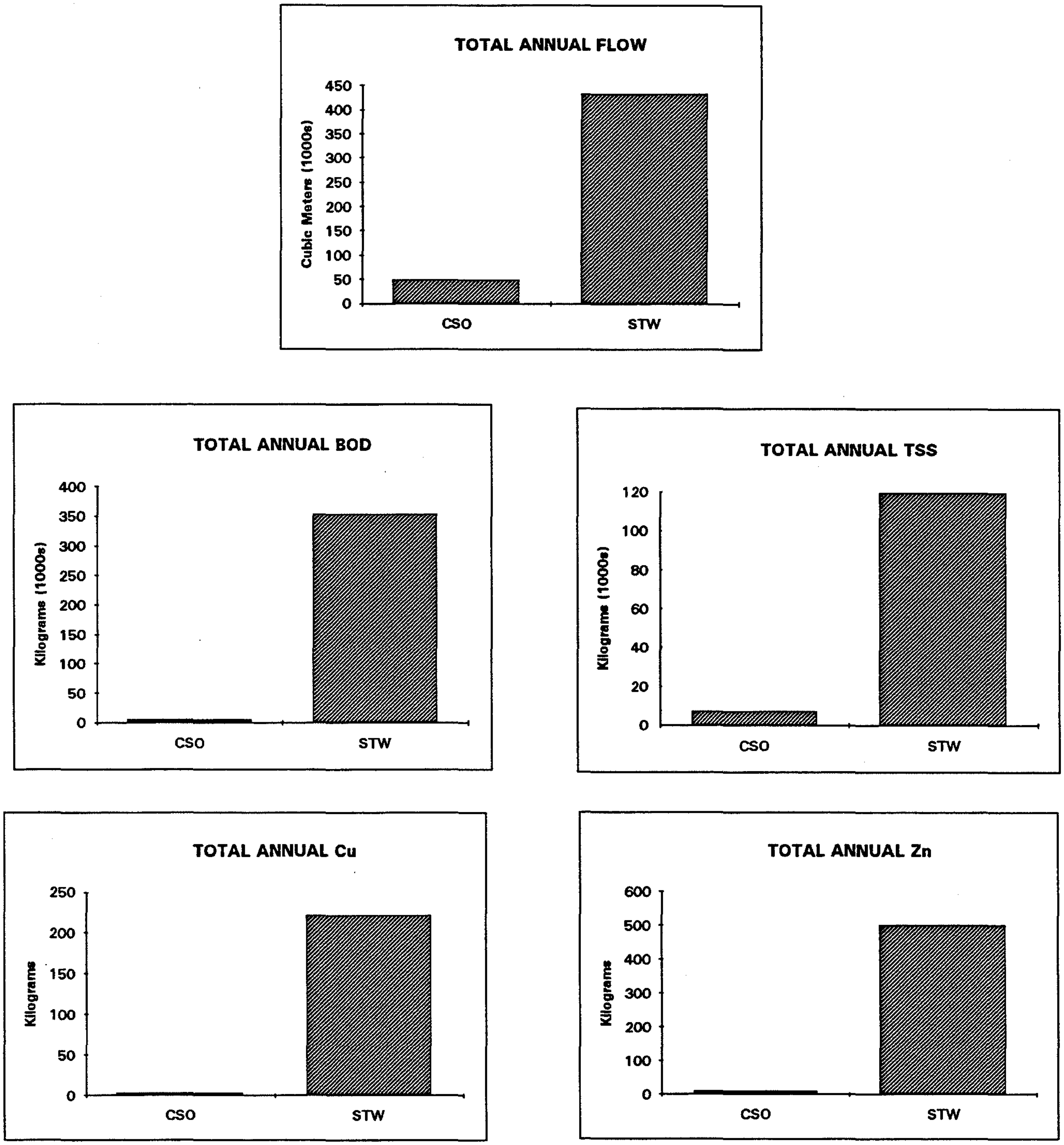


FIGURE 11-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - LOWER INNER HABOR
(a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

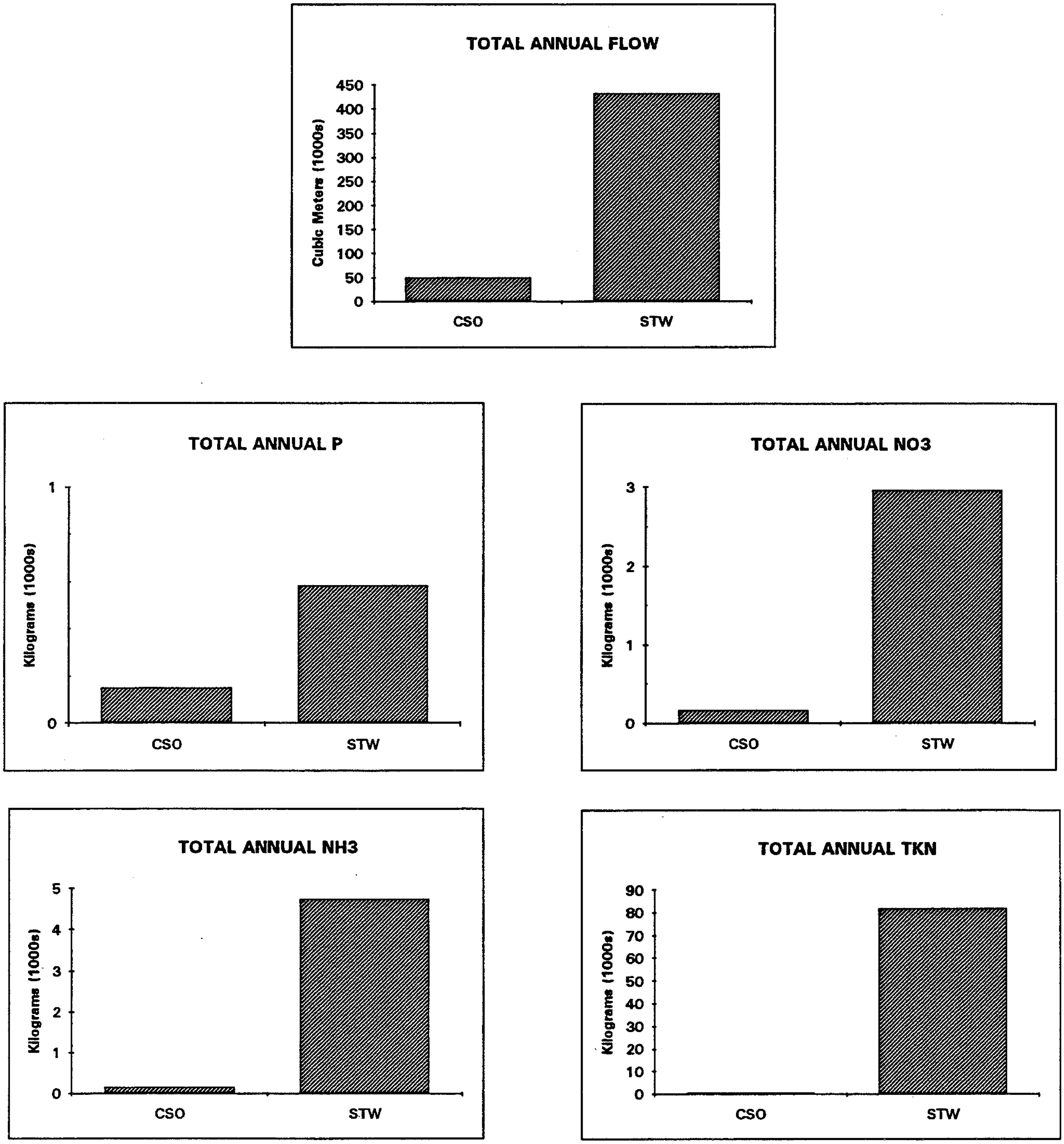


FIGURE 11-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS-LOWER INNER HARBOR
(b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

similar in concentrations in terms of metals, somewhat lower in concentration for nutrients, and higher in concentration for BOD. In the loading estimates, we have included the portion of the additional wintertime BOD load due to airport deicing that would enter the lower Inner Harbor (Alber & Chan, 1994; Metcalf & Eddy, 1994b).

BWSC dry weather screening of two small separate storm drains in South Boston showed no evidence of contamination with sewage (BWSC, 1993).

11.4.3 CSO Discharges

None of the CSOs discharging into the lower Inner Harbor are treated. In 1992 monitoring, two CSOs overflowed after about 0.15" of rain, and two others overflowed with about 0.4" of rain (MWRA, 1993a). No leaky tide gates, sedimentation, debris accumulation, or other problems were reported as a result of CSO inspections (MWRA, 1993a).

11.5 HYDRODYNAMICS

11.5.1 Nearfield Mixing

The lower Inner Harbor receiving water segment is tidal with a range of approximately ten feet; it is weakly stratified. Most of the CSOs in the lower Inner Harbor have intertidal discharges so the wastewater enters at the water's surface and mixes more slowly than a subsurface discharge. However, the intermediate field dilution characteristics are good. Estimates made for a typical CSO event (discharge from BOS003 during the storm of August 17-18, 1992) suggest that dilutions of about 4, 8, and 20 are obtained at distances of 30, 100, and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994). The maximum tidal current in the lower Inner Harbor is about 0.5 m/s (Eldridge, 1992) so the plumes would tend to stay close to the shore during periods of flood and ebb. Because CSOs in the lower Inner Harbor are closer to the harbor mouth than is the Charles River, contaminant residence times will be lower and harbor wide dilutions will be higher than those reported in Chapter 9 for the upper Inner Harbor.

Fecal coliform counts at the mouth of the Inner Harbor are less strongly correlated with rainfall than in the middle of the Inner Harbor, (closer to CSOs), indicating that bacteria from CSOs are diluted and die off towards the mouth of the Inner Harbor (Rex, 1993).

11.5.2 Farfield Mixing and Flushing

The receiving water model (Appendix A) predicts that bacteria counts rise slightly more gradually in the lower Inner Harbor segment than in the upper Inner Harbor; the bacteria disappear at about the same rate as in Fort Point Channel, reaching background in about five days after the three-month storm.

11.6 EXISTING RECEIVING WATER QUALITY

Lower Inner Harbor water quality is summarized in Figure 11-4.

11.6.1 Bacterial Contamination

Fecal coliform bacteria levels in the lower Inner Harbor sometimes fall below the primary contact (swimming) limit of 200/100 ml, and are, in general, lower than those in the upper Inner Harbor (Rex, 1993). *Enterococcus* levels in this part of the harbor frequently do not meet the EPA criterion for swimming (Rex, 1993). At the surface, fecal coliform counts are greater during ebb tide than during flood tide. This is consistent with the operation of CSOs (Rex, 1993) which discharge as the tide lowers and the tidegates open. CSO discharge, being freshwater, are less dense than the marine receiving waters and tend to rise to the surface.

In the lower Inner Harbor, bottom bacteria counts are higher than surface water counts in samples taken through 1991 (Rex, 1993). This indicates the presence of a remote source. Sludge discharged up through the end of 1991 is one possible source; statistical analysis of the post-sludge cessation (1992 and 1993) data is needed to confirm this. Fecal coliform data from the first five years of MWRA CSO receiving water monitoring are shown in Figure 11-5.

11.6.2 Dissolved Oxygen

Daytime dissolved oxygen levels in surface and bottom water generally meet the water quality standard of 5 mg/l in wet and dry weather (Rex, 1993). Early-morning samples show very low dissolved oxygen in bottom waters (Alber *et al.*, 1993). In MWRA CSO receiving water monitoring between 1989 and 1992, the minimum daytime surface DO concentration was 3.0 mg/l and the minimum bottom DO concentration was 3.1 mg/l; the surface mean concentration was 7.5 mg/l and the bottom mean concentration was 7.3 mg/l. Dissolved oxygen data from one lower Inner Harbor station from the first five years of MWRA CSO receiving water monitoring are shown in Figure 11-6.

11.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

Floating debris from extreme high tides is found in the lower Inner Harbor receiving water segment.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	◍	●	●	bottom counts higher indicates remote sources as well as CSO	boating	◍	CSOs; SW, boats?
	Dissolved Oxygen (1,6)	◍	◍	◍	bottom DO often low especially at dawn	aquatic life fishing lobstering	◍	CSO airport
Aesthetics	Solids and Floatables (1,2)	◍	◍	◍	debris	aquatic life	?	high tides
	Color and Turbidity	?	?	?		aquatic life	?	
	Odor (2,8)	○	◍	◍	low tide			CSOs
	Oil and grease (1,2,8)	◍	◍	◍	oil slicks along edge	aquatic life	◍	ships, boats, airport, CSO
	Bottom pollutants or alterations (10,11)	N/A	N/A	●	contam. levels among highest in harbor; degraded	aquatic life	●	CSOs, airport, sludge; high organic carbon
	Nutrients (3,5,9) (algal blooms)			◍	mesotrophic	aquatic life	◍	CSOs, sludge, effluent?
	Toxic Pollutants (4)	◍	◍	◍		aquatic life fishing lobstering	◍	CSO; SW? sludge, and effluent?
	Temperature (6)	○	○	○		aquatic life	○	
	pH (N/A)							

Key:

● poor quality or high risk

◍ fair quality or moderate risk

○ good quality or low/no risk

? insufficient data

SW=stormwater

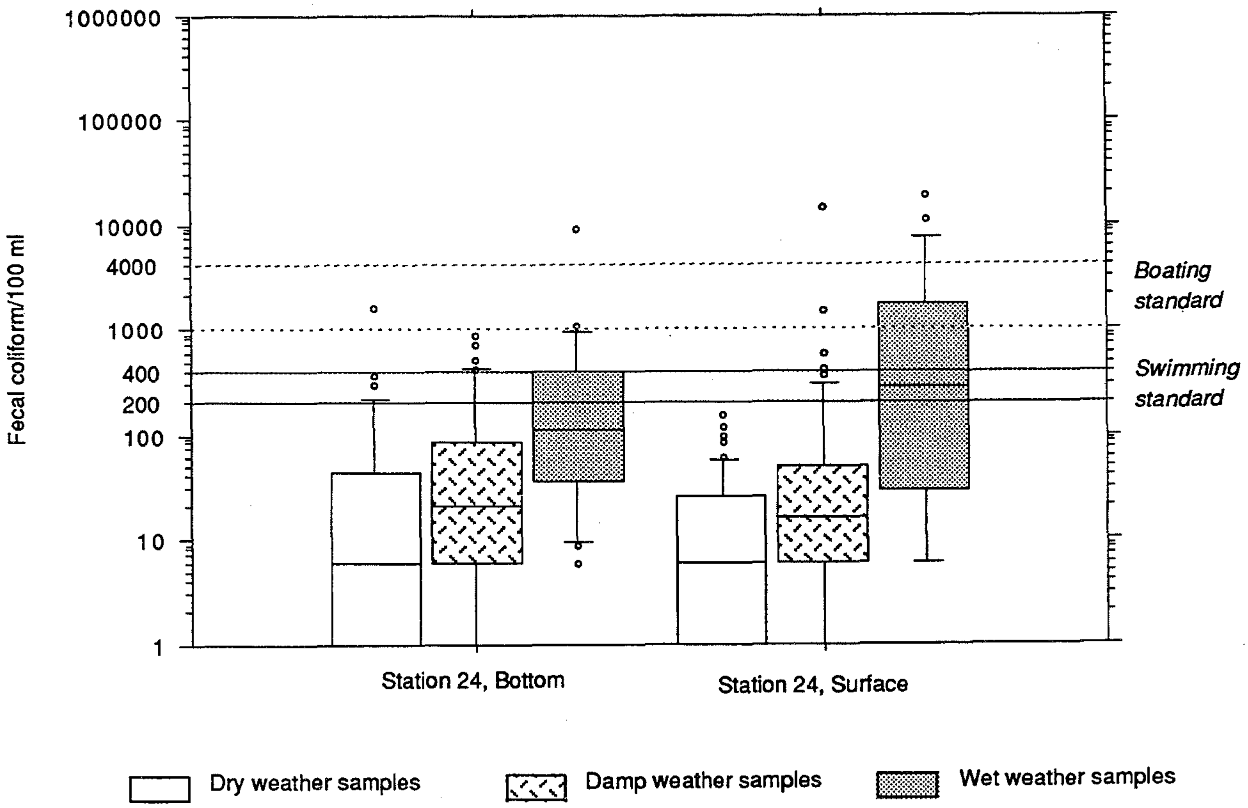
N/A= not applicable

PAH=polycyclic aromatic hydrocarbons

Sources of information on present conditions

1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993
3 - New England Aquarium unpublished data
4 - Wallace et al. 1987
5 - Robinson, et al. 1990
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989
9 - ENSR, 1993
10-Corps of Engineers 1990, 1993; Normandeau Associates, 1993
11-MacDonald, 1991

FIGURE 11-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - LOWER INNER HARBOR



Station	Sample Type	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
24	Bottom	Dry	42	1	1661	9
24	Bottom	Damp	46	1	879	22
24	Bottom	Wet	18	6	9151	116
24	Surface	Dry	47	1	156	6
24	Surface	Damp	51	1	14976	21
24	Surface	Wet	20	1	19851	190
		TOTAL	224	1	19851	19

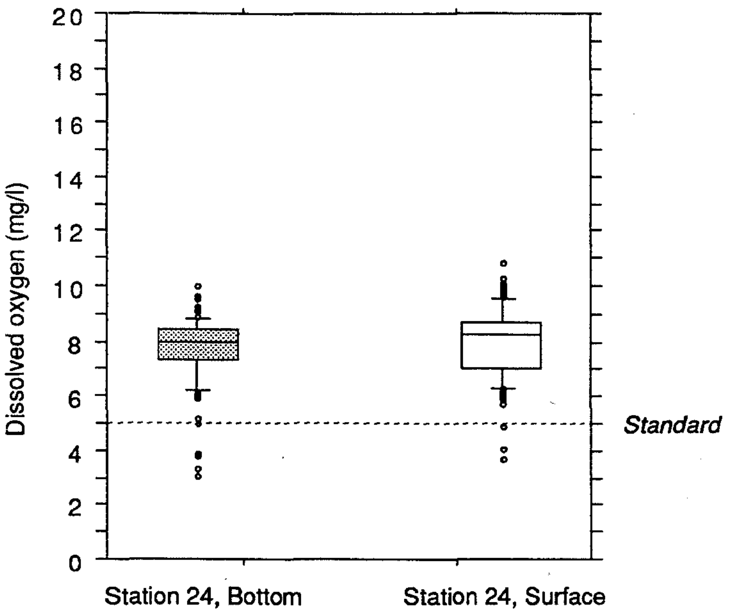
* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 11-5. FECAL COLIFORM MONITORING DATA FOR LOWER INNER HARBOR



Station	Sample Type	No. of Samples	Concentration (mg/l)			
			Mean	Median	Minimum	Maximum
24	Bottom	102	7.7	7.9	3.1	10.0
24	Surface	107	7.9	8.2	3.7	10.8
	TOTAL	209	7.8	8.0	3.1	10.8

FIGURE 11-6. DISSOLVED OXYGEN CONCENTRATIONS IN LOWER INNER HARBOR (1989-93)

11.6.4 Oil and Grease

There are oil slicks along the water's edge, especially in piers where boats are docked and at various fuel docks. Sampling in 1988 showed oil and grease concentrations of about 5 mg/l or less in the lower Inner Harbor (CH2M Hill, 1989).

11.6.5 Bottom Pollutants or Alterations

Inner Harbor sediments are the most contaminated of any area of the harbor[1] (MacDonald, 1991; Hathaway *et al.*, 1992), and are particularly high in polycyclic aromatic hydrocarbons (Shiaris and Jambard-Sweet, 1986). Inner Harbor sediment contamination measurements are summarized in Chapter 9 (Table 9-1). Data on sediment quality in berthing areas in the lower Inner Harbor include very elevated ("Level III") concentrations of lead and zinc, and elevated ("Level II") concentrations of arsenic, cadmium, chromium, copper, and mercury (Normandeau, 1993). Both total PAHs and total PCBs were measured at Level III concentrations.

In summer, the sediment is anoxic or has a very shallow (< 1 cm) oxygenated layer (SAIC 1990, 1992). Sediment toxicity testing shows that some Inner Harbor sediments are toxic to *Ampelisca*, an organism common in other parts of the harbor (U.S. Army Corps of Engineers, 1990). Because of the lack of oxygen, the high loading of organic carbon, and the high levels of chemical contaminants, the Inner Harbor floor has a low abundance and diversity of benthic organisms (Kelly and Kropp, 1992, Blake *et al.*, 1993).

It is likely that the Inner Harbor sediments are affected not only by nearby sources (such as CSOs and rivers) but also by effluent and sludge discharged at the harbor entrance (Stolzenbach *et al.*, 1993; Leo *et al.*, 1993).

11.6.6 Nutrients

Only limited monitoring information is available for the lower Inner Harbor area. ENSR (1993) measured nutrient and chlorophyll concentrations at two lower Inner Harbor sites on a single date in 1993. MWRA monitored one site in this region on seven occasions during the summer of 1993. The most recent year in which the area was monitored regularly (New England Aquarium, unpublished) was 1991; however, no dissolved inorganic nitrogen data are available from this earlier monitoring. The range of nutrient concentrations in 1991 and 1993 are presented in Table 11-1. The mean 1991 phosphorus concentrations in this portion of the harbor corresponds to the "fair" category of the EPA's Use Attainability Guidelines (EPA undated). While the mean 1993 concentrations fall into the "healthy" category, the ranges of concentrations observed in both years cover all three categories, ranging from "healthy" to "poor".

---

[1] There are very few data on riverbed contamination.

TABLE 11-1. LOWER INNER HARBOR NUTRIENT MEASUREMENTS

	Dissolved Inorganic N (mg/l)		Total P (mg/l)		Chlorophyll (μg/l)
	1991	1993	1991	1993	1993
minimum	-	0.12	0.07	0.08	0.67
maximum	-	0.41	0.23	0.16	11.26
mean	-	0.25	0.15	0.12	4.43

Sources: 1991 data from New England Aquarium (unpublished), 1993 data from MWRA (unpublished) and ENSR (1993).

Summer-autumn chlorophyll concentrations measured in the Inner Harbor in 1993 showed a peak during a bloom in late August. The mean chlorophyll concentration falls within the mesotrophic range of chlorophyll concentrations, but the August 1993 peak suggests that the area may occasionally be eutrophic.

11.6.7 Toxic Pollutants and Toxicity

Water quality in the harbor generally meets applicable water quality standards and criteria for toxic contaminants; a possible exception is copper, which may exceed the EPA water quality criterion in the Inner Harbor (Wallace *et al.*, 1987, Rex, 1989). More recent samples by UMass/Boston (Wallace, *et al.*, 1993) do not show any metals acute criteria exceedances.

11.6.8 Temperature

Temperature measurements in the lower Inner Harbor made during the 1989-1992 MWRA CSO receiving water monitoring program never exceeded the class SB standard of 85°F; the maximum temperature recorded in surface water was 23.0 C (73.4°F).

11.7 USE ATTAINMENT

11.7.1 Existing water quality and affected uses

Figure 11-7 shows how water quality affects the uses of the lower Inner Harbor segment. At the mouth of the Inner Harbor, bacterial levels meet the swimming standard in dry and "damp" weather; the boating standard of 1000 fecal coliform/100 ml is exceeded in larger storms.

Dissolved oxygen levels meet the state standard of 5 mg/l in the daytime, but low dawn measurements have been made in this segment, as in other areas of the Inner Harbor. Organic-rich, contaminated sediment affects bottom-dwelling aquatic life. Prior to 1991, when sludge was discharged at the entrance to the Outer Harbor, some effects of this discharge could be seen in the lower Inner Harbor.

11.7.2 Baseline ("Future Planned") Water Quality and Affected Uses

Between now and future planned conditions (c. 1997), water quality is expected to improve, since CSO flows to this segment will decrease substantially. Table 11-2 summarizes the status of bacterial impacts in the lower Inner Harbor now and under future planned conditions. The receiving water model predicts that for the three month storm, a violation of the swimming standard of 200/100 ml that now lasts 1½ days will continue for only 17 hours under future planned conditions. Although non-CSO sources contribute to this swimming standard exceedance, the swimming standard would not be violated after the three-month storm if CSOs were completely eliminated.

There are no active shellfish beds in the Inner Harbor; model predictions for the nearest shellfish bed -- just east of Logan Airport -- do not indicate any violations of the restricted shellfishing criterion (88 fecal coliform/100 ml) during either design storm.

Table 11-3 summarizes the level of use of this segment and the factors affecting attainment of the uses.

Figure 11-7. Beneficial uses affected by water quality in Lower Inner Harbor

Class SB

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			FCA for Lobster
Aquatic Life	C	ok		ok	ok	C	C		?		?		C		
Primary Contact Rec.								W	?	?	C	W		C	
Secondary Contact Rec.								W							
Aesthetics									?	?	C	W	C	C	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

TABLE 11-2. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN LOWER INNER HARBOR

	Current Conditions		3-Month Storm Event				1-Year Storm Event		
Resource Area	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Center of Lower Inner Harbor									
Swimming[(a)]	OK	Violates	36	17	8	0	36	35	0
Boating[(b)]	OK	?	0	0	0	0	0	0	0

Note:

(a) Swimming (hours fecal coliform count > 200/100 ml)

(b) Boating (hours fecal coliform count > 1000/100 ml)

TABLE 11-3. USE ATTAINMENT FACTORS - LOWER INNER HARBOR

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attain
Primary Contact Recreation	None	2	Stormwater, CSO
Secondary Contact Recreation	Moderate	2	Stormwater, CSO
Aquatic Life	Moderate	2	Sediment, stormwater, CSO
Fish Consumption	Moderate	(?)	(?)
Aesthetics	Low	2	Stormwater, CSO

* Preliminary determination; may be corrected through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 12
RESERVED CHANNEL

12.1 DEFINITION OF RECEIVING WATER SEGMENT

The Reserved Channel (Figure 12-1) is a narrow ship channel, about 11 meters deep and 1700 meters long, located in South Boston. Its mouth lies at the mouth of the Inner Harbor. There are four fairly large CSOs along its length.

12.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

Reserved Channel is designated as Class SB - Fishable/Swimmable plus restricted shellfishing (MassDEP, 1990). At this time, there are no shellfish resources identified within the channel. The Reserved Channel is a highly protected area offering low wave exposure and can be used as a refuge in an extreme weather event. There is deep water access and adjacent land area includes large pier and wharf areas used for container shipping. The north side of the channel is bordered by a ship terminal and warehouses. The south side has a container port at the mouth extending to Castle Island. Upstream is an oil tank farm, and a large thermal power station. There is also some commercial activity and several small marinas. A low bridge crosses the channel near the upstream end. The Reserved Channel is a designated port area. Residential uses in South Boston abut these maritime uses. This area has been used for large-scale public events such as the 1992 Tall Ships celebration because of the ability to provide dockage along the sides of the Channel. Land use in the Boston Harbor drainage area, including Reserved Channel, was presented in Figure 8-2.

Red-breasted mergansers overwinter in the Reserved Channel, feeding on the striped bass which are attracted by the warmer water. Double-crested cormorants overwinter here as well.

12.3 DESCRIPTION OF WATERSHED

12.3.1 Location

This area drains much of South Boston. There are no streams draining into the area.

12.3.2 Topography and Soils

The area is flat with no major hills. Most of the areas on or near the coastline are urban, paved land. The coastline consists of fill.

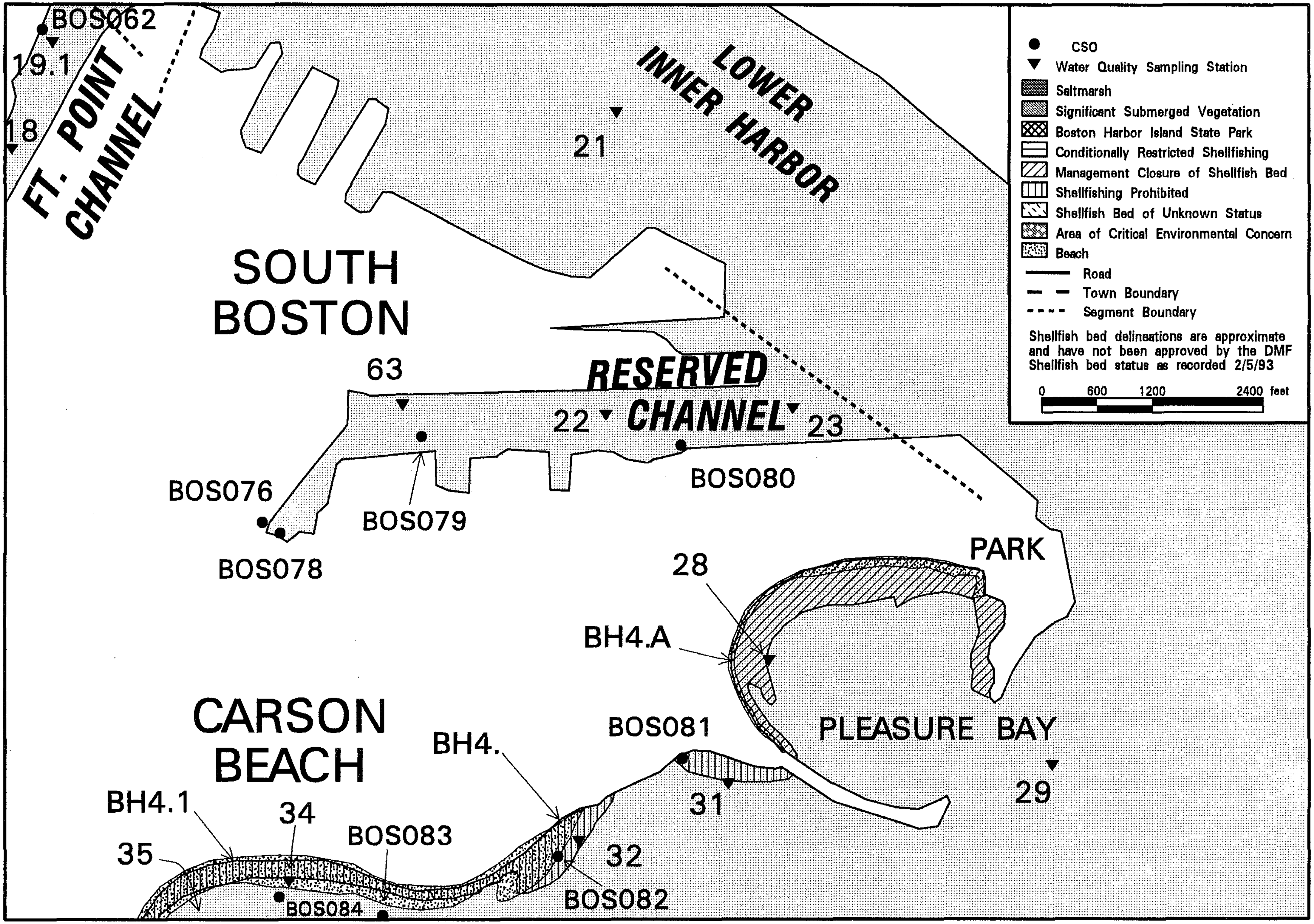


FIGURE 12-1. RESERVED CHANNEL

12.4 SOURCES OF POLLUTION

12.4.1 General

The sources of pollution to the Reserved Channel include CSOs, shipping, stormwater, and the wastewater discharge from Boston Edison's New Boston power plant. The Boston Edison discharge of 0.01 m^3/s contributes 2.5 tonnes/year of TSS, 42.5 ky/yr of copper, and 11.1 kg/yr of zinc (Alber and Chan, 1994). Boston Edison also discharges cooling water to the Reserved Channel.

Other NPDES discharges to the Reserved Channel include stormwater discharges from Seabrook Enterprises and Belcher New England (S. Halterman and K. Colhane, DEP, pers. comm., 1994). Leaking underground storage tanks at Logan Airport are another source of pollutants (Menzie *et al.*, 1991).

Estimated flows and loads of CSOs (future planned) and stormwater are shown in Figures 12-2 and 12-3. For the three-month storm, CSO discharges will decrease 19% between existing and future planned conditions.

12.4.2 Stormwater Discharges

The area surrounding the Reserved Channel has mostly combined sewers. Of two storm drains screened by BWSC in dry weather (BWSC 1991, 1993), one showed evidence of possible sewage input. Two other storm drains were not examined. This area is highly urbanized with commercial activities and heavy industrial use. There are storm drains from both land and highway activities into receiving waters. However, given the limited stormwater data available, a relationship between land use and stormwater quality in the CSO study area has not been found (Metcalf & Eddy, 1994b).

12.4.3 CSO Discharges

None of the four CSOs discharging into the Reserved Channel are treated. In 1992 monitoring (MWRA, 1993), one CSO discharged after about 0.12 inches of rain, another CSO discharged with about 0.16 inches of rain, and the last two discharged with about 0.3 inches of rain. In 1992 inspections, some sedimentation was found in BOS080, which has since been cleaned by BWSC. No tide gate or other problems were reported for Reserved Channel CSOs.

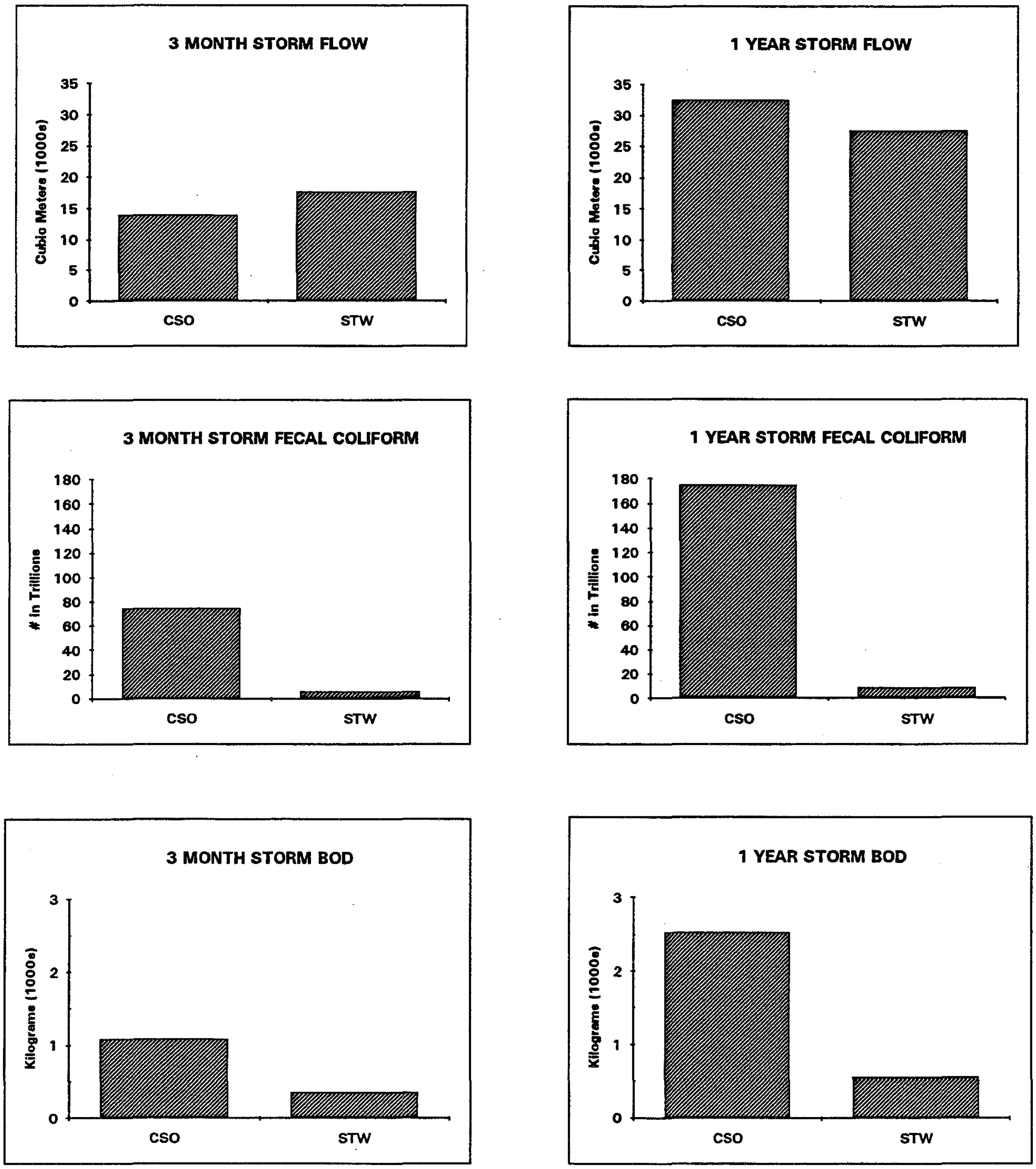
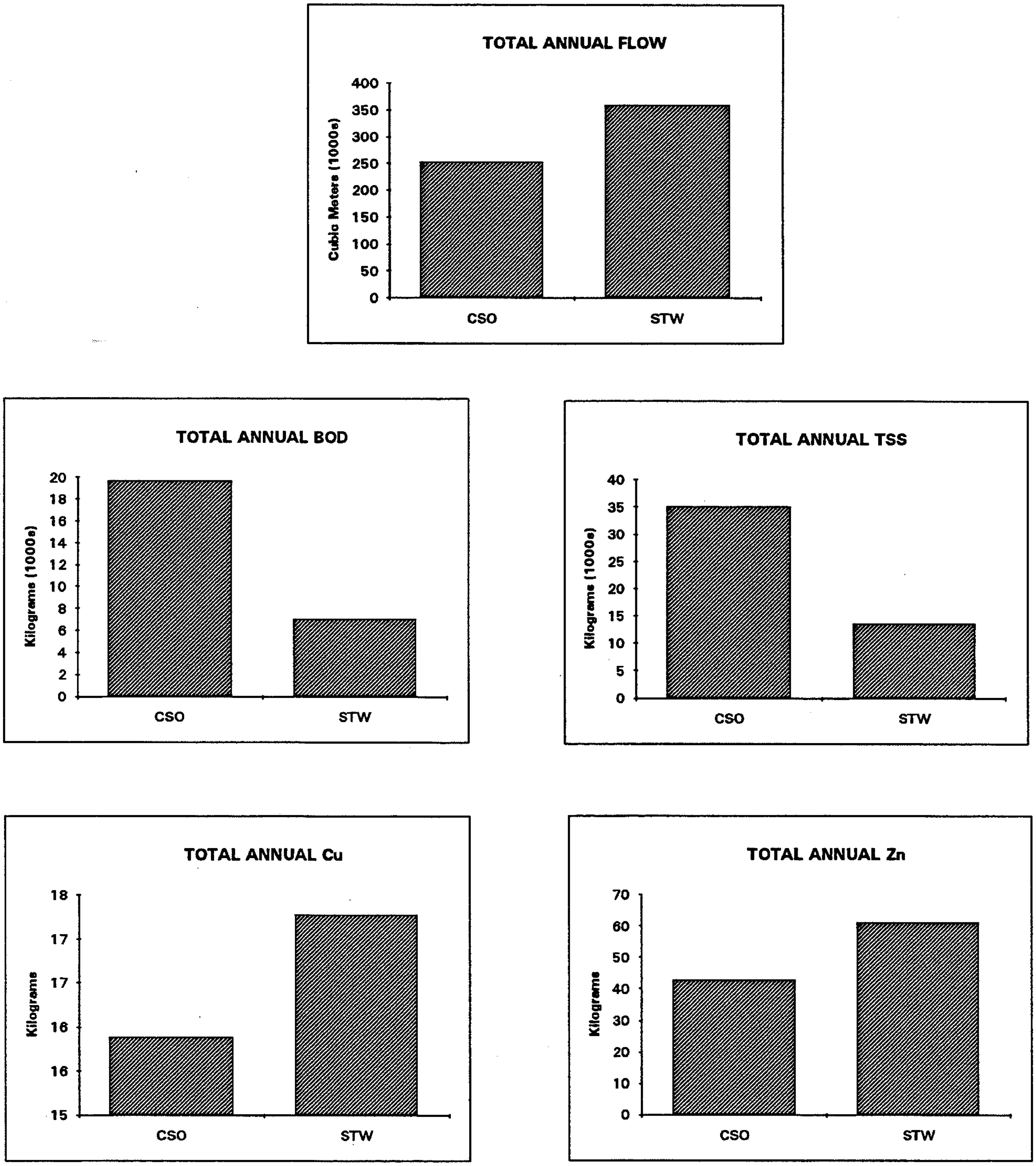


FIGURE 12-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - RESERVED CHANNEL



TOTAL ANNUAL FLOW

TOTAL ANNUAL BOD

TOTAL ANNUAL TSS

TOTAL ANNUAL Cu

TOTAL ANNUAL Zn

FIGURE 12-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - RESERVED CHANNEL
(a) FLOWS, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

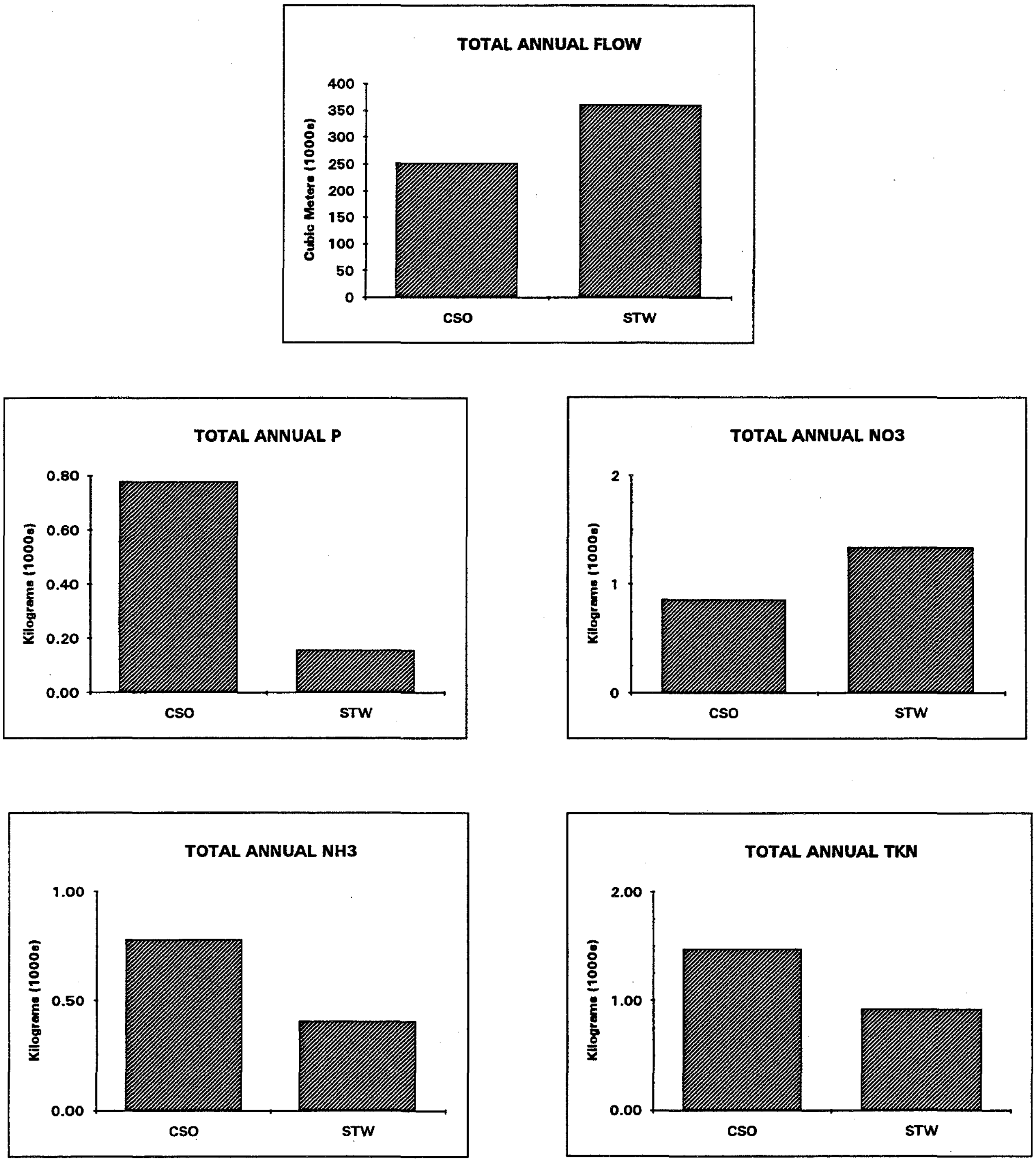


FIGURE 12-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - RESERVED CHANNEL (b) FLOWS, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

12.5 HYDRODYNAMICS

12.5.1 Hydrography and Nearfield Mixing

The Reserved Channel is tidal with a range of approximately ten feet. In summer monitoring data, the channel was stratified in temperature; the temperature difference was sometimes several degrees. (unpublished MWRA Harbor Studies monitoring data.)

Salinity measurements in the Reserved Channel suggest good initial mixing downstream from the channel's CSOs. Subsequent mixing is governed by tidal flushing of the channel which would be similar to that in Fort Point Channel. Residence times for Reserved Channel would be somewhat longer than those in Fort Point Channel, because of greater water depth and less freshwater inflow.

12.5.2 Farfield Mixing and Flushing

Receiving water model results (see Appendix A) indicate that bacteria disappear from the channel at a faster rate than other parts of the Inner Harbor, returning to background levels in about 4.5 days after the three-month storm.

12.6 EXISTING RECEIVING WATER QUALITY

Reserved Channel water quality is summarized in Figure 12-4.

12.6.1 Bacterial Contamination

MWRA CSO receiving water monitoring data for 1989 through 1993 show that the Reserved Channel met the state standard for fecal coliform in surface and bottom samples during dry weather. The SB standard for fecal coliform were not met during wet weather; note that there are relatively few wet weather data for this segment. These fecal coliform data, from the first five years of MWRA CSO receiving water monitoring, are shown in Figures 12-5 and 12-6.

12.6.2 Dissolved Oxygen

During MWRA CSO receiving water monitoring conducted between 1989 and 1992, the minimum surface dissolved oxygen concentration was 4.8 mg/l and the minimum bottom concentration was 3.4 mg/l. The surface mean DO concentration was 6.9 mg/l and the bottom mean concentration was 7.0 mg/l. Dissolved oxygen data from the first five years of MWRA CSO receiving water monitoring are shown in Figure 12-7.

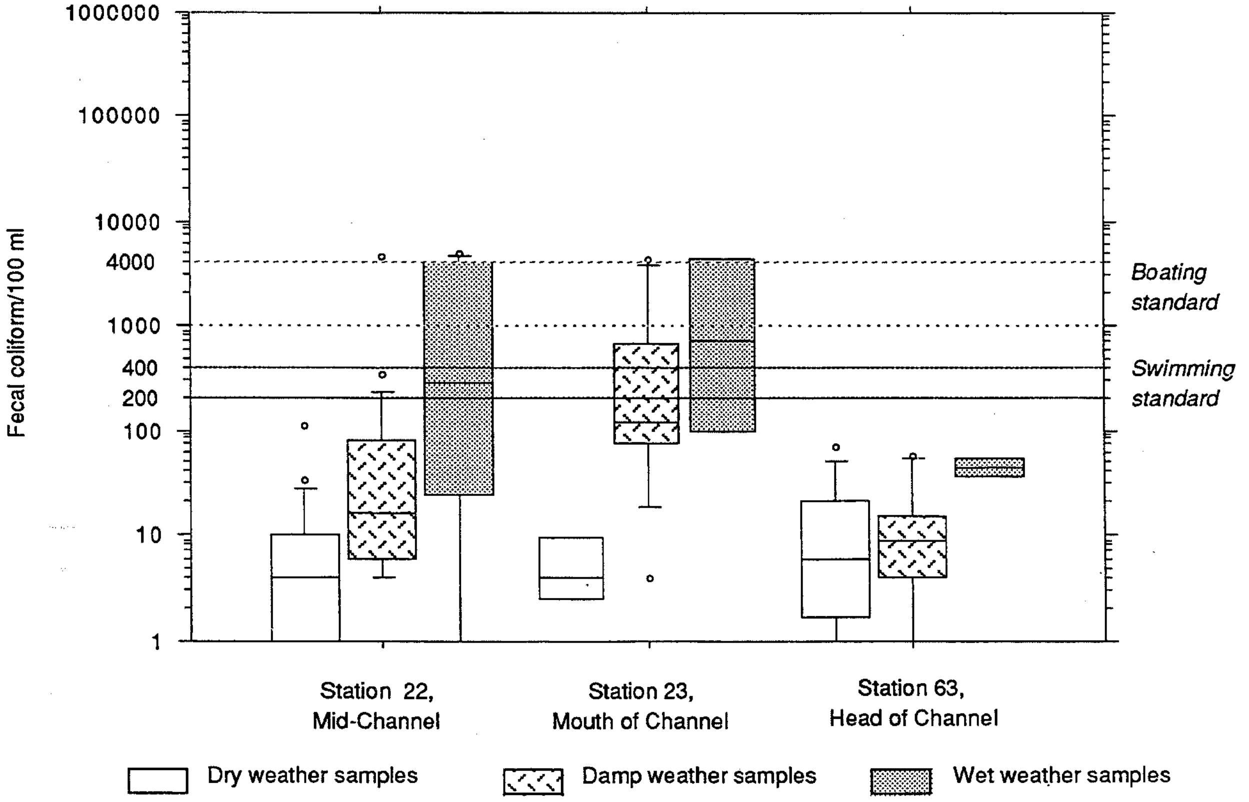
		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	○	◍	○	due to chlorinated power plant discharge?	boating?	○	
	Dissolved Oxygen (1,6)	○	○	○	strong T stratification but no mid-day bottom DO problem	aquatic life	○	
Aesthetics	Solids and Floatables (2)	○	?	?				CSOs; SW?
	Color and Turbidity (2)	○	?	?				
	Odor (2)	○	?	?				
	Oil and grease (2)	○	?	?		aquatic life	?	shipping, CSO, SW?
	Bottom pollutants or alterations (3,8,10)	N/A	N/A	●	contam. levels among highest; high PCB, PAH, extremely degraded, seasonally azoic	aquatic life	●	CSOs, shipping, sludge; high organic carbon
	Nutrients (4,9) (algal blooms)			◍	no chlorophyll data	aquatic life	◍	CSOs; sludge, effluent?
	Toxic Pollutants (5)	?	?	?		aquatic life	?	shipping, CSO, SW?
	Temperature (6)	○	○	○	strong T stratification	aquatic life	○	
	pH (N/A)							

Key:
● poor quality or high risk
◍ fair quality or moderate risk
○ good quality or low/no risk
? insufficient data

PP = Prison Point CSO facility
SW=stormwater
OC= organic carbon
N/A= not applicable
PAH=polycyclic aromatic hydrocarbons

Sources of information on present conditions
1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993
3 - MacDonald, 1991
4 - DWPC, 1986
5 - Wallace, et al. 1987
6 - Harbor Studies data
7 - MWRA, 1991
8 - Hubbard and Bellmer, 1989
9 - ENSR, 1993
10-Corps of Engineers 1990, 1993; Normandeau Associates 1993

FIGURE 12-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - RESERVED CHANNEL



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
22	Dry	19	1	116	4
22	Damp	25	1	4751	23
22	Wet	11	1	5001	177
23	Dry	4	1	16	4
23	Damp	7	4	4576	153
23	Wet	4	11	7551	382
63	Dry	11	1	74	6
63	Damp	15	1	59	9
63	Wet	2	36	54	44
	TOTAL	98	1	7551	18

* Number of Counts per 100 ml

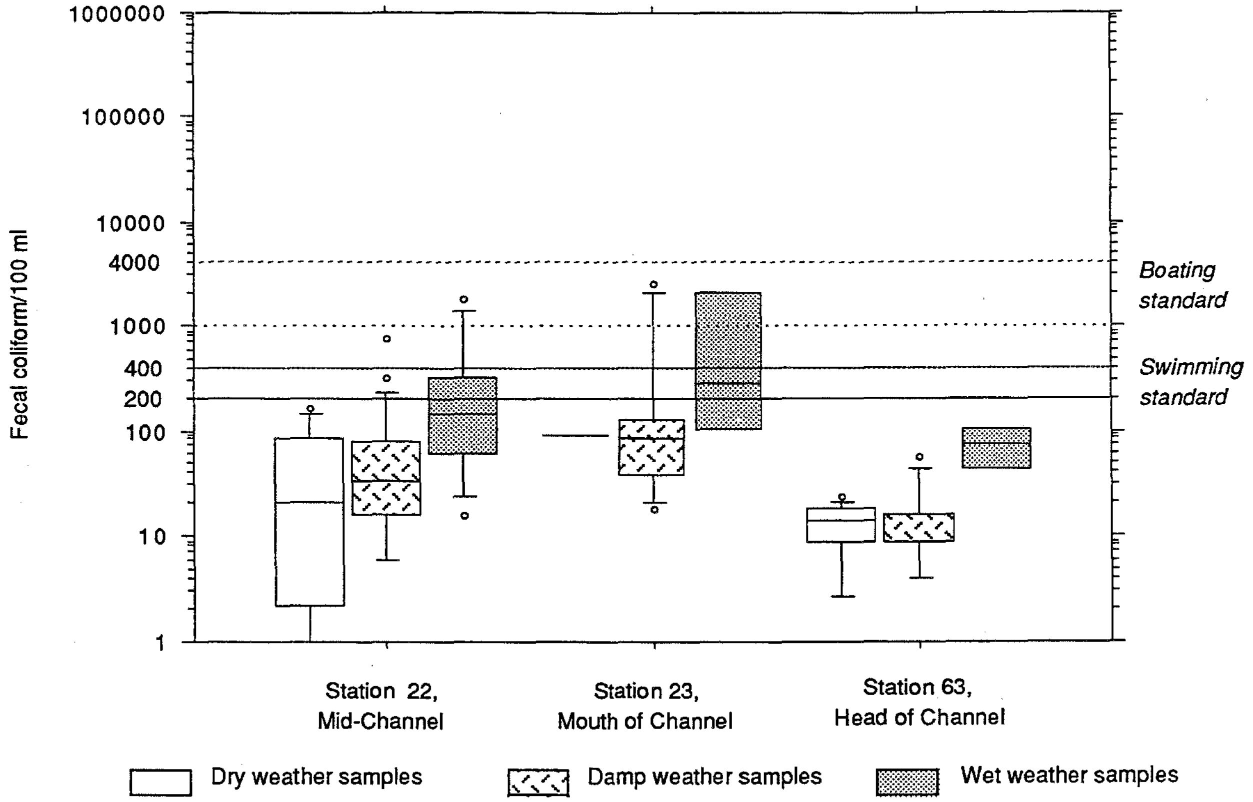
Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

Note: Not all stations were sampled in all years.

FIGURE 12-5. FECAL COLIFORM MONITORING DATA FOR RESERVED CHANNEL - SURFACE SAMPLES (1989-93)



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
22	Dry	15	1	174	15
22	Damp	21	1	776	35
22	Wet	8	16	1901	151
23	Dry	1	96	96	96
23	Damp	7	19	2701	103
23	Wet	4	69	3826	359
63	Dry	11	1	24	10
63	Damp	15	1	59	11
63	Wet	2	44	109	69
	TOTAL	84	1	3826	30

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

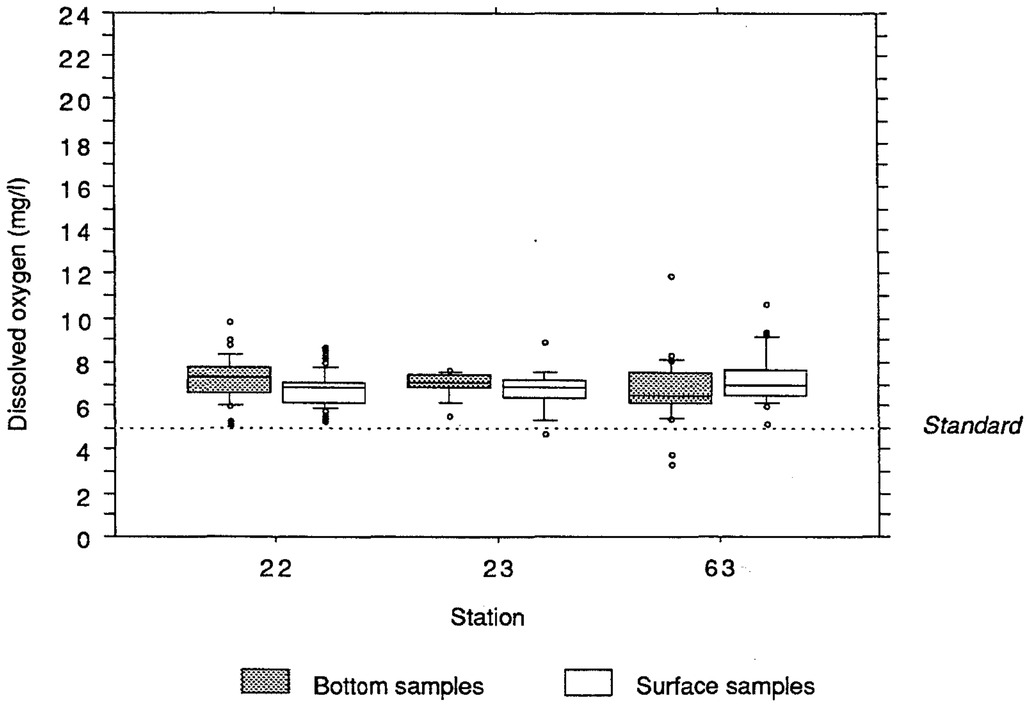
Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

Note: Not all stations were sampled in all years

FIGURE 12-6. FECAL COLIFORM MONITORING DATA FOR RESERVED CHANNEL - BOTTOM SAMPLES (1989-93)

3756jp



Station	Sample Type	No. of Samples	Concentration (mg/l)			
			Mean	Median	Minimum	Maximum
22	Bottom	43	7.2	7.3	5.1	9.9
22	Surface	53	6.8	6.8	5.3	8.7
23	Bottom	12	7.0	7.1	5.6	7.7
23	Surface	15	6.7	6.8	4.8	8.9
63	Bottom	27	6.7	6.5	3.4	12.0
63	Surface	27	7.2	7.0	5.2	10.7
	TOTAL	177	6.9	6.9	3.4	12.0

Note: Not all stations were sampled in all years

FIGURE 12-7. DISSOLVED OXYGEN CONCENTRATIONS IN RESERVED CHANNEL (1989-93)

12.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

MWRA CSO receiving water monitoring staff have not observed floatables, grease, or sewage plumes in the Reserved Channel.

12.6.4 Oil and Grease

There are no data on oil and grease available for this receiving water segment. MWRA CSO receiving water monitoring staff have not observed any slicks in the Reserved Channel.

12.6.5 Bottom Pollutants or Alterations

The U.S. Army Corps of Engineers (1993) measured sediment contamination in the Reserved Channel in 1986 and 1993. Highly elevated ("Class III") concentrations of lead were measured in some Reserved Channel samples, while arsenic, chromium, mercury, nickel and zinc reached "Class II" concentrations. Data on sediment quality in berthing areas in the Reserved Channel include very elevated ("Level III") concentrations of cadmium, chromium, lead, mercury, and nickel, and elevated ("Level II") concentrations of arsenic, copper, and zinc (Normandeau, 1993). Both total PAHs and total PCBs were at Level III concentrations.

Sediments were also tested for toxicity in the Normandeau (1993) and U.S. Army Corps of Engineers (1993) studies. Sediments in the main channel and in the berth areas of the Reserved Channel showed toxicity to amphipods significantly greater than that of the control sediments. In bioassay tests, the main channel and berth sites showed good survival of worms and clams.

The benthic biology of the Reserved Channel was most recently studied in 1986 by the U.S. Army Corps of Engineers during an environmental assessment of the impacts of Harbor improvement dredging (Hubbard and Bellmer, 1989). The bottom community in the channel was extremely degraded, with sparse assemblages of a very few species. Sediments at some locations in the Reserved Channel are at least seasonally azoic (Hubbard and Bellmer, 1989) and later testing has identified some sediment toxicity to *Ampelisca* (U.S. Army Corps of Engineers, 1990).

12.6.6 Nutrients

ENSR (1993) measured nutrient and chlorophyll concentrations at one site in the Reserved Channel on a single date in 1993. The last year in which the area was monitored regularly was 1986. The range of nutrient concentrations in 1986 and the single 1993 measurement are presented in Table 12-1. The mean 1993 total phosphorus concentrations in this portion of the harbor correspond to the "fair" category of the EPA's Use Attainability Guidelines (EPA undated), with the maximum 1986 values falling in the "poor" category The 1993 data place the area in the "good" - "fair" categories but is unlikely to reflect the annual average concentration as it is a single sample. No chlorophyll data are available for this portion of the Inner Harbor.

TABLE 12-1. RESERVED CHANNEL NUTRIENT MEASUREMENTS

	Dissolved Inorganic Nitrogen (mg/l)	Total Phosphorus (mg/l)	
	1993	1986	1993
minimum		0.13	
maximum		0.22	
mean	0.245	0.17	0.08

Sources: 1993 data from ENSR (unpublished) and 1986 data from DWPC, 1986.

12.6.7 Toxic Pollutants and Toxicity

Water quality in the harbor generally meets water quality standards for toxic contaminants; an exception is copper, which exceeds the water quality criterion in the Inner Harbor (Wallace *et al.*, 1987; Rex, 1989; DWPC, 1986).

12.6.8 Temperature

In the 1989-1992 MWRA CSO receiving water monitoring program data set, the temperature in the Reserved Channel never exceeded the class SB standard of 85°F; the maximum temperature recorded in surface water was 24.0 C (75.2°F). However, the water in the channel is frequently about 1°C warmer than that of the Inner Harbor as a whole (MWRA CSO receiving water monitoring data). The temperature may be affected by the cooling water discharge from Boston Edison.

12.7 USE ATTAINMENT

12.7.1 Existing Water Quality and Affected Uses

Figure 12-8 shows the effect of water quality on uses of the Reserved Channel. In general, the bacterial swimming standard (200 fecal coliform/100 ml) is met in dry weather; the few

Figure 12-8. Beneficial uses affected by water quality in Reserved Channel

Class SB

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			
Aquatic Life	ok	ok		?	?	?	C				?		C		
Primary Contact Rec.								W	?		?	?		?	
Secondary Contact Rec.								ok							
Aesthetics									?	?	?	?	C	?	
Shell Fishing (Rest.)															

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

available wet weather data indicate that the swimming standard is violated in wet weather while the less restrictive boating standard (1000/100 ml) is met. Aquatic life is affected by sediment contamination. There are fewer monitoring data for the Reserved Channel than for other parts of the harbor, especially in wet weather; however, the water quality appears to be surprisingly good considering the large volume of CSO and stormwater entering this segment. It is likely that the deep, straight configuration of the Reserved Channel allows relatively rapid tidal flushing.

12.7.2 Baseline ("Future Planned") Water Quality and Affected Uses

Future planned conditions will be improved somewhat over existing conditions, as CSO flows to this segment are expected to decrease. Table 12-2 summarizes bacterial impacts in Reserved Channel now and under future planned conditions. The receiving water model predicts that the swimming standard is violated for only a few hours after the three-month storm at the mouth of the Reserved Channel, under both existing and baseline conditions. After the larger one-year design storm, however, the bacteria counts are predicted to exceed the standard for one day. The results for CSOs alone are similar to those for all sources; stormwater alone is not predicted to cause the swimming standard to be violated except in the immediate vicinity of the source.

Table 12-3 summarizes the level of use of this segment and the factors affecting attainment of the uses.

TABLE 12-2. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS AT MOUTH OF RESERVED CHANNEL

Resource Area	Current Conditions		3-Month Storm Event				1-Year Storm Event		
	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Center of Lower Inner Harbor									
Swimming(a)	OK	Violates	7	5	3	0	24	21	0
Boating(b)	OK	OK	0	0	0	0	0	0	0

Note:
(a) Swimming (hours fecal coliform count > 200/100 ml)
(b) Boating (hours fecal coliform count > 1000/100 ml)

TABLE 12-3. USE ATTAINMENT FACTORS - RESERVED CHANNEL

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attain
Primary Contact Recreation	None	2	CSO, Stormwater
Secondary Contact Recreation	Low-Moderate	1	CSO, Stormwater
Aquatic Life	Moderate	2	Sediments, stormwater, CSO
Fish Consumption	Low	(?)	(?)
Aesthetics	Low	2	CSO, Stormwater

* To be determined through public participation process
**1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 13
CONSTITUTION BEACH

13.1 DEFINITION OF RECEIVING WATER SEGMENT

The Constitution Beach CSO receiving water segment lies between Logan Airport and the Orient Heights section of East Boston (Figure 13-1).

13.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The Constitution Beach area of East Boston is designated Class SB-Fishable/Swimmable plus restricted shellfishing. A large area north of the airport runways is currently designated for restricted shellfishing by commercial harvesters. Additional beds designated as Prohibited are present along the northern part of the water.

The main water use for this area is swimming at Constitution Beach, also known locally as Shea's Beach. The area surrounding the beach is multiple and single family housing and commercial activities. Logan Airport and its entrances also border the beach area. There are also some marinas and yacht clubs in the area. Land use in the Boston Harbor drainage area, including Constitution Beach, was presented in Figure 8-2. About 275 acres of Belle Isle Marsh north of Saratoga Street is part of the Rumney Marsh Area of Critical Environmental Concern.

The marshes of Winthrop and East Boston are host to migratory shorebirds in the spring, and herons and other shorebirds in late summer. Brant geese, bufflehead ducks, mallards, Canada geese, mute swans, great blue herons, black ducks, and other ducks are found there in the fall and winter. Snowy owls are seen at Logan Airport in some years.

13.3 CHARACTERIZATION OF WATERSHED

13.3.1 Location

Constitution Beach is located in East Boston in the northern part of Boston Harbor. It is a small beach on tidal flats in a bay surrounded on three sides by high density residential housing, commercial activity and Logan Airport. The bay opening is circuitous.

13.3.2 Topography and Soils

The area is flat with no major hills except Orient Heights in East Boston. Some of the coastline is fill. Most of the areas on or near the coastline are urban, paved land, or salt marsh.

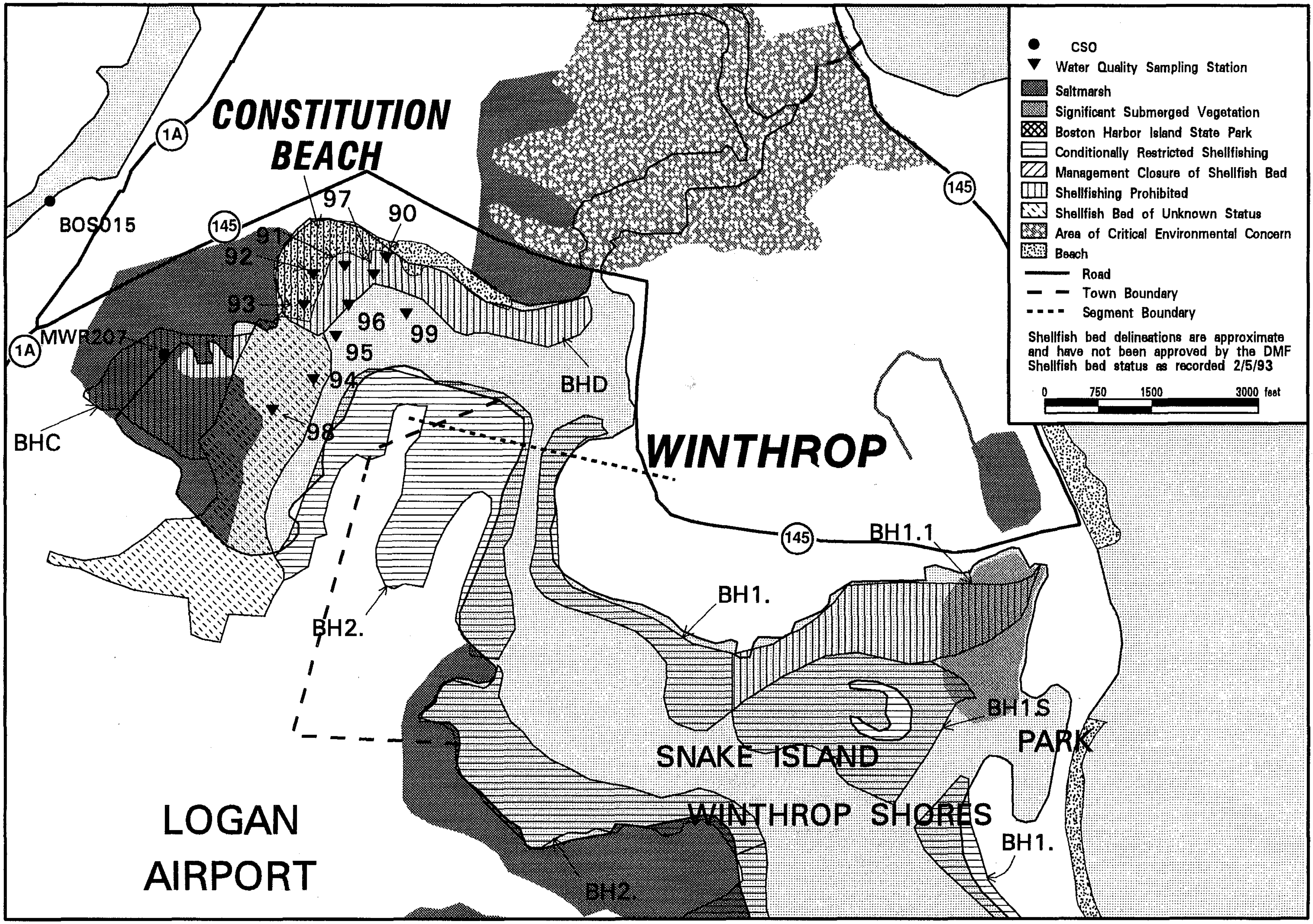


FIGURE 13-1. CONSTITUTION BEACH

13.3.3 Dams, Highways, and Other Man-Made Features

The west side of the beach is bordered by Bennington Street, a major roadway in East Boston. Between the roadway and the beach are MBTA Blue Line tracks.

13.3.4 Wetlands

There are marshes just west of Constitution Beach, as well as around the nearby Belle Isle inlet and further south at the eastern end of Logan Airport.

13.4 SOURCES OF POLLUTION

13.4.1 General

Constitution Beach is polluted by combined sewage and stormwater. Estimated flows of combined sewage (future planned) and stormwater are shown in Figures 13-2 and 13-3. There is presently a 600 m^3 (160,000 gallons) discharge during the three-month storm from the CSO treatment facility. This flow is expected to be nearly eliminated for the three-month storm in "future planned" conditions.

13.4.2 Stormwater Discharges

This area is largely separate stormwater. During stormwater monitoring, BWSC identified the largest of the storm drains as possibly contaminated with sewage (BWSC 1991, 1993). Stormwater runoff into this area of the harbor includes runoff from Logan Airport. Compared to non-airport stormwater, airport runoff during non-deicing period from spring through autumn is similar in terms of metals, somewhat lower in nutrients and TSS, and higher in BOD. During periods of deicing of airplanes and runways, all stormwater pollutant concentrations from the airport (except nitrate and nitrite) are expected to increase (Metcalf & Eddy, 1994b).

The total additional BOD load to the harbor from deicing has been estimated as about 500 to 600 tonnes/winter (Alber and Chan, 1994); however, not all of this would enter the Constitution Beach segment.

13.4.3 CSO Discharges

The only CSO in the Constitution Beach segment is treated at the Constitution Beach CSO facility. In the 1992 monitoring period, it required about 1.3 inches of rain to cause an overflow (Table 6-6 in MWRA, 1993a). CSO inspections (MWRA, 1993a) showed that this CSO tends

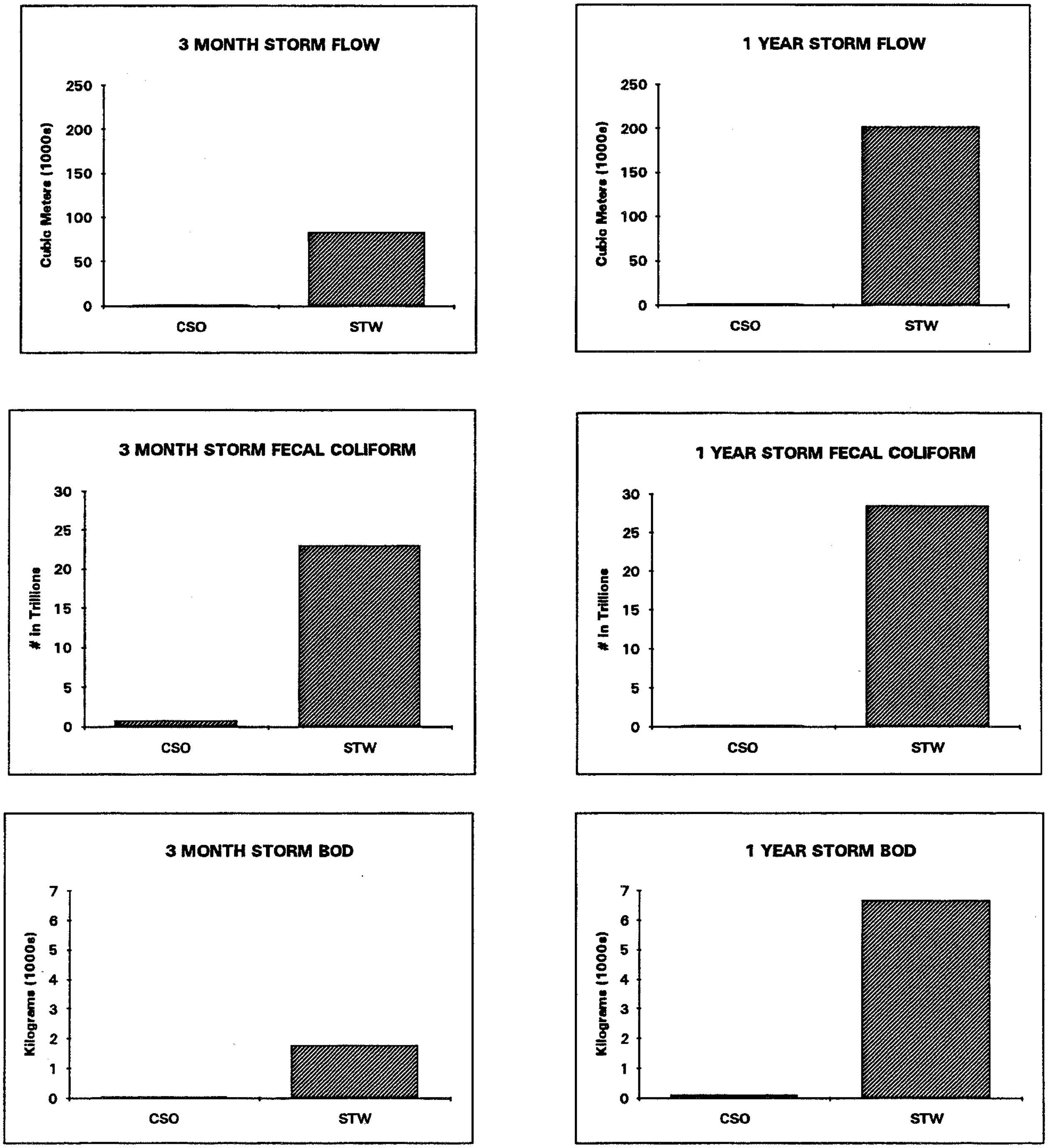


FIGURE 13-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - CONSTITUTION BEACH

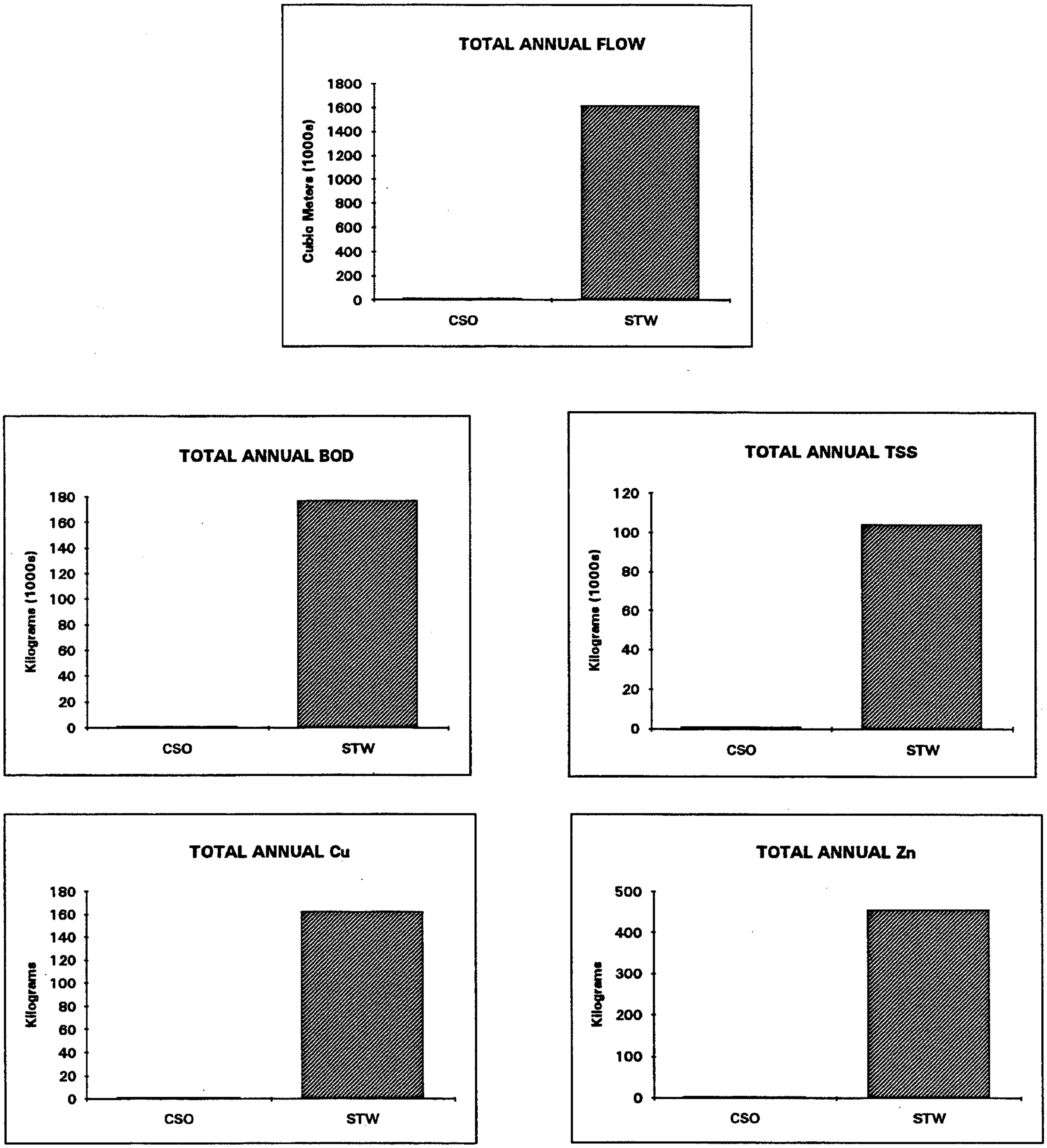


FIGURE 13-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS -CONSTITUTION BEACH (a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

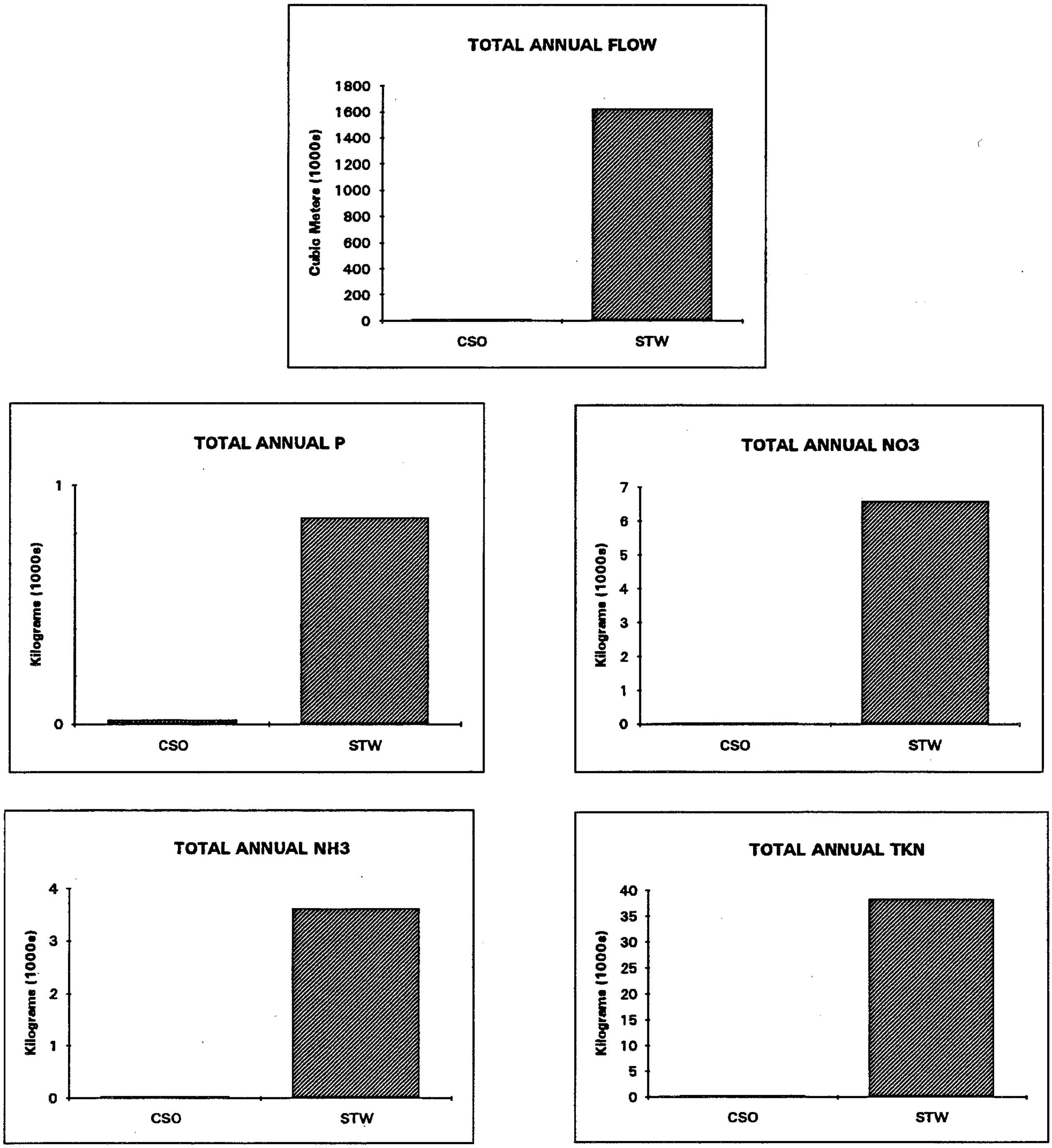


FIGURE 13-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS -CONSTITUTION BEACH (b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

to accumulate sediment and needs periodic cleaning by BWSC to avoid dry weather overflows. The Constitution Beach CSO facility screens and disinfects combined sewage prior to discharge; accurate flow information is not available (MWRA, 1993a). Improvements in pumping capacity and CSO system optimization projects are expected to reduce the discharges from this facility.

13.4.4 Illegal Connections

Several illegal connections to storm drains were identified and fixed between 1989 and 1993 by BWSC (Rex, 1993; Paul Barden, BWSC personal communication to W. Leo, 1994).

13.5 HYDRODYNAMICS

13.5.1 Nearfield Mixing

The segment is tidal with a range of approximately 3 meters. The CSO treatment facility discharges into a shallow, marshy area. Its nearfield mixing, and the rate of tidal flushing of this segment, are not known.

13.5.2 Farfield Mixing and Flushing

The receiving water model (Appendix A) predicts that bacteria counts rise somewhat more gradually in the Constitution Beach segment than in the Inner Harbor. The disappearance rate is slower, probably because of the less effective tidal flushing, but because the levels are relatively low they reach background in about 2.5 days after the three-month storm.

13.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized on Figure 13-4.

13.6.1 Bacterial Contamination

Bacteriological water quality at Constitution Beach improved after the CSO facility was commissioned in 1987 (Rex, 1993). However, there were still high bacteria counts; a 1989 study found that a large storm drain was a source of bacteria (MWRA, unpublished data). BWSC eliminated improper sewage connections to this storm drain, and water quality improved (Rex, 1993). Monitoring data are shown in Figures 13-5 and 13-6.

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,3,6)	◍	◍	◍		swimming shellfishing	◍	illegal connect. to SW; CSO (CB)
	Dissolved Oxygen (1)	○	○	○		aquatic life	○	airport
Aesthetics	Solids and Floatables (2)	○	○	○		swimming		
	Color and Turbidity (2)	○	○	○		swimming		
	Odor (2)	○	○	○		swimming		
	Oil and grease (2)	○	○	○		swimming, aquatic life		
	Bottom pollutants or alterations (7,8)	N/A	N/A	●		aquatic life	●	
	Nutrients (5) (algal blooms)			○ ?	Winth. Bay nutrients OK, meso-eutrophic	aquatic life		
	Toxic Pollutants (4)	?	?	?	Winthrop Bay metals exceed std?	aquatic life	?	
	Temperature (6)	○	○	○		aquatic life	○	
	pH (N/A)							

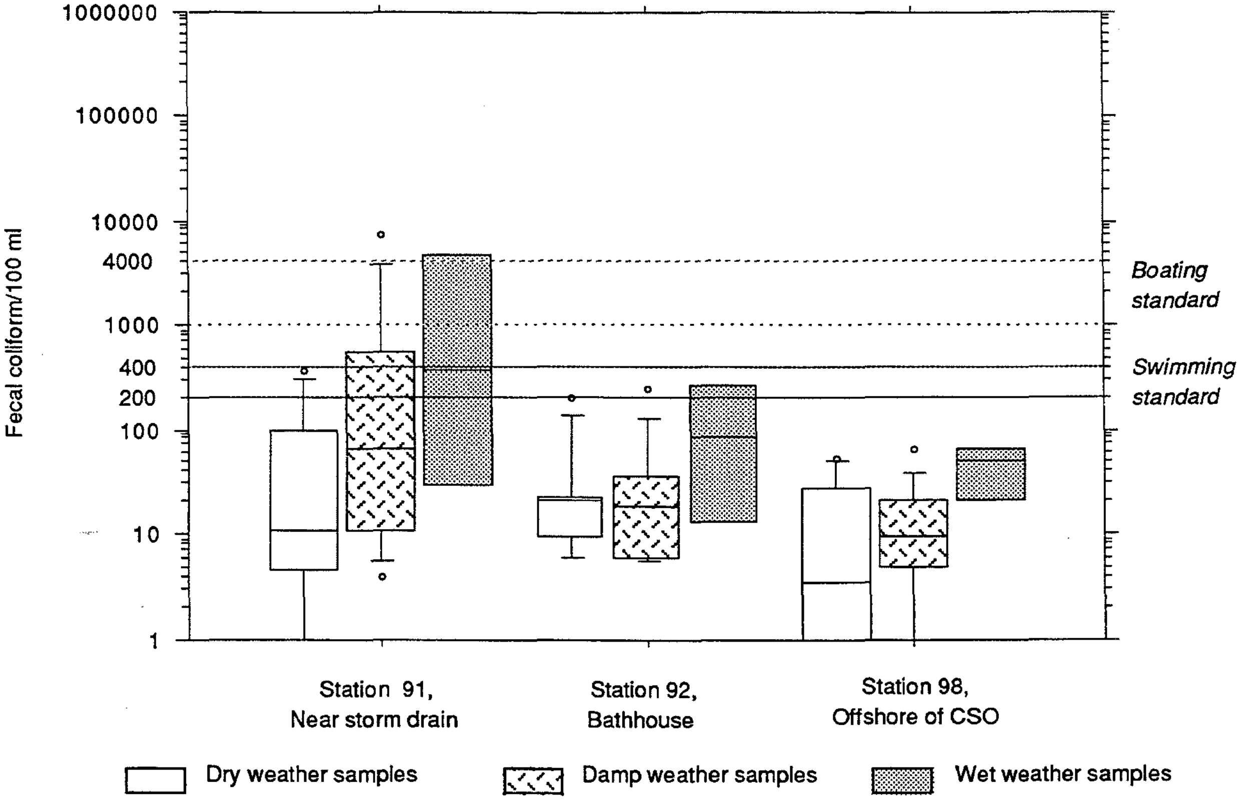
Key:

●	poor quality or high risk
◍	fair quality or moderate risk
○	good quality or low/no risk

CB = Constitution Beach CSO facility
SW=stormwater
OC= organic carbon
N/A= not applicable

Sources of information on present conditions
1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993
3 - MDC beach data
4 - DEP, 1993
5 - Robinson, et al. 1990 and unpublished Aquarium data
6 - Harbor Studies data
7 - Bergholtz and Robinson, 1983
8 - Battelle, 1983

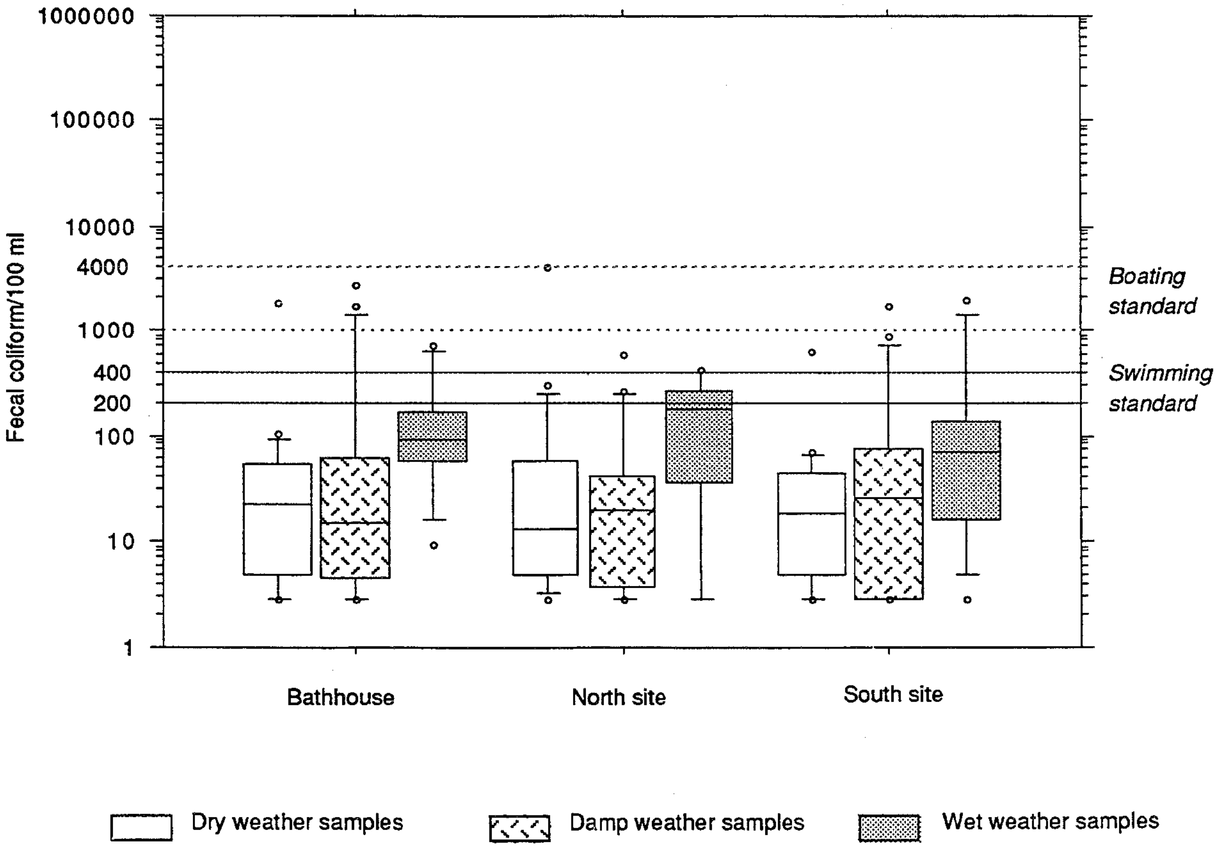
FIGURE 13-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - CONSTITUTION BEACH



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean
91	Dry	9	1	376	16
91	Damp	14	4	7701	102
91	Wet	4	26	9051	280
92	Dry	9	6	211	19
92	Damp	14	1	261	18
92	Wet	4	6	386	52
98	Dry	8	1	56	5
98	Damp	12	1	66	9
98	Wet	4	1	71	21
	TOTAL	78	1	9051	23

* Number of Counts per 100 ml

FIGURE 13-5. FECAL COLIFORM MONITORING DATA FOR CONSTITUTION BEACH (MWRA DATA) (1991)



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
Bathhouse	Dry	18	3	1940	22
Bathhouse	Damp	17	3	2780	25
Bathhouse	Wet	7	10	757	97
North	Dry	18	3	4220	23
North	Damp	17	3	610	19
North	Wet	8	3	442	72
South	Dry	18	3	660	19
South	Damp	17	3	1760	27
South	Wet	8	3	2040	58
	TOTAL	128	3	4220	28

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 13-6. FECAL COLIFORM MONITORING DATA FOR CONSTITUTION BEACH (MDC DATA) (1991 - 1993)

13.6.2 Dissolved Oxygen

Surface dissolved oxygen at Constitution Beach ranged from 4.5 to 11.5 mg/l, with a mean of 7.8 mg/l, in daytime sampling for the routine receiving water monitoring in 1991 (MWRA, 1991; Rex, 1993, unpublished MWRA Harbor Studies data). Monitoring data are shown in Figure 13-7.

13.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

MWRA CSO receiving water monitoring staff have not noted any aesthetic problems in the Constitution Beach area.

13.6.4 Oil and Grease

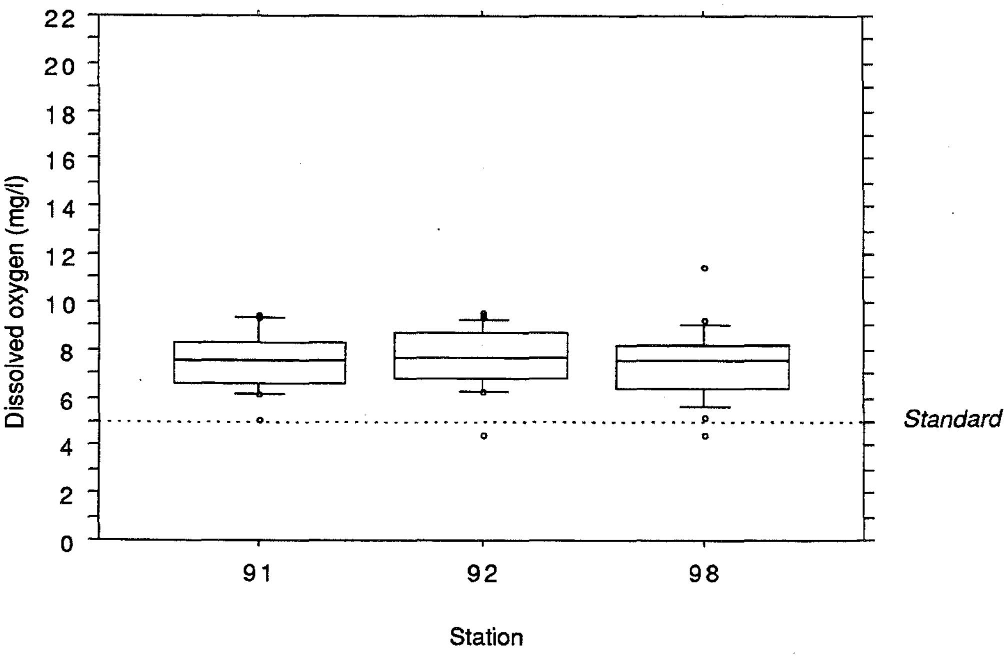
A 1987 study focused on the start-up of the new CSO facility and included oil and grease measurements (unpublished MWRA data). Most samples had concentrations of less than 20 mg/l oil and grease; the maximum concentration measured was 3.9 mg/l. Wet and dry weather samples had approximately equal concentrations of oil and grease.

13.6.5 Bottom Pollutants or Alterations

The only data on sediment conditions in the Constitution Beach area are studies of the benthic communities off of Runway 22L at Logan International Airport. These studies were carried out for Massport in September 1982 and August 1983 in support of runway extension plans since discarded. In both studies, the area sampled contained a severely degraded benthos (Bergholtz & Robinson, 1983; Battelle, 1983).

13.6.6 Nutrients

No monitoring for nutrients has been undertaken of the Constitution Beach area by the MWRA, the New England Aquarium, or MassDEP. The closest site to Constitution Beach which was regularly monitored is just west of Point Shirley in Winthrop, monitored by the New England Aquarium up to 1991. The range and mean nutrient concentrations for this site are given in Table 13-1. Total phosphorus concentration range overlaps the "healthy" and "fair" categories of the EPA's guidelines for use attainability (EPA undated). The mean concentration corresponds to "healthy."



Station	No. of Samples	Concentration (mg/l)			
		Mean	Median	Minimum	Maximum
91	26	7.6	7.5	5.1	9.5
92	26	7.6	7.6	4.5	9.6
98	24	7.4	7.5	4.5	11.5
TOTAL	76	7.5	7.5	4.5	11.5

FIGURE 13-7. DISSOLVED OXYGEN CONCENTRATIONS AT CONSTITUTION BEACH (1991)

TABLE 13-1. POINT SHIRLEY NUTRIENT AND CHLOROPHYLL MEASUREMENTS

	Dissolved Inorganic Nitrogen (mg/l) 1991	Total Phosphorus (mg/l) 1991	Chl a (μg/l) 1991
Minimum	0.03	0.05	0.01
Maximum	0.34	0.11	9.33
Mean	0.14	0.06	3.23

Source: Data from New England Aquarium (unpublished).

The 1991 chlorophyll concentration in the area ranged from 0.01 to 9.33 μg/l with an annual mean of 3.23 μg/l. According to Wetzel (1983), this mean chlorophyll concentration corresponds to mesotrophic-eutrophic. As with most sites in the harbor, however, chlorophyll alone is unlikely to be a good indicator of trophic status as light or other non-nutrient factors may limit algal production.

13.6.7 Toxic Pollutants and Toxicity

The Massachusetts 305(b) 1992 Report (MassDEP, 1993) reports that Winthrop Bay (the closest area) is not attaining Class SB status in part because of metals concentrations.

13.6.8 Temperature

Surface temperature at Constitution Beach did not exceed the SB standard of 85°F in any of the routine receiving water monitoring between 1989 and 1992 (MWRA 1991, Rex 1993, unpublished MWRA Harbor Studies data).

13.7 USE ATTAINMENT

13.7.1 Watershed Context

The area draining into the Constitution Beach receiving water segment is urban residential, commercial, and industrial, but includes salt marsh as well. Logan Airport borders the southern edge of this segment. The closest area for which use attainment was described in the 1992

Massachusetts 305(b) report is Winthrop Bay; this area is not attaining Class SB status because of metals and pathogens (Mass DEP, 1993). The construction of the Constitution Beach CSO facility and BWSC's program to eliminate illegal connections to storm drains have reduced the violations of the swimming standard. However, shellfish beds in the vicinity are restricted.

13.7.2 Existing Water Quality and Affected Uses

Figure 13-7 compares beneficial uses of Constitution Beach with applicable criteria for attainment of these uses. Bacteria levels meet the swimming standard in dry weather, but can exceed it in wet weather. The boating standard of 1000 fecal coliform/100 ml is generally met; data collected near a contaminated storm drain in 1991 indicate that if all illegal connections have not been eliminated, there may be localized areas where the boating standard is not met. The restricted shellfishing standard appears to be met in dry weather, but not in wet weather.

Studies of bottom-dwelling communities, conducted near the airport, indicate degraded conditions. The Constitution Beach CSO facility discharge is chlorinated, and may therefore have a toxic effect on aquatic life.

13.7.3 Baseline ("future planned") Water Quality and Affected Uses

Between now and future planned conditions (c. 1997), the Constitution Beach CSO facility discharge is expected to be reduced so that it may not discharge during the three-month design storm or smaller storms. This may improve water quality, especially if the chlorinated discharge impacts aquatic life. Table 13-2 summarizes bacterial impacts at Constitution Beach now and under future planned conditions.

The receiving water model does not predict any violations of the restricted shellfishing, swimming, or boating standards for either design storm. Because shellfish bed closures are based on a more conservative measurement technique, actual shellfish bed closures are likely to be somewhat more frequent and of longer duration than we have indicated. The open shellfishing standard (14 fecal coliform/100 ml) is predicted to be violated for about a day at the beach and the nearby shellfish beds, for both storms with all sources and with only non-CSO sources. CSO alone is not predicted to cause the open shellfishing standard to be violated, even when the CSO discharges during the one-year storm, because the discharge is chlorinated.

The "existing conditions" 3-month storm prediction (see Appendix A) shows lower bacteria levels than those that are frequently measured; the model predicts a kind of "average three month storm." The environmental monitoring data, meanwhile, are very variable and depend not only on the amount of rainfall but also the effectiveness of chlorination, the tides, sunlight, and other factors. It is often difficult to establish a tight relationship between storm size and environmental response. The model is used not to give a prediction valid for all storms but rather to provide a basis of comparison between CSO control alternatives. Table 13-3 summarizes the level of use of this segment and the factors affecting attainment of the uses.

Figure 13-8. Beneficial uses affected by water quality at Constitution Beach

Class SB

Water Quality Assessment

MWRA CSO/System Master Plan

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			FCA for Lobster
Aquatic Life	ok	ok		▨ ?	▨ ?	?	?		?		?		ok ?		
Primary Contact Rec.								▨ W			ok	ok		ok	
Secondary Contact Rec.								ok							
Aesthetics									ok		ok	ok	?	ok	
Shell Fishing (Rest.)								W							

WET: Whole Effluent Toxicity

Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.

BIP: Balanced Indigenous Population

FCA: Fish Consumption Advisory

(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:

ok Attained for Criteria

▨ Proven or Probable Non-Attainment

W Wet Weather Non-Attainment

C Wet and Dry Weather Non-Attainment

TABLE 13-2. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN CONSTITUTION BEACH

Resource Area	Current Conditions		3-Month Storm Event				1-Year Storm Event		
	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Constitution Beach									
Swimming(a)	OK	Violates							
Boating(b)	OK	OK							
Restricted Shellfishing(d)	OK	Violates							
Orient Heights Beach									
Swimming(a)			0	0	0	0	0	0	0
Boating(b)			0	0	0	0	0	0	0
Shellfish Bed BHD									
Unrestricted(c)			24	24	0	24	27	0	27
Restricted(d)			0	0	0	0	0	0	0
Shellfish Bed BHC									
Unrestricted(c)			25	25	0	25	27	0	27
Restricted(d)			0	0	0	0	0	0	0

Note:

(a) Swimming (hours fecal coliform count > 200/100 ml).

(b) Boating (hours fecal coliform count > 1000/100 ml).

(c) Unrestricted shellfishing (hours fecal coliform count > 14/100 ml).

(d) Restricted shellfishing (hours fecal coliform count > 88/100 ml). Bed closures and contamination of shellfish are likely to be somewhat more frequent and of longer duration than contamination of water.

TABLE 13-3. USE ATTAINMENT FACTORS - CONSTITUTION BEACH

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	High	2	Stormwater,
Secondary Contact Recreation	Moderate	1	
Aquatic Life	Moderate	2	Chlorinated CSO, Stormwater, Sediment
Fish Consumption	Low (?)	?	
Aesthetics	Medium	1(?)	Stormwater, CSO
Shellfishing	Moderate (?)	Restricted	Stormwater CSO

* Preliminary determination; may be corrected through public participation process
** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 14
NORTHERN DORCHESTER BAY

14.1 DEFINITION OF RECEIVING WATER SEGMENT

The northern Dorchester Bay CSO receiving water segment extends from the mouth of the Reserved Channel/Boston Inner Harbor to Columbia Point in Dorchester, and offshore to Spectacle and Thompson's Islands (See Figure 14-1). Part of this segment is also known as Old Harbor.

14.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The northern portion of Dorchester Bay includes the area known as Pleasure Bay, and the Carson Beach area. This area is classified as SB-Fishable/Swimmable with Restricted shellfishing in approved areas. Water-based uses within this area are primarily recreational and include powerboating and sailboating, swimming, and fishing. Although the Division of Marine Fisheries has identified a significant shellfish resource in the Carson Beach area, shellfishing in this area is currently prohibited due to the fecal coliform levels in the overlying waters. Pleasure Bay also contains shellfish beds, which are currently closed for management reasons.

Many of the land-based uses along northern Dorchester Bay support the recreational uses discussed above. The MDC controls much of the waterfront in this area although there are parcels controlled by both the City and private interests. Fort Independence at Castle Island is used for picnicking and pathways for bicycle and pedestrian access along the South Boston/Dorchester waterfront begin in this area. The MDC would like to develop a public path from Castle Island to the Blue Hills Reservation in Milton, thereby further encouraging pedestrian and bicycle passive recreation in this area. Pleasure Bay between Castle Island and City Point is a very scenic area with harbor views to the east, south, and west. There is a narrow beach bordered by Day Boulevard and parkland; facilities include a bathhouse and children's play areas. On the other side of Day Boulevard is residential South Boston, and beyond that is the Reserved Channel tank farm and container port. West of City Point lie L Street and Carson Beaches. Bordering the narrow beaches is parkland, with housing on the other side of Day Boulevard. South of Carson Beach there is an area of commercial activity bordered by the Southeast Expressway. On Columbia Point there is the Umass/Boston campus, the John F. Kennedy Library, the Massachusetts Archives, and a model mixed income housing development. Land use in the Boston Harbor drainage area, including northern Dorchester Bay, was presented in Figure 8-2.

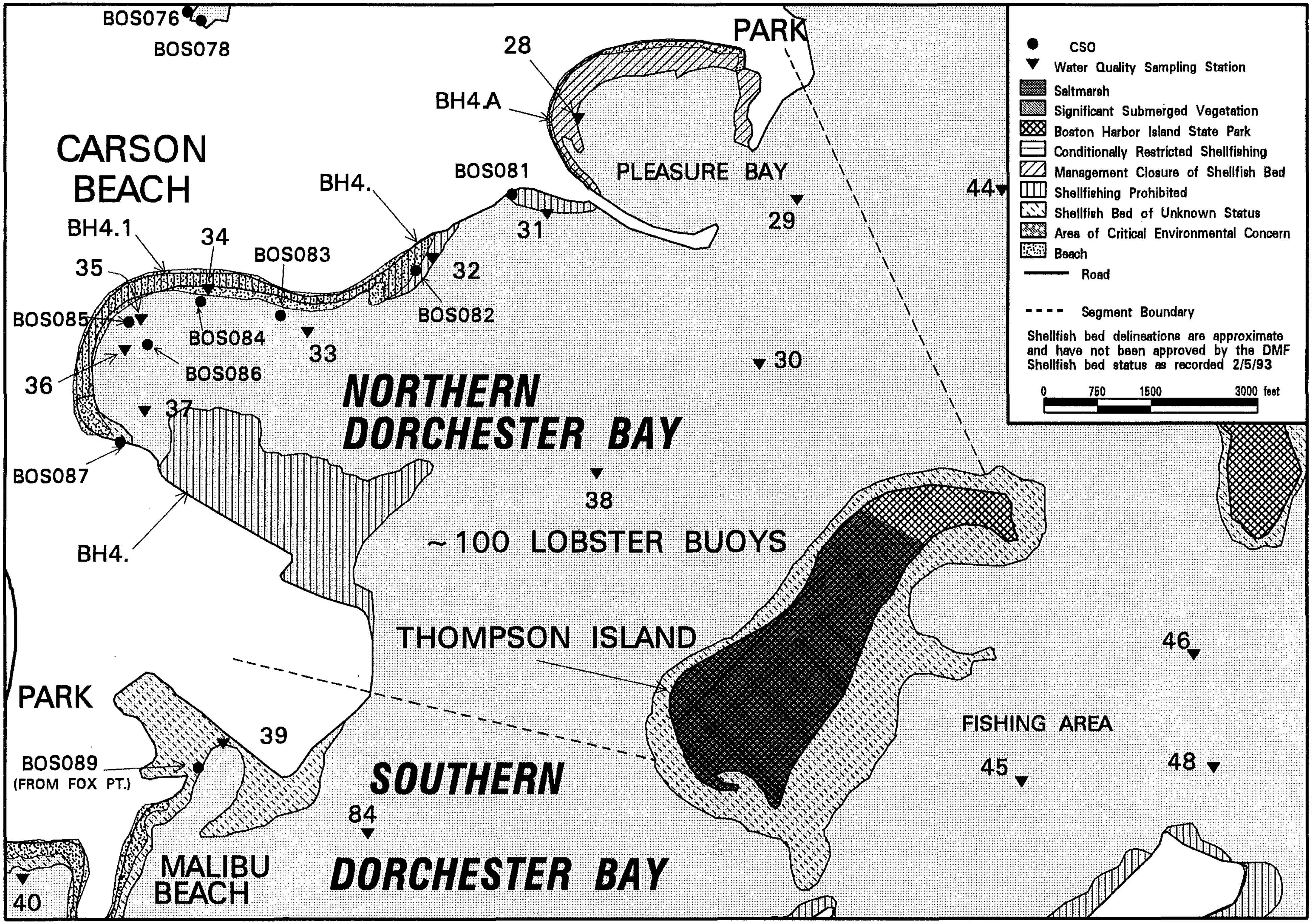


FIGURE 14-1. NORTHERN DORCHESTER BAY

14.3 DESCRIPTION OF WATERSHED

14.3.1 Location

This area drains parts of South Boston and Dorchester. There are no streams draining into the area. It extends from Castle Island in South Boston to Columbia Point in Dorchester.

14.3.2 Topography and Soil

The area is flat with no major hills except Telegraph Hill. Some of the coastline is fill.

Most of the areas on or near the coastline are urban, paved land. There is parkland with grass and trees between Carson Beach bathhouse and Columbia Point.

14.4 DEFINITION OF CAUSES OF NON-ATTAINMENT

14.4.1 General

Northern Dorchester Bay water quality is affected by CSOs and stormwater (Rex, 1993). Dissolved oxygen and sediment contamination may be affected by more remote sources (Rex, 1993, Durell *et al.*, 1991). Inner Harbor CSOs do not seem to affect Dorchester Bay (Rex, 1993, Adams and Zhang, 1991).

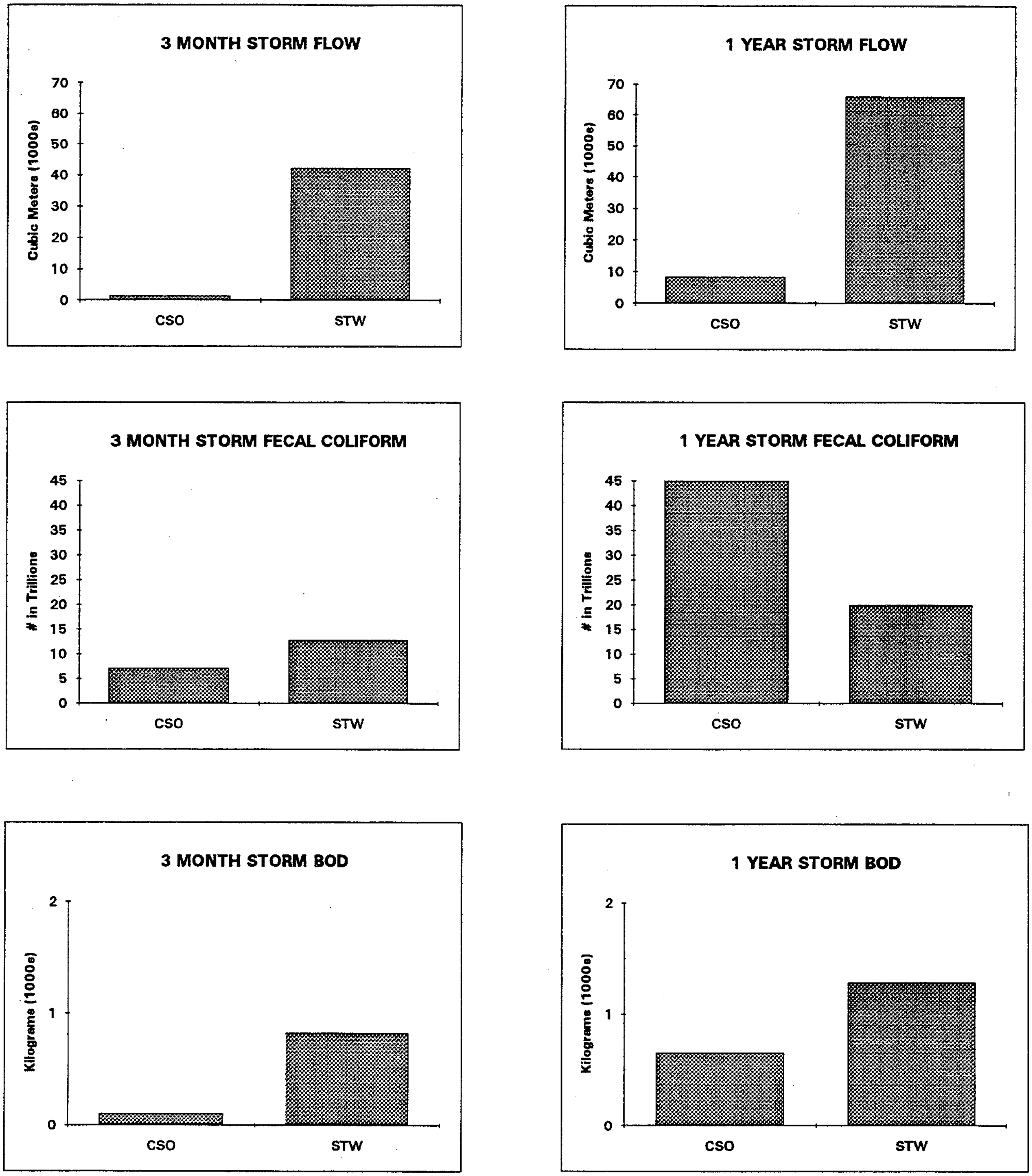
Estimated flows and loads of combined sewage (future planned) and stormwater to northern Dorchester Bay are shown in Figures 14-2 and 4-3. Existing CSO flows and loads from the three-month storm are more than twice what they will be under future-planned conditions.

14.4.2 Stormwater Discharges

This area is mostly combined sewage, with one small area of separate drainage. BWSC dry weather screening (BWSC 1991, 1993) indicated that this stormwater appears to be uncontaminated.

14.4.3 CSO Discharges

None of the CSOs discharging into northern Dorchester Bay are treated. Six of the seven CSOs were monitored during 1992 (MWRA, 1993a); of these, three required one inch or greater of rain to cause an overflow, two required about 0.4 inches of rain, and two overflowed after about



3 MONTH STORM FLOW

1 YEAR STORM FLOW

3 MONTH STORM FECAL COLIFORM

1 YEAR STORM FECAL COLIFORM

3 MONTH STORM BOD

1 YEAR STORM BOD

FIGURE 14-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - NORTHERN DORCHESTER BAY

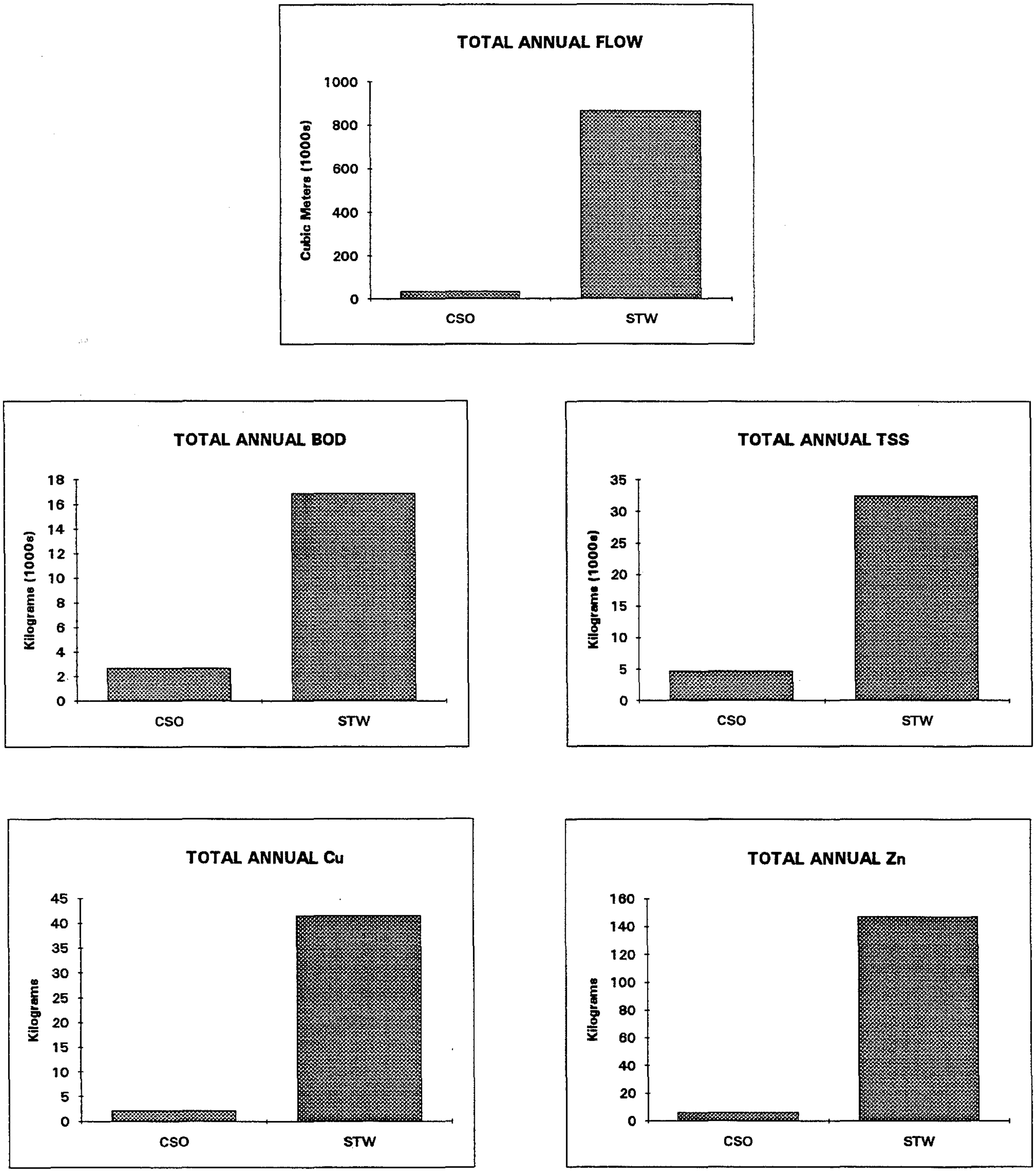


FIGURE 14-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - NORTHERN DORCHESTER BAY
(a) FLOW, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

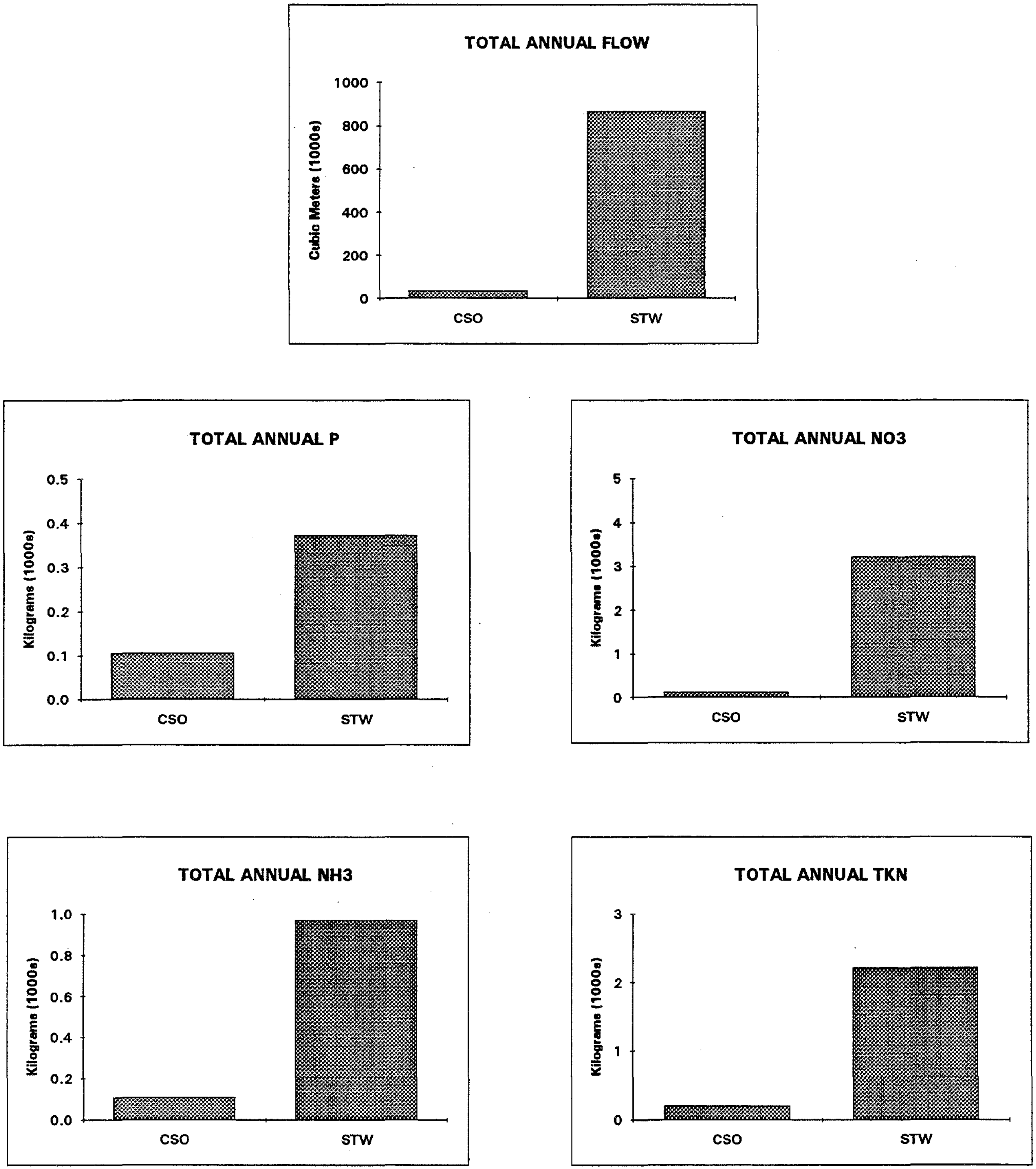


FIGURE 14-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS - NORTHERN DORCHESTER BAY
(b) FLOW, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

0.15 inches of rain (Table 6-6 in MWRA, 1993a). Inspections in 1992 indicated that there were leaky tide gates or other tide gate problems at four of the CSOs, infiltration in one CSO, and debris buildup in another CSO.

14.4.5 Remote Sources

Northern Dorchester Bay may be affected by remote sources such as effluent and (formerly) sludge, based on a sediment contamination study (Durell *et al.*, 1991). However, Inner Harbor CSOs do not appear to affect bacteriological water quality in Dorchester Bay (Rex, 1993; Adams and Zhang, 1991).

14.5 HYDRODYNAMICS

The area is tidal with a range of approximately ten feet. Because of the shallow depth, it is essentially unstratified.

14.5.1 Nearfield Mixing

The CSOs in northern Dorchester Bay are in the subtidal area, and hence behave as buoyant submerged discharges. Near field mixing is limited by the density differences between fresh water and saltwater, but the open area of the receiving water promotes good subsequent mixing. Estimates made for a typical CSO event (discharge from BOS086 during the storm of August 17-18, 1992) suggest that dilutions of about 5, 11 and 28 are obtained at distances of 30, 100 and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994).

The receiving water model (Appendix A) predicts that bacteria counts rise quickly during a storm in the northern Dorchester Bay segment, and disappear at a moderate rate. Bacteria levels return to background in about four days after the three-month storm.

14.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized on Figure 14-4.

14.6.1 Bacterial Contamination

Fecal coliform data from the first five years of MWRA CSO receiving water monitoring are shown in Figures 14-5 and 14-6. In general, fecal coliform indicator bacteria counts meet the Class SB standard in northern Dorchester Bay (Rex, 1993). Bacteria counts are related to rainfall; elevated counts are measured after heavy rain at Carson Beach and Pleasure Bay,

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	○	◍	○	very nearly meets swimming standard	swimming shellfishing	◍	CSOs; SW
	Dissolved Oxygen (1,6)	○	◍	○	3-5 mg/l depression after heavy rain	aquatic life fishing shellfishing	○	resuspension SOD; offshore; CSOs
Aesthetics	Solids and Floatables (1,2)	○	○	○		aquatic life, swim, boat, recreation	○	
	Color and Turbidity (1,2)	○	○	○		aquatic life, swim, boat, recreation		
	Odor (2,8)	○	○	○		aquatic life, swim, boat, recreation		
	Oil and grease (1,8)	○	○	○		aquatic life	○	
	Bottom pollutants or alterations (3,10,11,12)	N/A	N/A	◍		aquatic life	◍	CSOs, SW, remote sources
	Nutrients (5,9) (algal blooms)			◍	meso-eutrophic (few chl. data)	aquatic life	◍	SW, remote source
	Toxic Pollutants (4)	○	○	○		aquatic life fishing shellfishing	○	
	Temperature (6)	○	○	○		aquatic life	○	
	pH (N/A)							

Key:

● poor quality or high risk

◍ fair quality or moderate risk

○ good quality or low/no risk

? insufficient data

SW=stormwater
N/A= not applicable

Sources of information on present conditions

1 - Rex, 1993
2 - MWRA monitoring staff, pers. comm. 1993
3 - Durell et al. 1991
4 - Wallace et al. 1993
5 - Robinson, et al. 1990
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989
9 - ENSR, 1993
10-Leo et al. 1993
11-MacDonald, 1991
12-Gallagher and Grassle, 1991

FIGURE 14-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - NORTHERN DORCHESTER BAY

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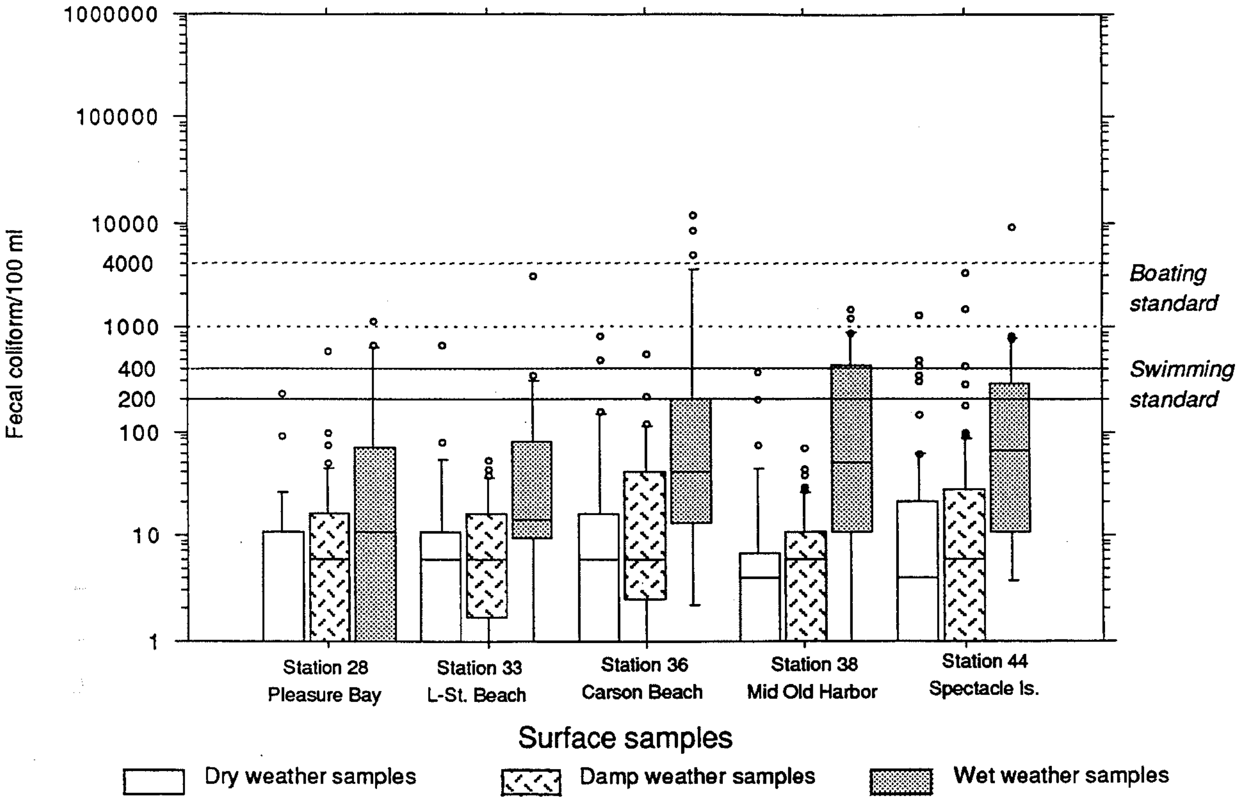

Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
28	Dry	25	1	241	4
28	Damp	38	1	599	5
28	Wet	16	1	1166	14
33	Dry	22	1	711	5
33	Damp	31	1	56	6
33	Wet	17	1	3201	23
36	Dry	31	1	831	7
36	Damp	40	1	581	9
36	Wet	29	1	11951	52
38	Dry	33	1	374	4
38	Damp	47	1	71	5
38	Wet	28	1	1536	54
44	Dry	74	1	1326	5
44	Damp	72	1	3401	8
44	Wet	34	1	9476	54
	TOTAL	537	1	11951	9

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 14-5. FECAL COLIFORM MONITORING DATA
FOR NORTHERN DORCHESTER BAY - SURFACE SAMPLES (1989-93)

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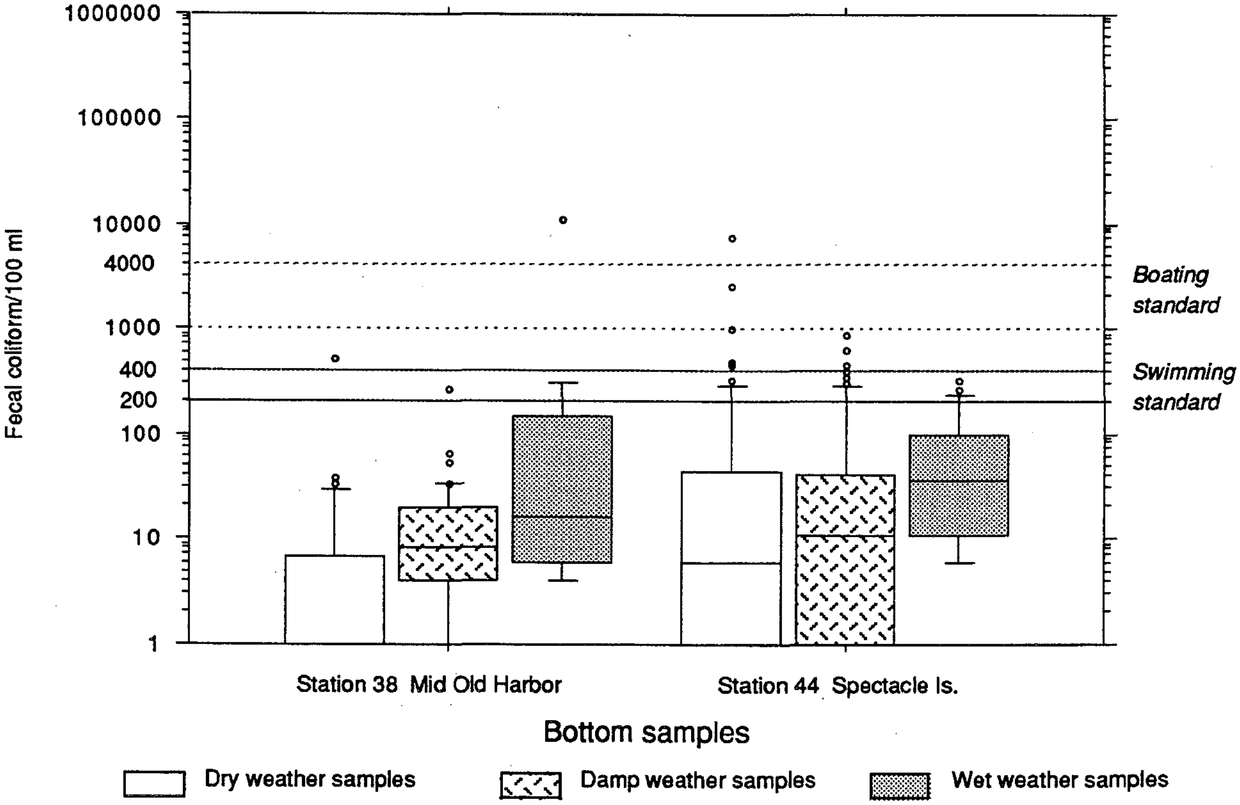


Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
38	Dry	28	1	536	3
38	Damp	36	1	269	9
38	Wet	15	1	11551	32
44	Dry	60	1	7701	10
44	Damp	58	1	931	12
44	Wet	21	1	326	33
	TOTAL	221	1	11551	11

* Number of Counts per 100 ml
Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".
Damp weather samples were collected when three-day rain was between 0.0" and 0.5".
Wet weather samples were collected when three-day rain >0.5".

FIGURE 14-6. FECAL COLIFORM MONITORING DATA FOR NORTHERN DORCHESTER BAY - BOTTOM SAMPLES (1989-93) although these areas still have lower counts than the Inner Harbor or southern Dorchester Bay (Rex, 1993).

14.6.2 Dissolved Oxygen

Daytime dissolved oxygen levels generally meet the water quality standard (Rex, 1993). After heavy rain, dissolved oxygen levels in both surface and bottom water are depressed about 3 to 5 mg/l below normal levels, although this depression appears to be due to other factors besides, or in addition to, CSO discharge (Rex, 1993).

Dissolved oxygen data from the first five years of MWRA CSO receiving water monitoring are shown in Figure 14-7.

14.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

Few sewage-related floatables or grease have been observed during routine MWRA CSO receiving water monitoring.

14.6.4 Oil and Grease

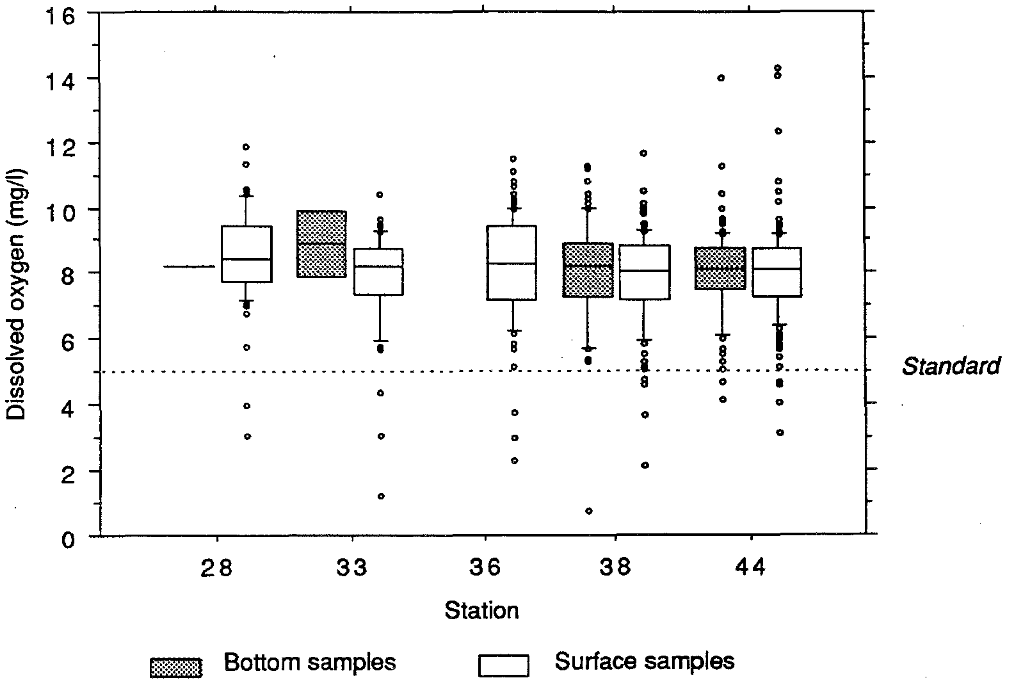
The 1988 sampling for the 1990 MWRA CSO Facilities Plan (CH2M, Hill 1989) included a station offshore in northern Dorchester Bay and one at Carson Beach. At both stations, all oil and grease measurements ~~at this station~~ were below 5 mg/l.

14.6.5 Bottom Pollutants or Alterations

Dorchester Bay sediment contaminant concentrations are lower than those in the Inner Harbor (MacDonald 1991, Hathaway *et al.* 1992).

A study of sediment contamination by CSOs was conducted for MWRA by Battelle Ocean Sciences in 1990 (Durell *et al.* 1991). Results from sites near CSOs were compared with those from more distant reference sites in Dorchester Bay. Samples were analyzed for three species of sewage indicator bacteria: fecal coliform, *Enterococcus*, and *Clostridium perfringens*. In the sediment samples, both fecal coliform and *Enterococcus* were fairly low in numbers, showing little fresh sewage impact. Counts of *Clostridium perfringens* spores ranged from 2,000 to 100,000 per gram dry weight, showing evidence of high long-term pollution throughout the study area.

Another indicator of the presence of domestic waste, coprostanol, was measured. The lowest coprostanol levels were measured at the site close to BOS087. Durell *et al.* (1991) note that



Station	Sample Type	No. of Samples	Concentration (mg/l)			
			Mean	Median	Minimum	Maximum
28	Bottom	1	8.2	8.2	8.2	8.2
28	Surface	72	8.6	8.5	3.1	11.9
33	Bottom	2	8.9	8.9	7.9	9.9
33	Surface	61	7.8	8.2	1.2	10.4
36	Surface	94	8.2	8.2	2.3	11.5
38	Bottom	76	8.0	8.2	0.8	11.3
38	Surface	98	7.9	8.0	2.2	11.7
44	Bottom	133	8.0	8.1	4.2	14.0
44	Surface	173	8.0	8.1	3.2	14.3
	TOTAL	710	8.0	8.2	0.8	14.3

FIGURE 14-7. DISSOLVED OXYGEN CONCENTRATIONS IN NORTHERN DORCHESTER BAY (1989-93)

although BOS087 has a high volume of discharge, most of the flow is stormwater rather than combined sewage. Sediment PAH concentrations indicate a "hot spot" near BOS087, while other sites in northern Dorchester Bay were relatively low in PAH. The average pyrogenic PAH concentrations were about twice as high as those measured in more offshore Mussel Watch sites in previous years (Battelle 1990b, 1991). It is interesting to note that the only hotspot near a CSO seems more representative of stormwater: high PAH, low coprostanol. Metals (cadmium, copper, lead and zinc) were elevated near BOS087 and also slightly elevated near BOS083. In some of the samples, metal levels were higher than Long and Morgan (1990) ER-L or ER-M threshold effects levels.

Sediments in Northern Dorchester Bay are substantially more spatially heterogeneous than are sediments in the Inner Harbor. Expanses of soft depositional sediments are interleaved with coarser, reworked sands and erosional gravels. This heterogeneity is reflected in the benthic communities in the bay (Gallagher and Grassle, 1991). While they still show clear evidence of disturbance associated with sewage pollution, benthic communities in northern Dorchester Bay are substantially more diverse and abundant than are those found in the Inner Harbor. More types of organisms are found, and the sediments are sometimes biologically mixed to depths of several centimeters (Leo *et al.*, 1993).

14.6.6 Nutrients

The only regularly collected water quality data for northern Dorchester Bay were collected by the MWRA in 1993. Chlorophyll *a* in August and September 1993 ranged from 0.11 μg/l to 12.55 μg/l, with a mean of 3.53 μg/l; these data should be used with caution as it is not known how representative the data are of annual mean concentrations. The area falls into the mesotrophic-eutrophic classification of waters based on Wetzel's (1993) classification by chlorophyll concentration. Total phosphorus concentration ranged from 0.043 to 0.82 mg/l with a mean of 0.075 mg/l. This mean concentration corresponds to the "fair" category of EPA's use attainability criteria. Nitrogen nutrients were measured at two stations in northern Dorchester Bay in 1988 in support of the 1990 MWRA CSO Facilities Plan (CH_2M Hill, 1989). The results are given in Table 14-1. Based on EPA guidance for estimating the nutrient status of estuaries (EPA, undated), northern Dorchester Bay appears to be of "fair" to "poor" quality in terms of nitrogen concentrations.

14.6.7 Toxic Pollutants and Toxicity

Water quality in the harbor generally meets water quality standards for toxic contaminants. Recent samples by UMass/Boston (Wallace, et al., 1993) do not show any exceedances of U.S. EPA acute aquatic life criteria for metals in northern Dorchester Bay.

TABLE 14-1. RANGES OF NUTRIENT CONCENTRATIONS IN NORTHERN DORCHESTER BAY (CH2M HILL 1989)

Station	TKN (mg/l)	NH_3 (mg/l)	NO_3 (mg/l)
Offshore N. Dot. Bay (RW7)	0.5 - 1.2	0.7 - 1.0	0.0 - 2.1
Carson Beach (RW11)	0.5 - 0.8	0.7 - 0.9	0.0 - 46.0

14.6.8 Temperature

Surface temperature in northern Dorchester Bay did not exceed the SB standard of 85°F in any of the routine receiving water monitoring between 1989 and 1992 (MWRA 1991, Rex 1993, unpublished MWRA Harbor Studies data).

14.7 USE ATTAINMENT

14.7.1 Watershed Context

The area draining into the northern Dorchester Bay receiving water segment is generally a mixture of parkland and urban land use. The area is heavily used for swimming; there are shellfish beds along most of the shoreline but shellfishing has been prohibited for several years because of high bacteria levels. BWSC sampling (BWSC, 1991, 1993) indicates that the stormwater drains in this area are relatively free of sewage contamination; therefore, our estimated stormwater loads are likely to be overestimates in this segment.

14.7.2 Existing Water Quality and Affected Uses

Figure 14-8 shows the effect of water quality on uses of northern Dorchester Bay. Bacteria levels meet the swimming standard of 200 fecal coliform/100 ml in dry weather, and in many locations nearly meet this standard in wet weather as well. The boating standard of 1,000 fecal coliform/100 ml is met under all conditions. The restricted shellfishing standard (88/100 ml) appears to be met in dry and damp weather, but is not generally met in wet weather. Dry and damp weather bacteria counts are similar, and the geometric mean falls below the open shellfishing standard of 14/100 ml.

The water quality for other parameters is also relatively good compared to other CSO receiving waters.

Figure 14-8. Beneficial uses affected by water quality in Northern Dorchester Bay
Class SB

Water Quality Assessment
MWRA CSO/System Master Plan

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						ok					?	?			FCA for Lobster
Aquatic Life	W	ok		ok	ok	ok ?	ok ?		?		ok		?		
Primary Contact Rec.								W	ok		ok	ok		ok	
Secondary Contact Rec.								ok							
Aesthetics									ok	?	ok	ok	?	ok	
Shell Fishing (Rest.)								W							

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

14.7.3 Baseline ("Future Planned") Water Quality and Affected Uses

Between now and future planned conditions (*c.* 1997), northern Dorchester Bay three-month storm CSO discharges are expected to be approximately halved. This should result in a slight improvement in water quality. Table 14-2 summarizes bacteria impacts in northern Dorchester Bay now and under future planned conditions.

The receiving water model predicts that the duration of violation of the restricted shellfishing standard, presently a day near Carson Beach (shellfish bed BH4) and City Point Beach (BH4.1) and a few hours at Pleasure Bay after the three-month storm, will be eliminated at Pleasure Bay and reduced to a few hours at City Point Beach. The swimming standard is predicted to be violated at Carson Beach, for about one day. The model does not predict any violations of the boating standard for the three-month design storm under future planned conditions. The one-year storm results in several hours of violation of the boating standard at Carson Beach, a violation of the swimming standard that lasts a day at Carson Beach and several hours at Pleasure Bay, and closure of the shellfish beds for a day or more. Actual closures based on shellfish (rather than water) contamination are likely to be more frequent and last longer.

The importance of CSOs to the total bacteria load is greater for the one-year storm, but for both storms, either CSOs alone or non-CSO sources alone cause bacteria counts to rise above standards for swimming and shellfishing.

Table 14-3 summarizes the level of use of northern Dorchester Bay and the factors affecting attainment of the uses.

TABLE 14-2. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN NORTHERN DORCHESTER BAY

	Current Conditions		3-Month Storm Event				1-Year Storm Event		
Resource Area	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Northern Dorchester Bay									
Swimming[(a)]	OK	Violates							
Boating[(b)]	OK	OK							
Restricted Shellfishing[(c)]	OK	Violates							
Pleasure Bay Beach									
Swimming[(a)]			0	0	0	0	8	0	0
Boating[(b)]			0	0	0	0	0	0	0
Shellfish Bed BH4.A									
Unrestricted[(c)]			45	42	15	39	57	42	46
Restricted[(d)]			8	6	0	4	22	9	9
City Point Beach									
Swimming[(a)]			9	9	0	5	19	9	10
Boating[(b)]			0	0	0	0	1	0	0
Shellfish Bed BH4.1									
Unrestricted[(c)]			53	51	23	44	57	42	51
Restricted[(d)]			24	22	2	18	31	17	26
Carson Beach									
Swimming[(a)]			23	21	3	20	26	16	21
Boating[(b)]			2	0	0	0	9	4	1

TABLE 14-2 (Continued). PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN NORTHERN DORCHESTER BAY

	Current Conditions		3-Month Storm Event				1-Year Storm Event		
Resource Area	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Shellfish Bed BH4									
Unrestricted[c]			53	50	26	48	58	42	52
Restricted[d]			29	29	10	28	33	25	29

Note:
(a) Swimming (hours fecal coliform count > 200/100 ml).
(b) Boating (hours fecal coliform count > 1000/100 ml).
(c) Unrestricted shellfishing (hours fecal coliform count > 14/100 ml).
(d) Restricted shellfishing (hours fecal coliform count > 88/100 ml). Bed closures and contamination of shellfish are likely to be somewhat more frequent than we have predicted.

TABLE 14-3. USE ATTAINMENT FACTORS - NORTHERN DORCHESTER BAY

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	High	2	CSO, Stormwater
Secondary Contact Recreation	High	1	
Aquatic Life	Moderate	1	Offshore sources?
Fish Consumption	Moderate	2	
Aesthetics	High	1	
Shellfishing	Low (no open beds)	2	CSOs, Stormwater

* Preliminary determination; may be corrected through public participation process
** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 15
SOUTHERN DORCHESTER BAY

15.1 DEFINITION OF RECEIVING WATER SEGMENT

The southern Dorchester Bay CSO receiving water segment extends from Columbia Point to the Port Norfolk Yacht Club in Dorchester, and offshore to Thompson's Island and Squantum (See Figure 15-1). A portion of the Neponset River mouth, including Commercial Point and Tenean Beach is also in this receiving water segment.

15.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

Southern Dorchester Bay is Class SB-Fishable/Swimmable with restricted shellfishing. Water-based uses in this area are primarily recreational including boating, swimming and fishing. Shellfish resources in this segment include restricted beds in the Squantum area of Quincy. The commercially harvested shellfish from this area must undergo purification at the depuration plant in Newburyport. Several dozen areas of shellfish bed in this area are classified as prohibited. On the Quincy Bay side of this area, both restricted and prohibited shellfish resource areas have been identified by the Massachusetts Division of Marine Fisheries.

This area is heavily used by the public for educational and recreational opportunities. There are a number of beaches under the control of the MDC and additional beach areas maintained by the City of Quincy. MDC areas include Malibu Beach and Savin Hill Beach in Dorchester, and Tenean Beach at the Neponset River mouth. Other public facilities in this portion of Dorchester Bay include parks, the UMass/Boston campus, the John F. Kennedy Library, the State Archives, and the Bayside Expo Center.

The land area between Columbia Point and Malibu Beach is generally a sandy narrow coastline bordered by a road and parkland landward of the parklands is high density residential housing. Bordering the west side of Malibu Beach is the Southeast Expressway with some industrial and commercial activity in the area behind it. The area by the mouth of the Neponset River, essentially northeast of Quincy Shore Drive, is primarily commercial, including marinas. Between the Quincy Shore Drive bridge and Commercial Point, there is heavy commercial activity to the west of the Expressway. To the east of the Expressway, there is parkland and the Boston Gas facility. There are CSO control facilities at both Commercial Point and Fox Point. Land use in the Boston Harbor drainage area, including southern Dorchester Bay, was presented in Figure 8-2.

From Savin Hill Cove all along the shoreline to Squantum, marshes attracts migratory shorebirds in the spring, and herons and other shorebirds in the late summer. In the fall and winter, bird watchers will find bufflehead ducks, brant geese, mergansers, Canada geese, great blue herons, mallards, mute swans, double-crested cormorants, black ducks, and other ducks.

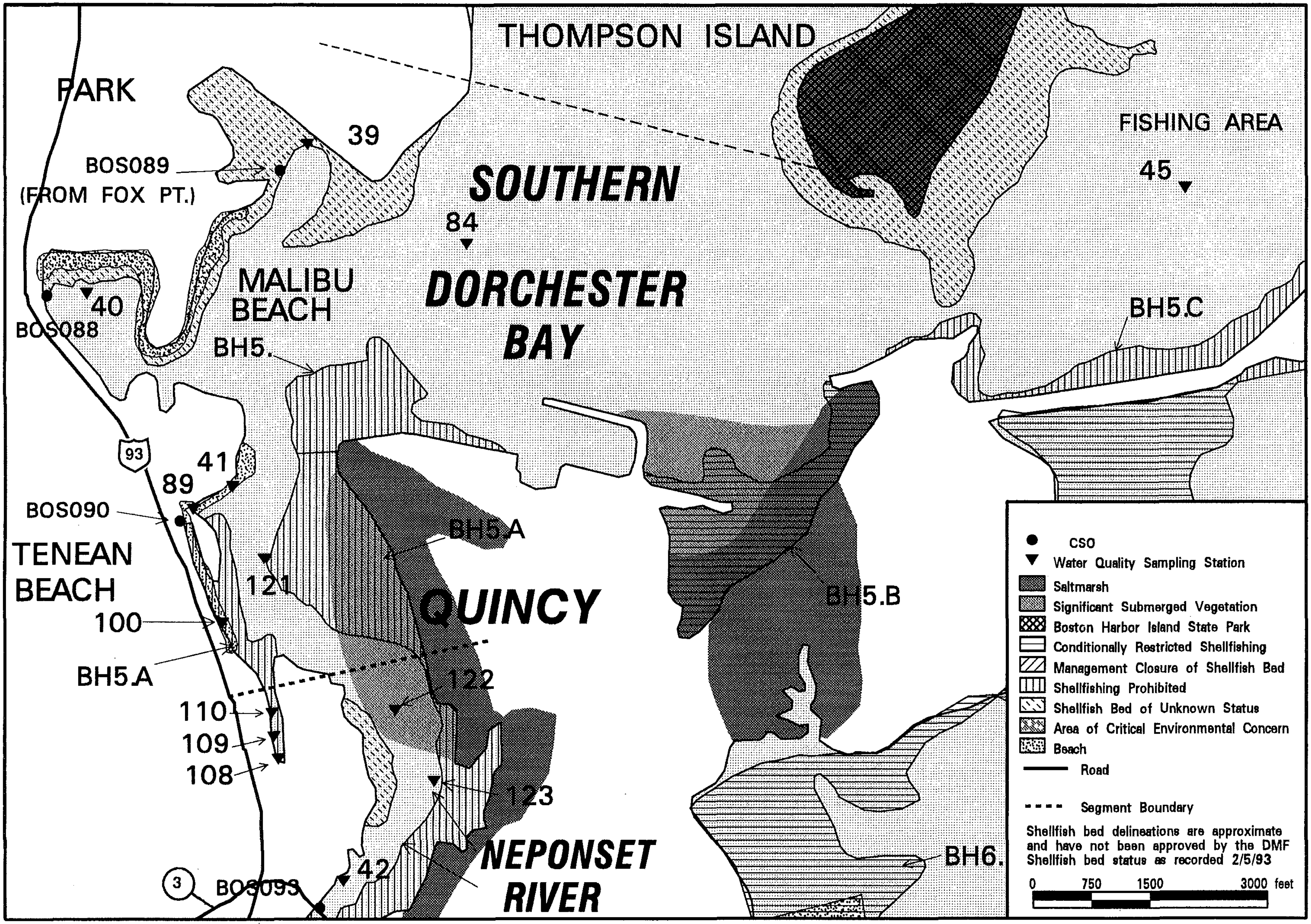


FIGURE 15-1. SOUTHERN DORCHESTER BAY

15.3 CHARACTERIZATION OF WATERSHED

15.3.1 Location

This Southern Dorchester Bay receiving water segment drains the Dorchester section of Boston and part of the Squantum section of Quincy. Pine Neck Creek drains parts of Dorchester, emptying into the Harbor near Tenean Beach. The area includes Savin Hill, Malibu Beach, Tenean Beach, and Squantum.

15.3.2 Topography and Soils

The area is flat with no major hills except Savin Hill. Some of the coastline is fill.

Most of the areas on or near the coastline are urban, paved land, but there is an extensive salt marsh at the mouth of the Neponset River.

15.3.3 Dams, Highways, and Other Man-Made Features

The shoreline of the area is bordered by Interstate 93, the Southeast Expressway and Morrissey Boulevard. In addition, the MBTA crosses the Neponset River.

15.3.4 Wetlands

There are wetlands in Squantum at the mouth of the Neponset River. There are also small areas of salt marsh vegetation in Savin Hill Cove, and upstream of Morrissey Boulevard on a small tidal creek tributary to Savin Hill Cove

15.4 SOURCES OF POLLUTION

15.4.1 General

Southern Dorchester Bay water quality is affected by the Neponset River, CSOs, and stormwater (Rex, 1993). Dissolved oxygen and sediment contamination may be affected by more remote sources (Rex, 1993; Durell *et al.*, 1991). Estimated flows and loads of CSO (future planned) and stormwater to southern Dorchester Bay are shown in Figures 15-2 and 15-3. CSO flows and loads are expected to decrease slightly (6%) during the three-month storm from existing to future planned conditions.

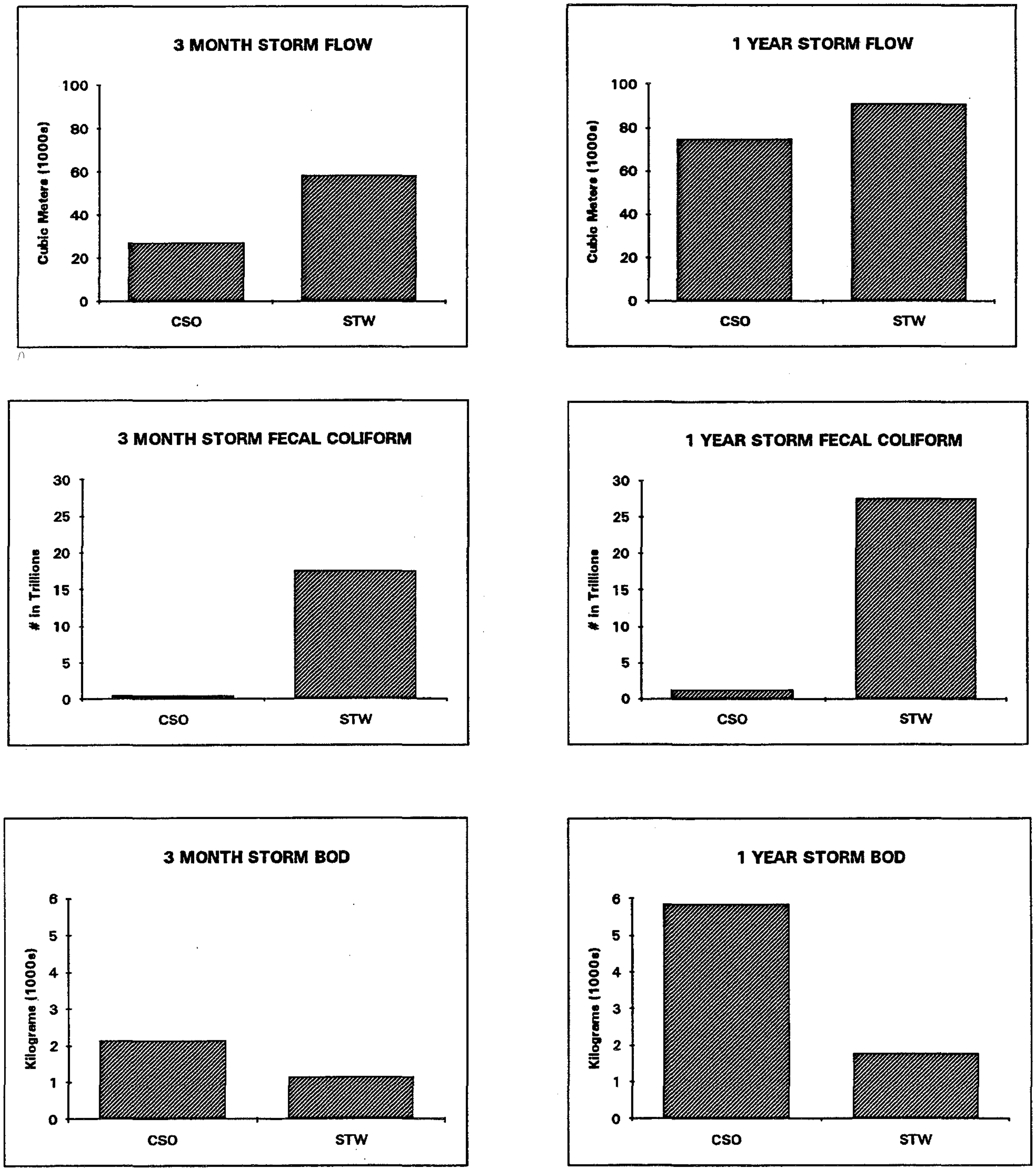
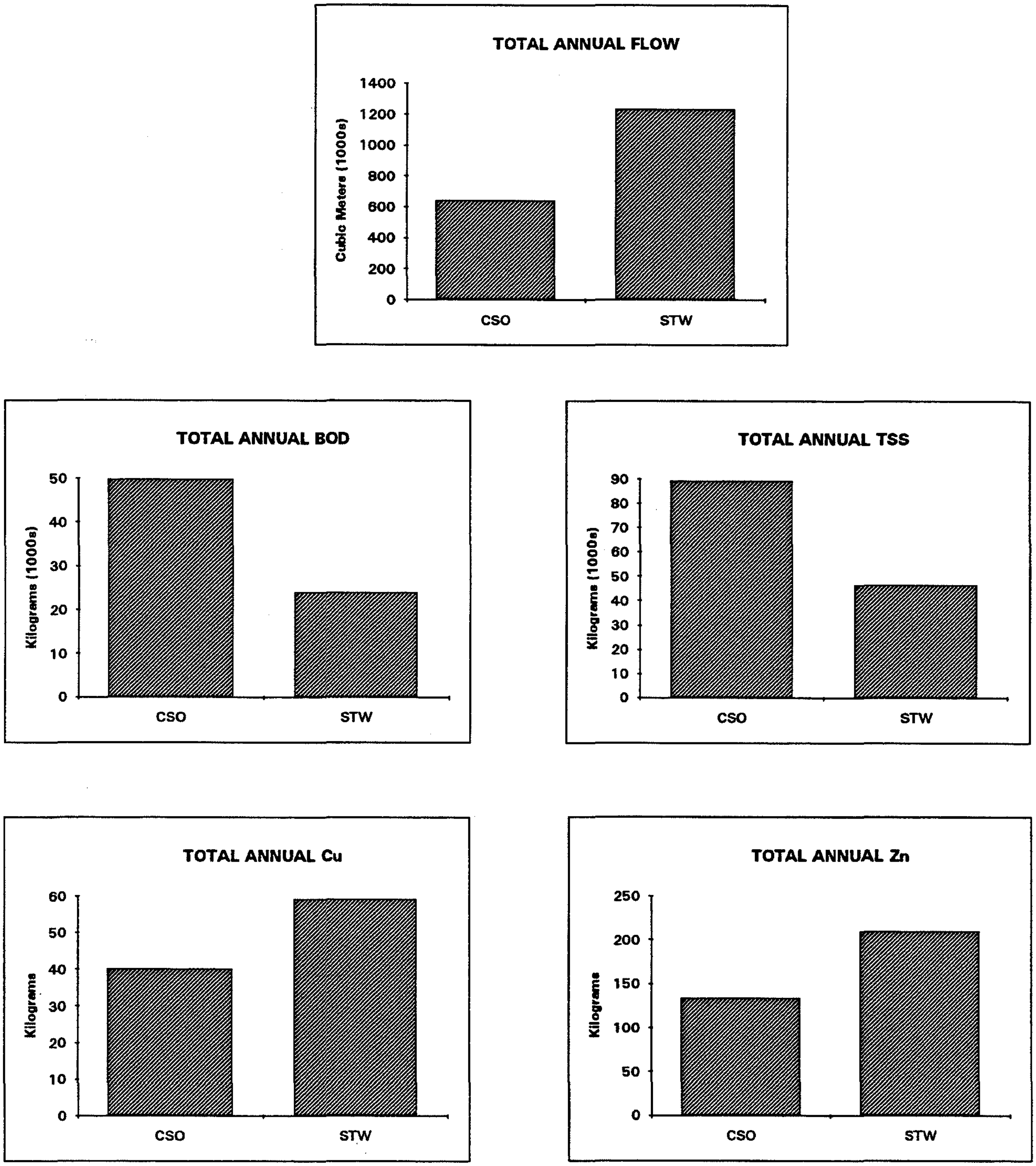


FIGURE 15-2. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENT - SOUTHERN DORCHESTER BAY


TOTAL ANNUAL FLOW

TOTAL ANNUAL BOD

TOTAL ANNUAL TSS

TOTAL ANNUAL Cu

TOTAL ANNUAL Zn

FIGURE 15-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS FOR SOUTHERN DORCHESTER BAY
(a) FLOWS, BIOCHEMICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, COPPER, ZINC

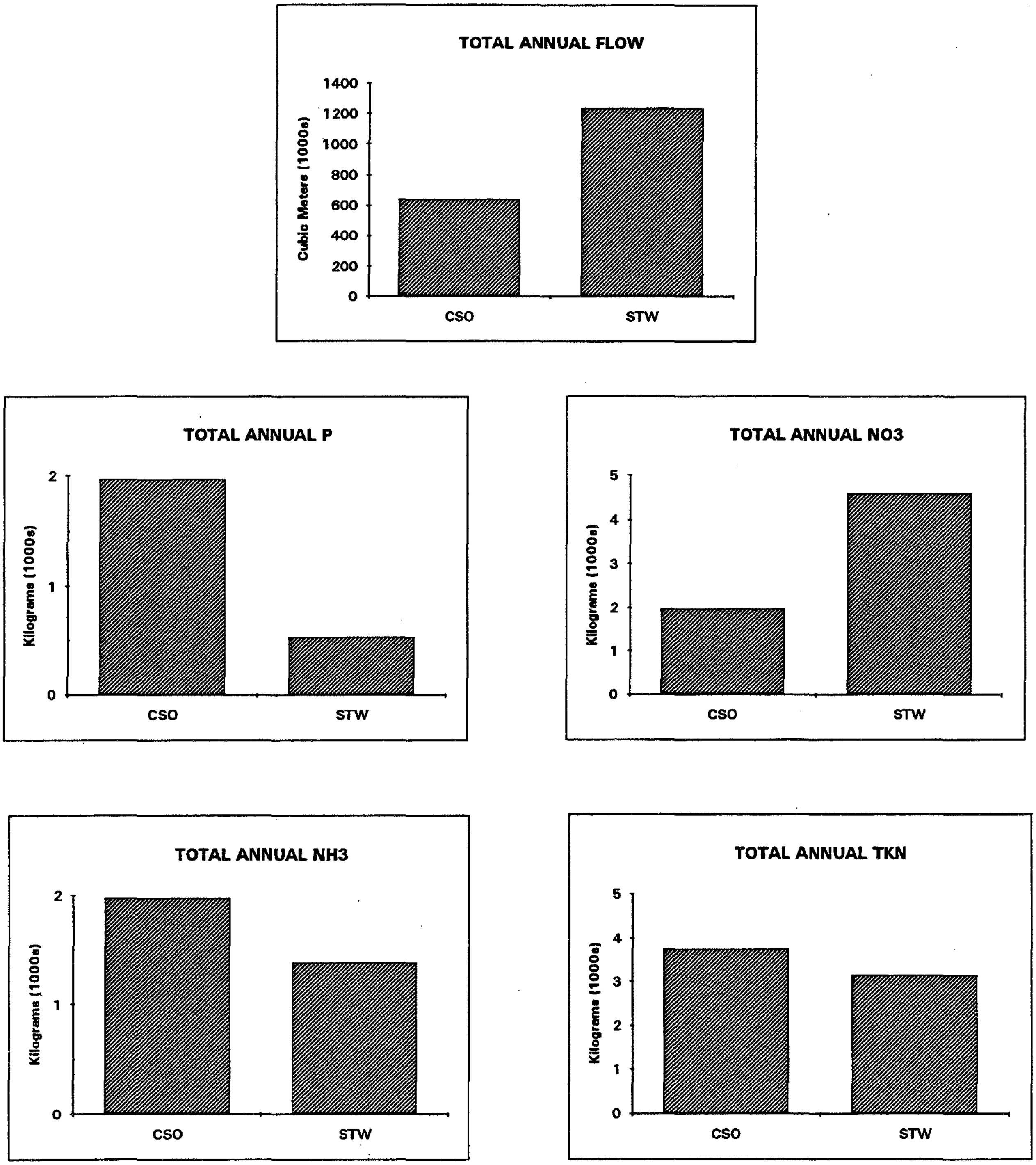


FIGURE 15-3. FUTURE PLANNED ANNUAL FLOWS AND LOADS FOR SOUTHERN DORCHESTER BAY (b) FLOWS, TOTAL PHOSPHORUS, NITRATE, AMMONIA, TOTAL KJELDAHL NITROGEN

15.4.2 Stormwater Discharges

This area is mostly combined with two small areas of separate drainage. BWSC dry weather screening (BWSC, 1991; 1993) indicated that one of these areas, draining into Pine Neck Creek adjacent to Tenean Beach, may be contaminated with sewage.

15.4.3 CSO Discharges

All of the three CSOs discharging into southern Dorchester Bay receive a mixture of treated and untreated combined sewage. The Fox Point CSO Facility screens and disinfects combined sewer overflow discharged through BOS089, with BOS088 serving as a relief outfall (MWRA, 1993a). There is additional CSO and stormwater that enters below the facility and is discharged through BOS089. There is also about 0.5 to 5.0 mgd of infiltration flow which passes through the treatment facility in dry and wet weather. Fox Point discharges much less than its rated capacity of 119 mgd even during large storms (MWRA, 1993a).

The Commercial Point CSO Facility provides screening and disinfection to CSO prior to discharge through BOS090. Like Fox Point, it receives dry weather infiltration flow, and there is additional flow entering downstream of the facility, and peak flows are much less than the facility's capacity (194 mgd); at both facilities, however, upstream system improvements may reduce discharges. Problems with leaky tide gates have been reported for both facilities (P. Carbone, MWRA, pers. comm. to M. Collins, 1993). Fox Point and Commercial Point facilities generally provide effective disinfection (Bigornia-Vitale and Sullivan, 1993). During the 1992 monitoring, BOS088 did not overflow during the monitoring period, BOS090 required about 0.38 inches to cause an overflow, and BOS089 overflowed after about 0.18 inches of rain (Table 6-6 in MWRA, 1993a).

15.4.4 Upstream and Remote Sources

The Neponset River adversely affects the bacteriological water quality of southern Dorchester Bay (MWRA, 1991; Rex, 1993). This area is also affected by remote sources, including effluent and the former discharge of wastewater sludge (Rex, 1993; Durell *et al.*, 1991).

15.5 HYDRODYNAMICS

15.5.1 Nearfield Mixing

The area is tidal with a range of approximately ten feet. It is weakly stratified due to the inflow from the Neponset River. The CSOs in southern Dorchester Bay are subtidal, and hence behave as buoyant submerged discharges much like those in northern Dorchester Bay. The largest

CSOs are located at Commercial Point and Fox Point. Estimates made for the Commercial Point CSO during the August 17-18, 1992 storm suggest dilutions of about 5, 8 and 13 at distances of 30, 100, and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994).

15.5.2 Farfield Mixing and Flushing

The receiving water model (Appendix A) predicts that bacteria counts are elevated before the beginning of a storm in southern Dorchester Bay, due to the effect of the Neponset River on this segment. The storm causes a gradual rise in bacteria levels, as nearby sources (CSOs and stormwater) and remote sources (the Neponset River upstream of the Milton Lower Mills Dam, and CSOs and stormwater into the Neponset River estuary) begin to affect the water quality. The predicted bacteria levels reach a few thousand/100 ml, and then disappear at a moderate rate. In the model, bacteria levels appear to return to (high) background in about five days after the three-month storm.

The southern Dorchester Bay wet weather sources, along with the Neponset River, affect areas relatively remote from CSOs, including the shellfish beds along Squantum in Quincy. However, the effect of shoreline sources does not appear to reach Wollaston Beach and other beaches in the southern part of the Outer Harbor.

15.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized on Figure 15-4.

15.6.1 Bacterial Contamination

Fecal coliform data for the first five years of MWRA CSO receiving water monitoring are shown in Figure 15-5. In general, southern Dorchester Bay water quality is worse than northern Dorchester Bay (Rex, 1993). Fecal coliform indicator bacteria counts do not meet the Class SB standard in northern Dorchester Bay in wet weather; Savin Hill Cove does not meet the standard in dry weather either. However, the CSO treatment facilities at Fox Point and Commercial Point have been effective at reducing bacteria levels, as water quality has improved since operation of the treatment facilities began (Rex, 1993).

Bacteria counts at Tenean Beach are highest after heavy rain but are also high in dry weather. Dry weather sources include the Neponset River and a possible contaminated storm drain in adjacent Pine Neck Creek (Rex, 1993).

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	◍	●	◍	meets boating std. in dry weather	swimming shellfishing boating	●	Neponset R CSOs; SW
	Dissolved Oxygen (1,6)	○	◍	○	3-5 mg/l depression after heavy rain	aquatic life fishing shellfishing	○	resuspension SOD; offshore; CSOs
Aesthetics	Solids and Floatables (1,2)	◍	●	●	sewage related floatables near shore scum slicks	aquatic life, swim, boat, recreation	●	FP and CB CSOs
	Color and Turbidity (1,2)		●	●	slicks	aquatic life, swim, boat, recreation	●	FP and CB CSOs
	Odor (2)		●	●	sewage odor	aquatic life, swim, boat, recreation	●	FP and CB CSOs
	Oil and grease (1,8)	○	●	◍	slicks; high meas. in bay center	aquatic life	●	FP and CB CSOs
	Bottom pollutants or alterations (3,4,9,10,11,12)	N/A	N/A	◍		aquatic life	◍	CSOs, SW, remote sources
	Nutrients (5,6) (algal blooms)	◍ ?	◍ ?	◍	meso-eutrophic	aquatic life	◍	
	Toxic Pollutants	?	?	?		aquatic life fishing shellfishing	?	
	Temperature (6)	○	○	○		aquatic life	○	
	pH (N/A)							

Key:

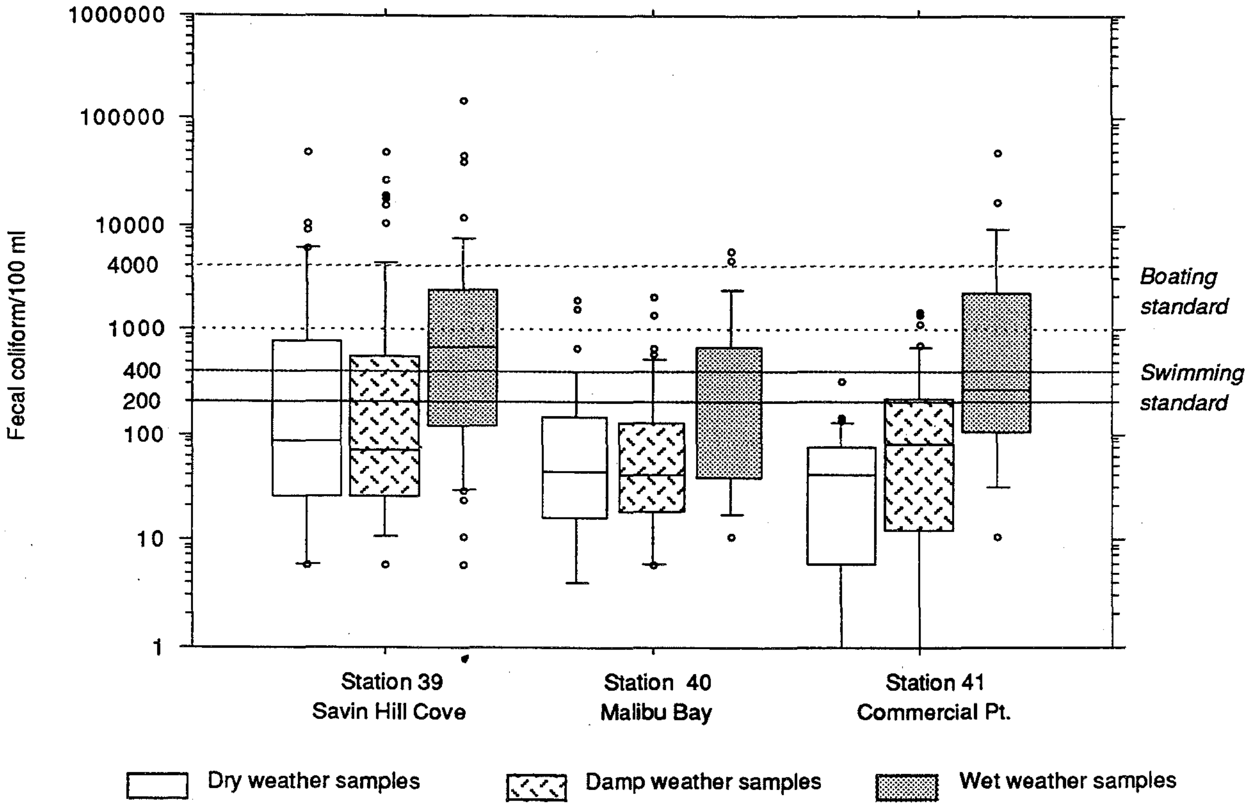
●	poor quality or high risk
◍	fair quality or moderate risk
○	good quality or low/no risk
?	insufficient data

FP = Fox Point CSO facility
CP=Commercial Pt. CSO facility
SW=stormwater
N/A= not applicable
PAH=polycyclic aromatic hydrocarbons
SOD = sediment oxygen demand

Sources of information on present conditions

1 - Rex, 1993
2 - A. Rex and other monitoring staff, pers. comm. 1993
3 - Durell et al. 1991
4 - Blake et al. 1993, SAIC 1992
5 - New England Aquarium unpublished data
6 - Harbor Studies data
7 - MWRA, 1991
8 - CH2M Hill, 1989
9 - Keay, 1988
10 - Kelly & Kropp, 1992
11 - MacDonald, 1991
12 - Gallagher and Grassle, 1989
Gallagher et al. 1992

FIGURE 15-4. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - SOUTHERN DORCHESTER BAY



Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
39	Dry	46	1	48251	115
39	Damp	62	1	50001	126
39	Wet	55	6	151501	539
40	Dry	31	1	1951	43
40	Damp	45	1	2226	48
40	Wet	24	1	5826	181
41	Dry	30	1	326	22
41	Damp	43	1	1551	54
41	Wet	21	1	49501	342
	TOTAL	357	1	151501	106

* Number of Counts per 100 ml

Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".

Damp weather samples were collected when three-day rain was between 0.0" and 0.5".

Wet weather samples were collected when three-day rain >0.5".

FIGURE 15-5. FECAL COLIFORM MONITORING DATA FOR SOUTHERN DORCHESTER BAY (1989-93)

15.6.2 Dissolved Oxygen

Dissolved oxygen data for the first five years (1989-1993) of MWRA CSO receiving water monitoring are shown in Figure 15-6. Daytime dissolved oxygen levels generally meet the water quality standard (Rex, 1993). After heavy rain, dissolved oxygen levels in both surface and bottom water are depressed about 3 to 5 mg/l below normal levels, although this depression appears to be due to other factors besides, or in addition to, CSO discharge (Rex, 1993).

15.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

Discharges from the CSO facilities (especially BOS070 on Commercial Point and BOS089 on Fox Point) result in slicks, sewage odors, and sewage related floatables near shore (Rex, 1993). In addition, sewage related floatables can be seen at the edge of the water in Pine Neck Creek.

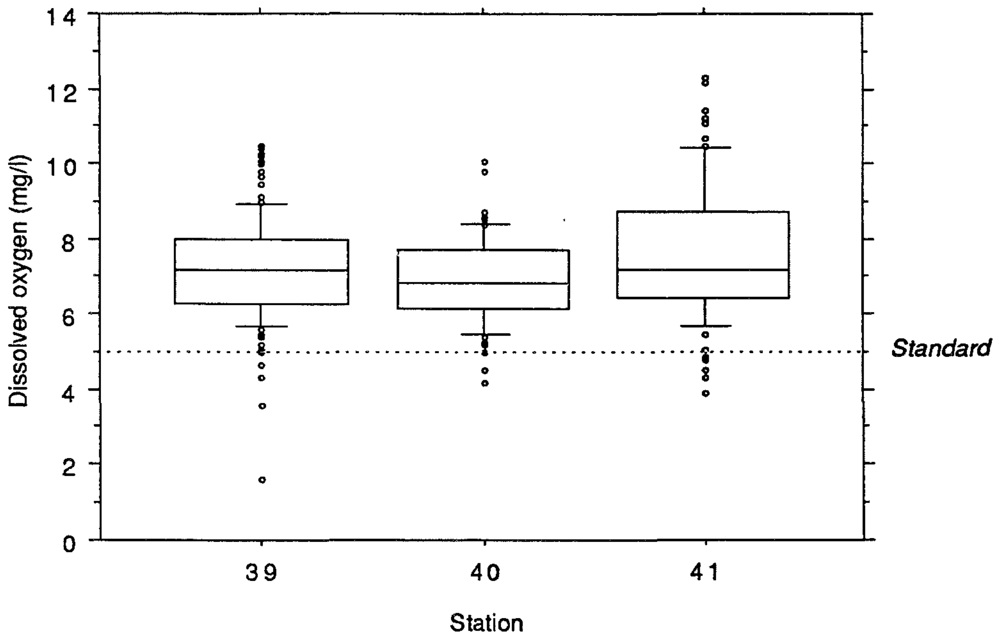
15.6.4 Oil and Grease

Sampling conducted in 1988 for the 1990 MWRA CSO Facilities Plan (CH2M Hill, 1989) included stations at Squantum, the center of southern Dorchester Bay, and the Dorchester Yacht Club. Oil and grease measurements were all 5 mg/l, except at the station in the center of the bay, where oil and grease ranged from 5 to 42 mg/l. Grease and scum slicks have been observed on many occasions at BOS090.

15.6.5 Bottom Pollutants or Alterations

In the 1990 study of Dorchester Bay sediment contamination (Durell *et al.*, 1991), the highest counts of *Clostridium perfringens* spores, and the highest concentrations of coprostanol and PAHs were near the Commercial Point CSO. The second highest PAH concentrations were in Pine Neck Creek, which is probably more affected by a large storm drain rather than by the Commercial Point CSO. The average pyrogenic PAH concentrations were about three times as high as those measured in more offshore Mussel Watch sites in previous years (Battelle 1990b, 1991). Metals (cadmium, copper, lead and zinc) were also somewhat elevated near BOS090, but neither the PAH nor the metals levels were dramatically higher than those measured at other southern Dorchester Bay sites. Many of the samples had metals levels higher than the ER-L or ER-M effects ranges proposed by Long and Morgan (1990). Elevated levels of pollutants found in southern Dorchester Bay cannot be confidently attributed only to CSOs, and may in fact derive from past sludge discharges and/or stormwater.

Because the sluggish currents in places such as Savin Hill Cove create highly depositional environments, the sediments in some parts of southern Dorchester Bay are highly contaminated with pollutants derived from nearby sources (i.e. CSOs) as well as from more distant sources (i.e. sewage effluent and wastewater sludge that was discharged through December, 1991)



Station	No. of Samples	Concentration (mg/l)			
		Mean	Median	Minimum	Maximum
39	127	7.2	7.2	1.6	10.5
40	81	6.9	6.8	4.2	10.1
41	84	7.6	7.2	3.9	12.3
TOTAL	292	7.3	7.1	1.6	12.3

FIGURE 15-6. DISSOLVED OXYGEN CONCENTRATIONS IN SOUTHERN DORCHESTER BAY - SURFACE SAMPLES (1989-93)

(Gallagher *et al.*, 1992; Durell *et al.*, 1991). While data are limited, benthic communities in open water areas of southern Dorchester Bay appear to be similar to those from northern Dorchester Bay (SAIC, 1992). However, the highly depositional subtidal sediments in Savin Hill Cove (adjacent to the discharge from BOS089) support communities that are among the most degraded in the Harbor. Frequent sampling since 1985 has documented that this area is frequently devoid of animals and at best harbors a sparse, ephemeral assemblage of pollution-tolerant species (Keay, 1988; Gallagher & Grassle, 1989; Kelly and Kropp, 1992; Blake *et al.*, 1993).

There is no evidence from this long-term data set of improvements in benthic conditions following the commissioning of the Fox Point CSO Facility in 1989 (K. Keay, pers. comm, 1993). This might be expected from the evidence that most of the solids and pollutants deposited in Savin Hill Cove are derived from sources other than the adjacent CSO (Gallagher *et al.*, 1992; Durell *et al.*, 1991). Additionally, bar screening and disinfection do not remove substantial amounts of the BOD, suspended solids and toxic contaminants that are associated with sea-floor alterations.

15.6.6 Nutrients

Southern Dorchester Bay was most recently monitored for nutrients in 1991 (New England Aquarium unpublished data). The ranges of nutrient concentrations measured in 1991 are presented in Table 15-1. The range of concentrations of total phosphorous overlap both the "healthy" and "fair" categories of the EPA guidelines while the segment appears to be "healthy" in terms of nitrogen. (EPA, undated). On the basis of mean 1991 chlorophyll concentrations, southern Dorchester Bay can be classified as mesotrophic to eutrophic by Wetzel's (1983) scheme.

Results of nutrient sampling conducted in 1988 in support of the 1990 MWRA CSO Facilities are given in Table 15-2.

15.6.7 Toxic Pollutants and Toxicity

There are no suitable data on toxic contaminants for this area of the harbor.

15.6.8 Temperature

Surface temperature in southern Dorchester Bay did not exceed the SB standard of 85°F in any of the routine receiving water monitoring between 1989 and 1992 (MWRA, 1991; Rex, 1993; unpublished MWRA Harbor Studies data).

TABLE 15-1. SOUTHERN DORCHESTER BAY NUTRIENT AND CHLOROPHYLL MEASUREMENTS

	Dissolved Inorganic N (mg/l) 1991	Total P (mg/l) 1991	Chl a (μg/l) 1991
minimum	.08	.02	0.01
maximum	.30	.12	10.30
mean	.18	.07	3.05

Sources: Data from MWRA and New England Aquarium (unpublished).

TABLE 15-2. RANGES OF NUTRIENT CONCENTRATIONS IN SOUTHERN DORCHESTER BAY

Station	Total P (mg/l)	TKN (mg/l)	NH_3 (mg/l)	NO_3 (mg/l)
Squantum (RW8)	0.1-0.7	0.6-0.9	0.6-1.0	0.0-2.2
S. Dorchester Bay (RW9)	0.1-0.3	0.3-4.8	0.6-1.0	0.0-39.0
Dorchester Yacht Club (RW10)	0.1-0.3	0.4-0.9	0.6-0.9	0.1-76.0

Source: CH2M Hill, 1989

15.7 USE ATTAINMENT

15.7.1 Watershed Context

The area draining directly into the southern Dorchester Bay receiving water segment includes transportation, industrial, and residential land uses, as well as some areas of salt marsh. Nearly all of the CSO into this segment is chlorinated at the Fox Point and Commercial Point CSO facilities; although these facilities have been effective at reducing bacteria levels, the water quality of southern Dorchester Bay is greatly affected by the Neponset River and by contaminated storm drains.

15.7.2 Existing Water Quality and Affected Uses

Figure 15-7 compares beneficial uses of southern Dorchester Bay with applicable criteria for attainment of these uses. High bacteria levels pose a risk to swimmers in wet weather, and in dry weather in parts of southern Dorchester Bay, as well as closing shellfish beds. The boating standard of 1000 fecal coliform/100 ml is violated in wet weather, but bacteria counts in excess of 10000/100 ml are very rare. A number of other water quality parameters are affected by wet weather. Dissolved oxygen levels drop during rain events, and sewage-related floatables, slicks, and odors affect the aesthetic quality of the area.

15.7.3 Baseline ("Future Planned") Water Quality and Affected Uses

Southern Dorchester Bay CSO discharges are not expected to change significantly between now and future planned conditions. Therefore, baseline water quality will be similar to existing water quality. Table 15-3 summarizes bacterial impacts in southern Dorchester Bay now and under future planned conditions.

Baseline bacteria levels following design storms were predicted with the MIT receiving water quality model. Note that the loads to the model may be slightly overestimated; most of the Neponset River mouth area was not included in the model domain, and the upstream loads and CSO loads to the Neponset River segment were put into the model at the model boundary, near Port Norfolk in Dorchester. Therefore, in the model these loads are not attenuated as they travel towards southern Dorchester Bay, as they would be in the environment.

After the three-month storm or the one-year storm, the receiving water model predicts that the boating standard will be violated for about half a day, and the swimming standard for about 1½ days. Because (chlorinated) CSO discharges are such a small fraction of the bacteria load, a big difference between the three-month and one-year storms characteristic of CSO-dominated areas is not seen in southern Dorchester Bay. However, CSO discharges alone can close the beaches for several hours and the shellfish beds for a day or longer after the one-year storm; this is likely due in part to CSO discharges into the Neponset River estuary (BOS093 and BOS095, "Group 12" in Appendix A) since the local CSOs ("Group 11") are fairly effectively disinfected.

Figure 15-7. Beneficial uses affected by water quality in Southern Dorchester Bay

Class SB

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			FCA for Lobster
Aquatic Life	▨ W	ok		▨ ?	▨ ?	?	▨ C		?		▨ W		▨ C		
Primary Contact Rec.								▨ C	▨ W		▨ W	▨ W		▨ W	
Secondary Contact Rec.								▨ W							
Aesthetics									▨ W	?	▨ W	▨ W		▨ W	
Shell Fishing (Rest.)								▨ C							

WET: Whole Effluent Toxicity
Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.
BIP: Balanced Indigenous Population
FCA: Fish Consumption Advisory
(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:

ok	Attained for Criteria
▨	Proven or Probable Non-Attainment
W	Wet Weather Non-Attainment
C	Wet and Dry Weather Non-Attainment

TABLE 15-3. PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN SOUTHERN DORCHESTER BAY

	Current Conditions		3-Month Storm Event				1-Year Storm Event		
Resource Area	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Southern Dorchester Bay									
Swimming[(a)]	Violates	Violates							
Boating[(b)]	OK	Violates							
Restricted Shellfishing[(d)]	Violates	Violates							
Malibu Beach									
Swimming[(a)]			33	33	0	33	36	0	34
Boating[(b)]			3	3	0	3	18	0	17
Tenean Beach									
Swimming[(a)]			37	37	0	37	39	14	37
Boating[(b)]			15	15	0	12	18	0	17
Shellfish Bed BH5.A									
Unrestricted[(c)]			85	85	12	85	85	43	85
Restricted[(d)]			47	45	0	44	50	23	46
Shellfish Bed BH5.B									
Unrestricted[(c)]			56	56	0	55	64	35	57

TABLE 15-3 (Continued). PREDICTED HOURS OF VIOLATIONS OF FECAL COLIFORM STANDARDS IN SOUTHERN DORCHESTER BAY

	Current Conditions		3-Month Storm Event				1-Year Storm Event		
Resource Area	Dry Weather	Wet Weather	Existing All	Future All	Future CSO	Future Non-CSO	Future All	Future CSO	Future Non-CSO
Restricted[(d)]			21	21	0	21	31	0	23
Shellfish Bed BH5.C									
Unrestricted[(c)]			33	31	0	30	44	5	38
Restricted[(d)]			0	0	0	0	0	0	0

Note:

(a) Swimming (hours fecal coliform count > 200/100 ml).
(b) Boating (hours fecal coliform count > 1000/100 ml).
(c) Unrestricted shellfishing (hours fecal coliform count > 14/100 ml).
(d) Restricted shellfishing (hours fecal coliform count > 88/100 ml). Bed closures and contamination of shellfish are likely to be somewhat more frequent than we have predicted.

Table 15-4 summarizes the level of use of southern Dorchester Bay and the factors affecting attainment of the uses.

TABLE 15-4. USE ATTAINMENT FACTORS IN SOUTHERN DORCHESTER BAY

Beneficial Use	Present Use Level* (H,M,L,N)	Existing Supported Use (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	High	3	Stormwater, CSO, Neponset River
Secondary Contact Recreation	High	2	Stormwater, CSO, Neponset River
Aquatic Life	Moderate	2	Stormwater, CSO, offshore sources
Fish Consumption	Moderate	(?)	
Aesthetics	High	2	Stormwater, CSO
Shellfishing	None	3	Stormwater, CSO, Neponset River

* To be determined through public participation process

** 1 = almost always; 2 = sometimes, 3 = almost never

CHAPTER 16
NEPONSET RIVER

16.1 DEFINITION OF RECEIVING WATER SEGMENT

The Neponset River is located south and southwest of Boston and drains into Dorchester Bay. This discussion emphasizes the portion of the watershed impacted by CSOs, i.e. downstream of Mattapan Square in Boston; it includes the mouth of the river down to the Port Norfolk Yacht Club in Dorchester (Figure 16-1).

16.2 EXISTING WATER QUALITY STANDARDS AND PRESENT USE

The Neponset River is currently classified SB-Fishable/Swimmable plus restricted shellfishing. Water-based uses of the Neponset River include boating. Shellfish beds have been identified by the Massachusetts Division of Marine Fisheries along the Neponset but harvesting in this areas is currently prohibited.

Land uses near the mouth of the river include parks and land designated by the MDC for future park development (Figure 16-2). Further upstream along the river, the land use in Quincy, Milton and Boston becomes primarily residential. Public open space includes the Neponset Marshes and the Blue Hills Reservation. This section of river would be part of MDC's proposed plan to link Castle Island to the Blue Hills Reservation with a public path.

16.3 CHARACTERIZATION OF WATERSHED

16.3.1 Location

The Neponset River watershed is located in eastern Massachusetts and flows 45 km from Neponset Reservoir in Foxboro to Dorchester Bay (Figure 16-2) (Massachusetts Water Resources Commission, 1991). Total drainage is 323 square km. The eleven towns with a portion of their land area in the watershed are listed below:

Canton
Dover
Medfield
Norwood
Stoughton
Westwood
Dedham
Foxborough
Milton
Sharon
Walpole
Boston
Quincy

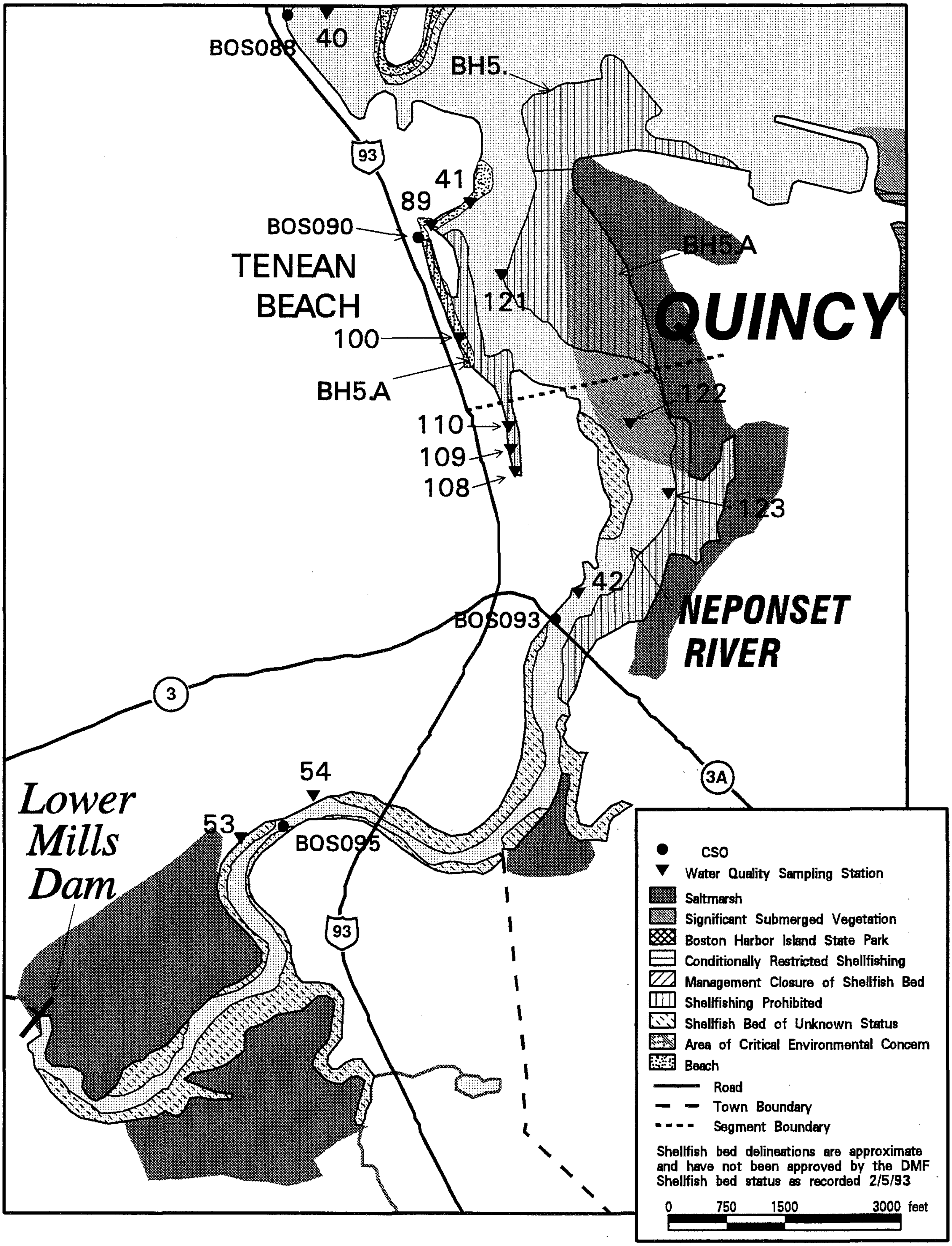


FIGURE 16-1. NEPONSET RIVER

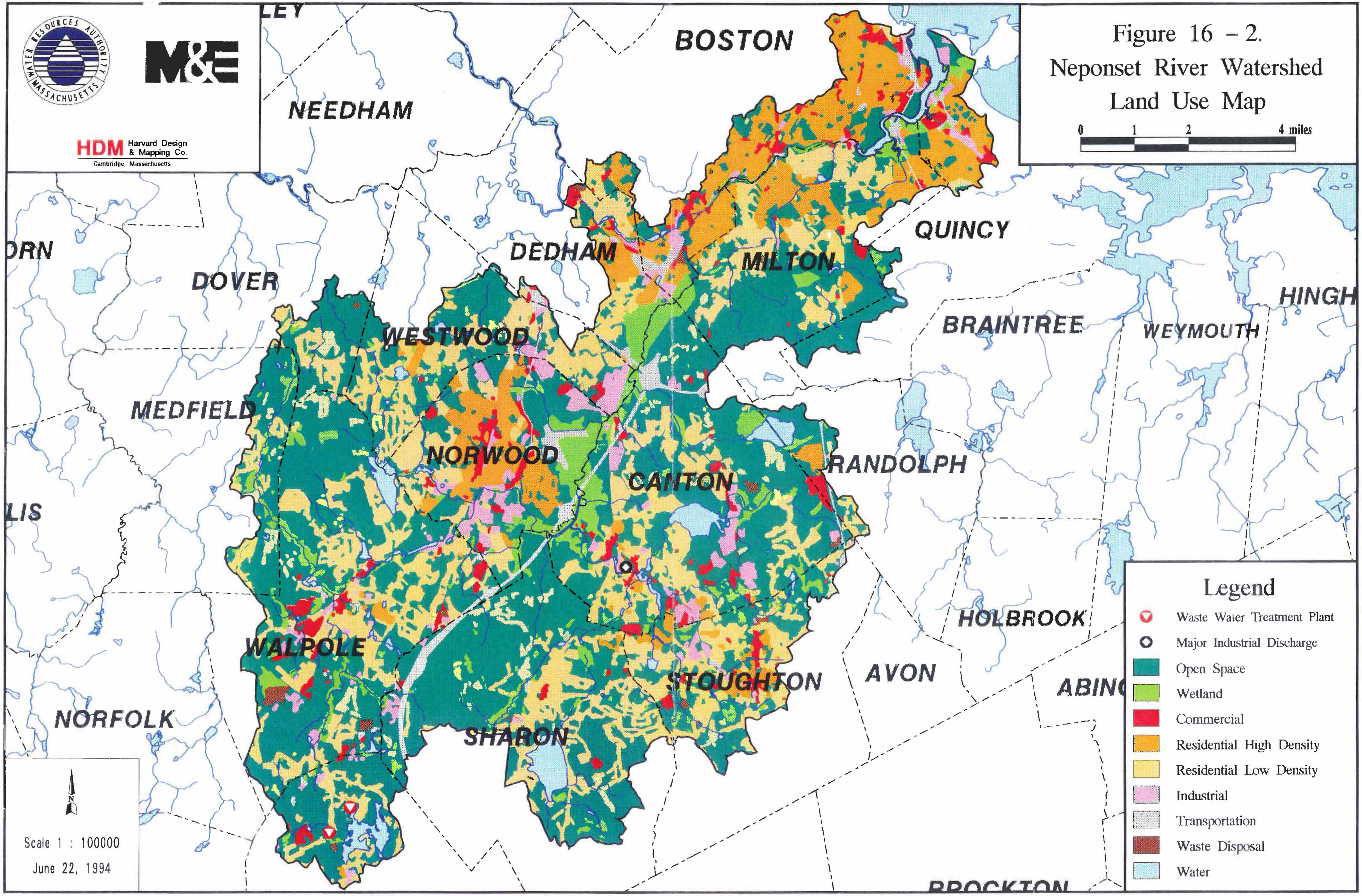


Figure 16 – 2.
Neponset River Watershed
Land Use Map

16.3.2 Topography and Soils

The river has a low hilly topography, resulting in a small gradient and several large wetlands (Massachusetts Water Resources Commission, 1991). The upper portion of the watershed has many forests, swamps, and wetlands. The lower portion is heavily urbanized, with the exception of Neponset River State Reservation, a large natural wetland and grassy area of approximately two square miles downstream of Milton Village in Milton, Boston, and Quincy. The last four miles of the Neponset River, below Milton Lower Mills Dam, are tidal.

Major tributaries to the Neponset River include the Mine Brook in Walpole, Hawes Brook in Norwood, Massapoag Brook in Canton, East Branch Neponset River in Canton, and Mother Brook from the Charles River in Dedham. Pine Neck Creek discharges into the estuary near Tenean Beach.

There are two continuous gages in the watershed: Neponset River at Canton and East Branch Neponset River at Norwood. Over the period 1939 to 1989 the Neponset River flow at Norwood (area of 89.9 km^2) had an average annual flow of 1.6 m^3/s. Mean monthly flows vary from 0.59 m^3/s in July and September to 3.2 m^3/s in March. Average monthly flows during the 1980-81 drought (15 year recurrence interval) ranged from 0.11 m^3/s to 3.45 m^3/s. Flows in the watershed are generally slowly varying due to the stratified drift covering approximately 50 percent of the watershed, wetland areas, impoundments in the watershed, and the low slope.

The soils of the non-paved and undisturbed portions of the lower watershed are either Merrimac (MnB), Charlton (ChB), Ipswich (Ip), or Paxton (PaD) (USDA, 1991). These are of low erosion potential. In the upper watershed, soils include Merrimac (MnB, MmB), Saco (Sa), Sudbury (SuB), Swansea (Sw), Canton (CaB), Hinckley (HfD, HfC) and Rippowam(Rm) (USDA, 1991). With the exception of the Saco soil, these are all of low erosion potential. Saco is of moderate erosion potential.

16.3.3 Dams, Highways, and Other Man-Made Features

The watershed is impacted by several major highways. Routes 1 and I-95 pass through the upper portion of the watershed. The heavily urbanized lower part of the watershed is crossed by the Southeast Expressway (Interstate 93) and Quincy Shore Drive, Granite Avenue, and the MBTA Red Line tracks. A commuter rail bridge is currently under construction.

The Neponset Reservoir in the headwaters is controlled by industries in the watershed. The reservoir is used to store water in the winter and the spring and release it in the summer to improve low flows. There are also other impoundments in the watershed. The impoundment closest to the mouth of the river (most downstream) is the Milton Lower Mills Dam.

16.3.4 Wetlands

There are many wetlands in the upper watershed. Extensive wetlands are also in the State Reservation near the mouth.

16.3.5 Watershed Towns, Upstream Land Use, and Upstream Pollution Sources

The watershed area upstream of Mattapan Square is generally residential with large areas of wetlands and forests near the river. The water quality of the river above Milton Lower Mills Dam (approximately one mile below Mattapan Square) is nonsupporting of Class B/WWF (MassDEP, 1993a). Causes include pathogens, suspended solids, organic enrichment/dissolved oxygen, and oil and grease. Immediate causes are listed as CSOs (or interceptor overflows) and stormwater runoff. A 1986 river survey found water quality to be generally poor throughout the watershed (Massachusetts Water Resources Commission, 1991). DO concentrations were below 5.0 mg/l in some stations. Nutrient levels were high throughout and all impoundments had high levels of algal and weed growth. Fecal coliform standards were violated at least once at each station. Nonpoint sources were cited as a significant problem. Besides stormwater runoff and CSOs, nonpoint sources included malfunctioning sewer systems, failing septic systems in nonsewered areas (upper reaches), and in-place sediments (Massachusetts Water Resources Commission, 1991).

In 1988, there were three cooling water discharges to the Neponset River and a small discharge from Foxborough State Hospital (Massachusetts Water Resources Commission, 1991).

16.4 SOURCES OF POLLUTION

16.4.1 General

The Neponset River is polluted by upstream sources, storm drains and CSOs. Estimated flows and loads from these sources (future planned conditions) are shown in Figures 16-3 and 16-4. The small CSO flows and loads of the three-month storm will increase about 120% from existing to "future planned" conditions. The "boundary" flow is the net freshwater flow of the river over the Lower Mills Dam.

16.4.2 Stormwater Discharges

The lower portion of the watershed is highly urbanized with high density housing and commercial activities. There are storm drains from both land and highway activities in the area. The Neponset River State Reservation wetland may mitigate some of the runoff water quality impacts. BWSC screening of storm drains below the Lower Mills Dam identified only one

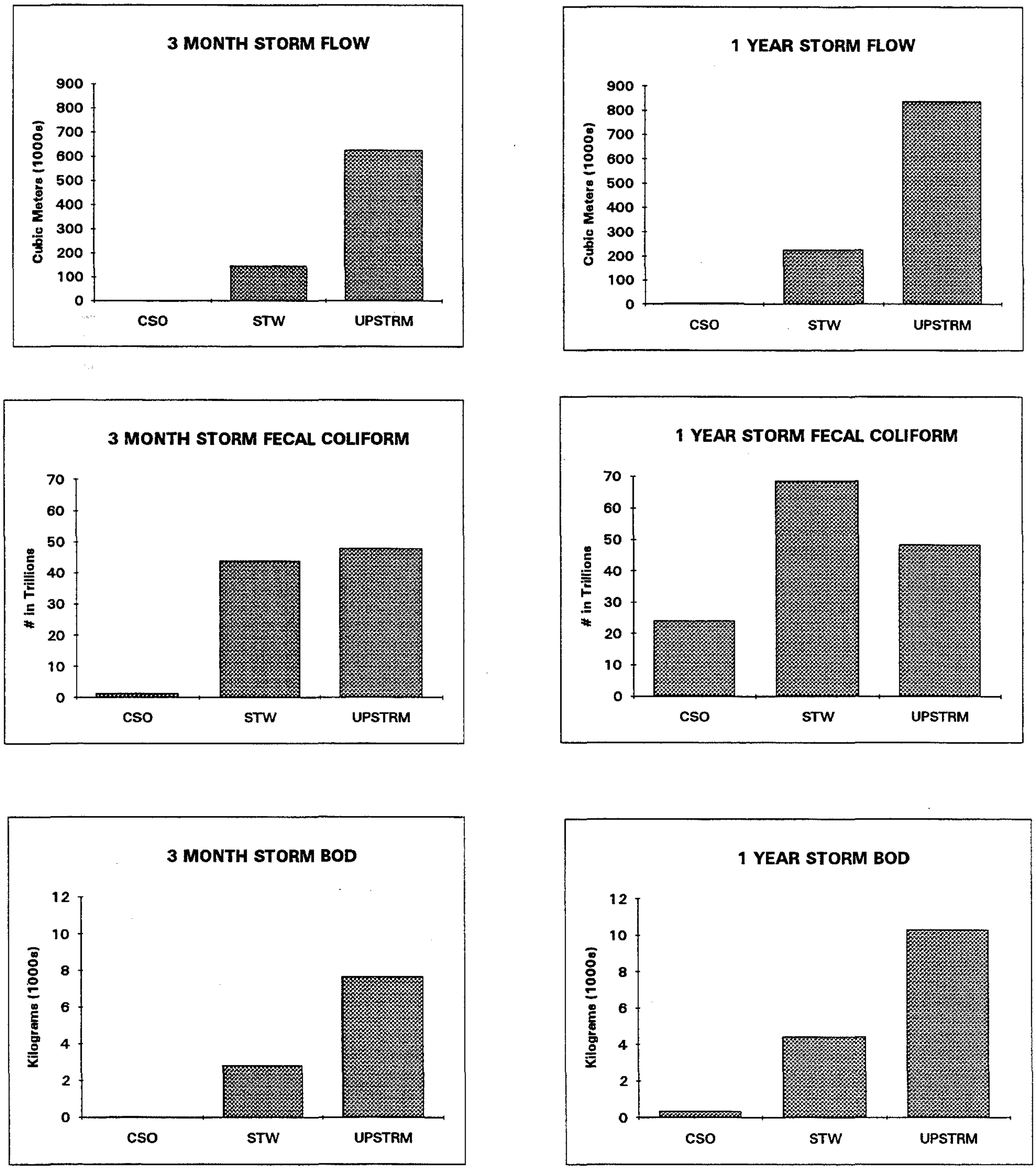


FIGURE 16-3. FUTURE PLANNED FLOWS AND LOADS FOR THREE MONTH AND ONE YEAR STORM EVENTS - NEPONSET RIVER

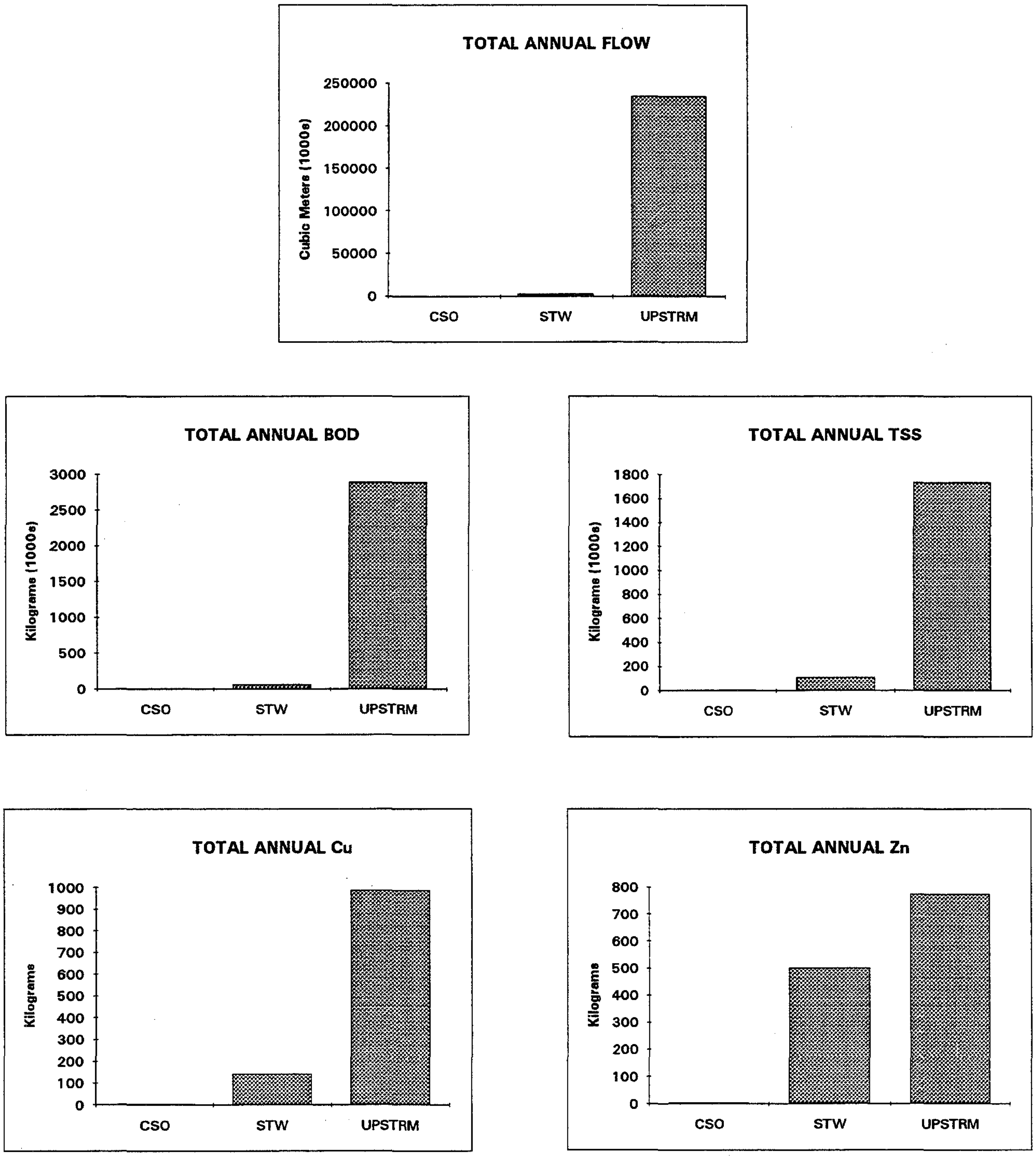


FIGURE 16-4. FUTURE PLANNED ANNUAL FLOWS AND LOADS - NEPONSET RIVER
(a) FLOWS, BIOCHEMICAL OXYGEN DEMAND,TOTAL SUSPENDED SOLIDS, COPPER, ZINC

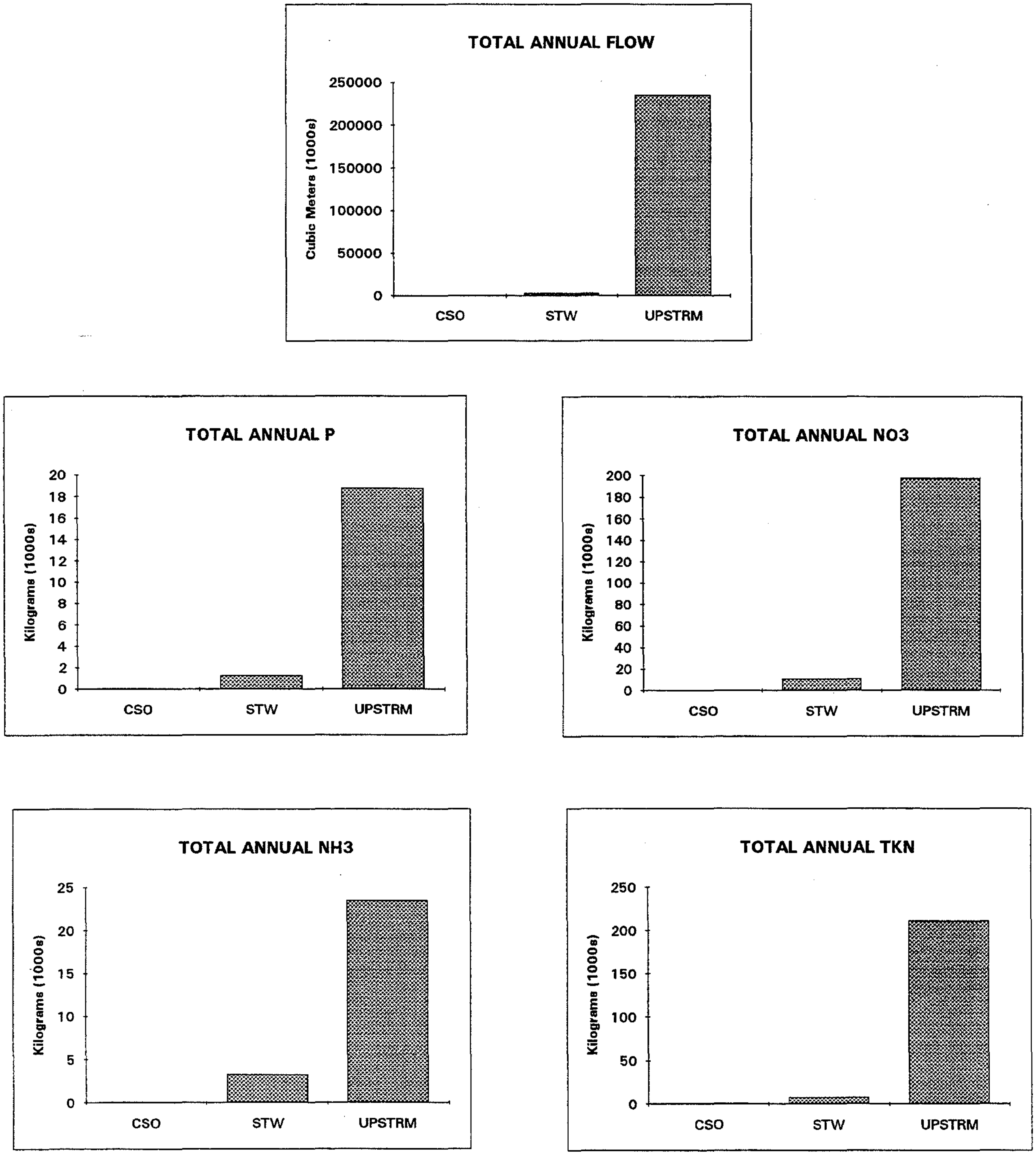


FIGURE 16-4. FUTURE PLANNED ANNUAL FLOWS AND LOADS - NEPONSET RIVER
(b) FLOWS, TOTAL PHOSPHORUS, NITRATE,AMMONIA, TOTAL KJELDAHL NITROGEN

which may have contamination with debris and/or oil (BWSC 1991, 1993). Contamination of stormwater upstream of the CSO receiving water segment is discussed in Section 16.4.4 of this report. In general, stormwater concentrations of fecal coliform bacteria, suspended solids, and BOD are lower than concentrations in combined sewage, while the concentrations of nutrients and metals are similar (Metcalf & Eddy 1994a, 1994b).

16.4.3 CSO Discharges

There are active CSOs in the State Reservation and downstream of Quincy Shore Drive. Both of the CSOs were monitored during 1992 (MWRA, 1993a); of these, one required one-half inch or greater of rain to cause an overflow, while the other overflowed after about 0.1 inches of rain (Table 6-6 in MWRA, 1993a). CSO inspections in 1992 identified possible tide gate problems and accumulated sand and debris at BOS093.

16.4.4 Upstream Inputs

The bacteriological water quality of the Neponset River upstream of the CSOs is nearly always worse than that near the CSOs, in both dry and wet weather, indicating that the river upstream is an important source (Rex, 1993). A study by MWRA and the Neponset River Watershed Association indicated that upstream problems are due to a number of sources of sewage along the river (Rex, 1993). Several storm drains above the Lower Mills Dam were found to be contaminated with sewage in BWSC dry-weather screening (BWSC 1991, 1993).

16.5 HYDRODYNAMICS

16.5.1 Nearfield Mixing

CSO discharges to the Neponset River would receive similar initial mixing as those in Dorchester Bay. Because of the relatively narrow width, especially at times of low tide, the plumes would mix across the river, and those discharging far from the mouth would be limited by tidal flushing which results in a build-up of background concentrations. Estimates made for a typical CSO event (discharge from BOS095 during the storm of August 17-18, 1992) suggest that dilutions of about 5, 12, and 30 are obtained at distances of 30, 100, and 300 meters downstream from the CSO (E. Adams, MIT, pers. comm., 1994).

16.5.2 Farfield Mixing

Farfield mixing of shoreline discharges is affected by tides and river flow. As the estuary opens out toward southern Dorchester Bay, pollutant concentrations will be reduced by dilution with relatively clean Boston Harbor water.

16.6 EXISTING RECEIVING WATER QUALITY

Existing water quality conditions are summarized on Figure 16-5.

16.6.1 Bacterial Contamination

Fecal coliform data from the first five years (1989-1993) of MWRA CSO receiving water monitoring are shown in Figure 16-6. Fecal coliform counts decrease downstream in both wet and dry weather, with the highest counts upstream of the CSOs. At the upstream station, the fecal coliform counts exceed the Class SB (and Class SC) standards under both wet and dry conditions.

16.6.2 Dissolved Oxygen

Dissolved oxygen data for the first five years of MWRA CSO receiving water monitoring are shown in Figure 16-7. Surface dissolved oxygen concentrations in the Neponset River ranged from 1.3 to 12.0 mg/l, with a mean of 6.3 mg/l, in daytime sampling for the routine receiving water monitoring between 1989 and 1992 (MWRA, 1991, Rex, 1993, unpublished MWRA Harbor Studies data). In the same period, bottom dissolved oxygen concentrations ranged from 2.6 to 7.3 mg/l, with a mean of 5.6 mg/l.

16.6.3 Aesthetics - Solids and Floatables; Odor; Color and Turbidity

In 1991, sewage related floatables were detected on the shore in vicinity of BOS093 by the Granite Avenue drawbridge. Small discharges from BOS093 were observed during and after rain in 1991.

16.6.4 Oil and Grease

There were two stations in the Neponset River during the 1988 sampling for the 1990 MWRA CSO Facilities Plan (CH2M Hill, 1989). At the upstream station (SS8) at the Lower Mills Dam, oil and grease measurements ranged from 1 to 5 mg/l, while at the downstream station (SS9, near BOS093), oil and grease ranged from 1 to 58 mg/l (with a mean concentration of 8 mg/l

		Dry Conditions	Wet Conditions	Overall Quality	Comments	Existing uses affected	Health/ eco-system risk	Pollutant Sources
	Bacteria (1,6,7)	●	●	●	worse than Alewife or Charles highest upstream, wet	swimming shellfishing boating	●	upstream, CSOs, SW
	Dissolved Oxygen (1,6)	◍	◍	◍	lower than Dot Bay but mostly meets standard	aquatic life fishing shellfishing	◍	upstream CSO, SW
Aesthetics	Solids and Floatables (1,2)	○	●	●	sewage related floatables near BOS93	aquatic life, swim, boat, recreation	●	CSO
	Color and Turbidity (1,2)	○	●	●	plumes near BOS093	swimming boat, recreation		CSO
	Odor (2)	○	○	○		swimming, boat, recreation		
	Oil and grease (2,4)	○	●	◍	slicks, high grease @ BOS093 and @ dam	aquatic life	●	CSO, upstream
	Bottom pollutants or alterations (3)	N/A	N/A	◍?		aquatic life	◍	upstream CSO, SW remote source
	Nutrients (4,5) (algal blooms)			●	fair/poor based on total P; few data	aquatic life	●	
	Toxic Pollutants	?	?	?		aquatic life fishing shellfishing	?	
	Temperature (6)	○	○	○		aquatic life	○	
	pH (4)			◍?	few data	aquatic life	?	

Key:
- ● poor quality or high risk
- ◍ fair quality or moderate risk
- ○ good quality or low/no risk
- ? insufficient data

FP = Fox Point CSO facility
CP=Commercial Pt. CSO facility
SW=stormwater
N/A= not applicable
PAH=polycyclic aromatic hydrocarbons

Sources of information on present conditions
1 - Rex, 1993
2 - A. Rex and other monitoring staff, pers. comm. 1993
3 - Durell et al. 1991
4 - CH2M Hill, 1989
5 - DWPC, 1988
6 - Harbor Studies data
7 - MWRA, 1991

FIGURE 16-5. SUMMARY OF EXISTING WATER QUALITY CONDITIONS - NEPONSET RIVER

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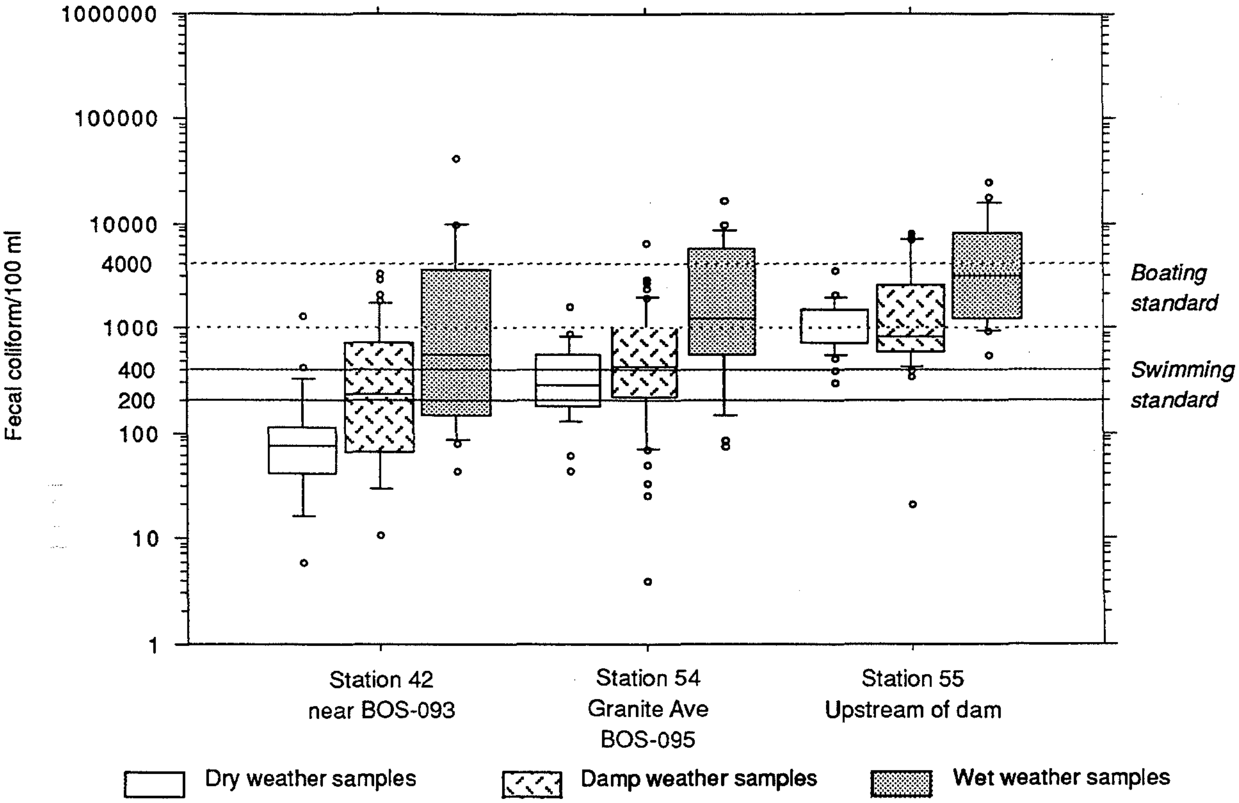
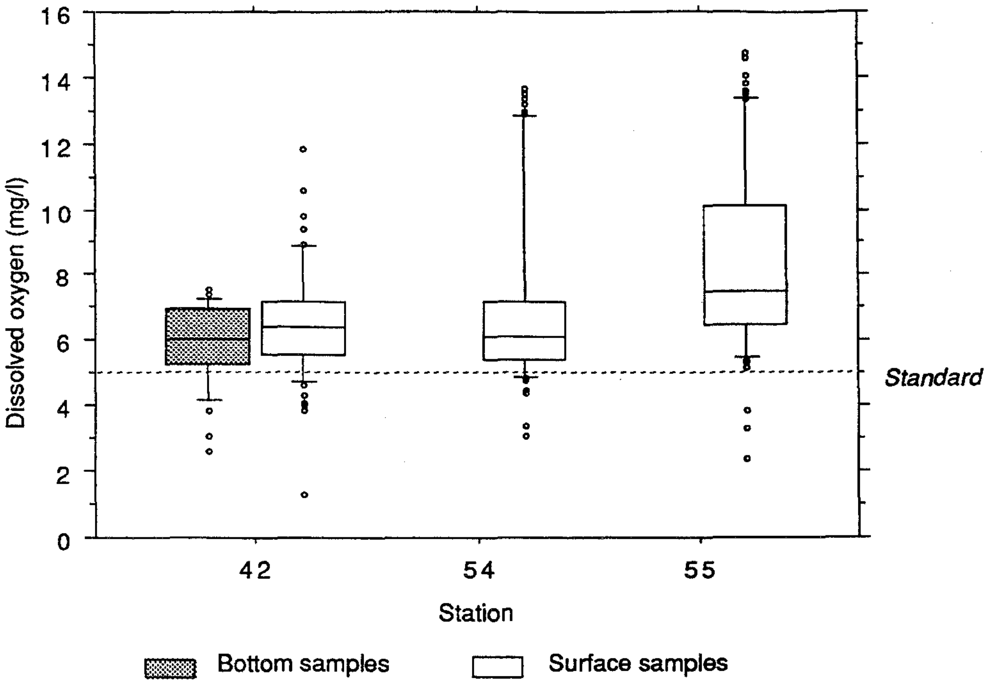


Station	Condition	No. of Samples	Minimum*	Maximum*	Geom. Mean*
42	Dry	25	6	1386	73
42	Damp	36	1	3551	198
42	Wet	17	46	44001	739
54	Dry	22	46	1611	313
54	Damp	46	4	6701	412
54	Wet	24	76	17001	1389
55	Dry	30	321	3726	1039
55	Damp	42	21	8101	1151
55	Wet	18	566	25501	3353
	TOTAL	260	1	44001	544

* Number of Counts per 100 ml
Dry weather samples collected when the rain on the day of sampling plus the rain on the previous two days (three-day rain) = 0.0".
Damp weather samples were collected when three-day rain was between 0.0" and 0.5".
Wet weather samples were collected when three-day rain >0.5".

FIGURE 16-6. FECAL COLIFORM MONITORING DATA FOR NEPONSET RIVER - SURFACE SAMPLES (1989-93)



Station	Sample Type	No. of Samples	Concentration (mg/l)			
			Mean	Median	Minimum	Maximum
42	Bottom	35	5.9	6.0	2.6	7.6
42	Surface	69	6.6	6.4	1.3	11.8
54	Surface	85	7.1	6.1	3.1	13.7
55	Surface	87	8.4	7.5	2.4	14.8
	TOTAL	276	7.2	6.6	1.3	14.8

Note: No bottom measurements were made at stations 54 and 55

FIGURE 16-7. DISSOLVED OXYGEN CONCENTRATIONS IN NEPONSET RIVER (1989-93)

3756jp

and a sample size of 15). This indicates a possible oil and grease problem associated with BOS093. Occasionally during sampling, MWRA monitoring staff detected some oil slicks in the Neponset River at the Milton Lower Mills Dam.

16.6.5 Bottom Pollutants or Alterations

Durell *et al.* (1991) sampled one station in this segment at the mouth of the Neponset River; these data are discussed in Chapter 15. There are no available data on the benthic communities of the Neponset River estuary.

16.6.6 Nutrients

Nutrient concentrations in the Neponset River were last regularly monitored in 1987 by the Massachusetts Division of Water Pollution Control (Mass DWPC, 1988b). The data were all collected in summer and may not be representative of other times of the year. Nitrogen concentrations were not monitored. Total phosphorous ranged from 0.15 to 0.21 mg/l, with a mean of 0.19 mg/l. This range corresponds to the "fair" to "poor" categories of EPA's use attainability guidance (EPA undated). The 1986 concentrations were slightly lower than those observed in previous years; 1984 and 1985 mean total phosphorus concentrations were 0.25 and 0.28 mg/l, respectively. CH2M Hill (1989) measured nutrients at their two Neponset River stations; the data are given in Table 16-1. No chlorophyll data are available for this region of the harbor.

TABLE 16-1. RANGES OF NUTRIENT CONCENTRATIONS IN THE NEPONSET RIVER

Station	Total Phosphorus (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)
Upstream (SS8)	0.1 - 0.1	0.3 - 9.8	0.1 - 0.3	0.1 - 39.0
BOS093 (SS9)	0.1 - 0.2	0.2 - 0.8	0.3 - 0.9	0.1 - 38.0

Source: CH2M Hill, 1989

16.6.7 Toxic Pollutants and Toxicity

There are no suitable data on toxic contaminants for the Neponset River estuary.

16.6.8 Temperature

Surface temperature in the marine section of the Neponset River did not exceed the SB standard of 85°F in any of the routine receiving water monitoring between 1989 and 1992 (MWRA, 1991; Rex, 1993, unpublished MWRA Harbor Studies data).

16.6.9 pH

In the 1989 CH2M Hill sampling, pH in the Neponset River varied from 6.8 to 8.3, and thus, there were violations of the state standard, which allows a maximum of 8.0.

16.7 USE ATTAINMENT

16.7.1 Watershed Context

The area draining directly into the CSO receiving water segment at the mouth of the Neponset River includes parkland and transportation, industrial, and residential land uses. The water quality of the estuary is strongly affected by upstream water quality problems, above the Milton Lower Mills Dam. High bacteria counts in this area -- upstream of all CSOs -- appear to be due to a number of sources of sewage along the river's length.

16.7.2 Existing Water Quality and Affected Uses

Figure 16-8 shows the effect of water quality on uses of the Neponset River segment. Bacteria levels decrease downstream, but most of this segment violates the swimming standard in dry weather. The boating standard of 1000 fecal coliform/100 ml is violated in wet weather, but met in dry and damp weather. Aquatic life is affected by occasionally low dissolved oxygen, as well as by high nutrient and oil and grease levels. Oil slicks and sewage-related floatables associated with CSO discharges impair the river's aesthetic quality.

16.7.3 Baseline ("future planned") Water Quality and Affected Uses

The Neponset River CSO discharges are small and are expected to remain so under future planned conditions, so baseline water quality will be similar to existing water quality.

The Neponset River receiving water segment was not included in the water quality model. Based on model results in southern Dorchester Bay, it is likely that CSOs alone would close nearby shellfish beds and possibly nearby beaches as well. The CSOs discharges are small and have a relatively small impact on bacteria levels compared to upstream sources and stormwater.

Figure 16-8. Beneficial uses affected by water quality in Neponset River

Class B

Water Quality Assessment

MWRA CSO/System Master Plan

Use Criteria (1)

Beneficial Uses	D. O.	T	pH	Cl	WET	Toxics	BIP	Fecal Coliform	Turbidity	Color	Oil and Grease	Taste and Odor	Nutrients	Floatables	Other
Fish Consumpt.						?					?	?			
Aquatic Life	ok	ok	ok ?	ok	ok	▨ ?	?		?		?		▨ C ?		
Primary Contact Rec.								▨ C	?		?	?		?	
Secondary Contact Rec.								▨ W							
Aesthetics									?	?	▨ W ?	?	▨ C ?	?	
Shell Fishing (Rest.)								▨ C							

WET: Whole Effluent Toxicity

Toxics: Pesticides, Other Organics & Inorganics and Chronic Bioaccum.

BIP: Balanced Indigenous Population

(1) Use Criteria per WQS and 305(b) Use Attainment Guidelines

Legend:
ok Attained for Criteria
▨ Proven or Probable Non-Attainment
W Wet Weather Non-Attainment
C Wet and Dry Weather Non-Attainment

Unless these non-CSO sources are reduced, it is unlikely that criteria for achieving beneficial uses will be met. Table 16-2 summarizes bacterial impacts in the Neponset River now and under future planned conditions.

Table 16-3 summarizes the level of use of the Neponset River and the factors affecting attainment of the uses.

TABLE 16-2. IMPACTS OF FECAL COLIFORM FROM CSOs AND STORMWATER ON NEPONSET RIVER

	Current		3 month storm			1 year storm		
Neponset River	Dry	Wet	CSO	SW	Both	CSO	SW	Both
Primary	?	***	?	***	***	***	***	***
Secondary	OK	***	OK	***	***	OK	***	***
Shellfish	***	***	***	***	***	***	***	***

Key: CSO = CSO alone
SW = Stormwater alone
Both = CSO and stormwater
OK = Attains bacteria standard for class
*** = Violates bacteria standard for class
? = Partial attainment

TABLE 16-3. USE ATTAINMENT FACTORS IN THE NEPONSET RIVER

Beneficial Use	Present Use Level*	Existing Supported Uses (1,2,3)**	Causes of Non-Attainment
Primary Contact Recreation	Low-Moderate	2-3	Upstream flows, Stormwater CSO
Secondary Contact Recreation	Moderate	2	Upstream flows, Stormwater CSO
Aquatic Life	Moderate	2	Upstream flows, Stormwater CSO
Fish Consumption	Low-Moderate	(?)	
Aesthetics	High	2	Upstream flows, Stormwater CSO

* To be determined through public participation process

** 1 = almost always; 2 = sometimes; 3 = almost never

CHAPTER 17
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Interim Report

Receiving Water Model Description, Calibration and Baseline Assessment Report for the MWRA Master Planning and CSO Facilities Program

by

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May 1994
(revised June 1994)

(2nd revision June 1994)

Table of Contents

A Introduction

In support of MWRA's System Master Planning/Combined Sewer Overflow (CSO) Facilities Planning efforts, receiving water impacts from CSOs, stormwater and other sources are being evaluated. This evaluation is being performed by using fecal coliform bacterial loads computed from storm event (CSO, stormwater, and river boundary) modeling as input to receiving water quality models. Two such models are being used–one for the Charles River Basin and one for tidal receiving water adjacent to the greater Boston metropolitan region. This report provides a brief description of the two models, outlines the calibration procedures which were followed, and describes the results of baseline modeling efforts.

B Charles River Model Description

B.1 Model

Analysis for fecal coliform concentrations in the Charles River Basin (section between Watertown Dam and the Charles River Dam) uses a modified version of the one-dimensional, time-dependent model QUAL2EXP which was used in the previous 1990 MWRA CSO Facilities Plan (CDM, 1989b). The model was modified by stripping away most of the water quality analysis for non-bacterial pollutants which wasn't needed, leaving only the analysis for the transport and first order disappearance of fecal coliform bacteria. Although the basic solution methods were unchanged, the modified model required less than four pages of code which made it easier to incorporate changes such as those described below concerning dry weather loading.

The equations solved by the model are conservation of mass for water (continuity)

$$\partial Q/\partial x = q_L \qquad \text{(B.1)}$$

and conservation of "mass" for bacteria

$$\partial c/\partial t + (1/A)\partial(Qc)/\partial x = (1/A)\partial(AD\partial c/\partial x)/\partial x - kc + q_L c_L/A \qquad \text{(B.2)}$$

where $Q(x,t)$ is river flow rate, $q_L(x,t)$ is the lateral inflow rate per length of river, x is the downstream coordinate, $A(x)$ is the river crossectional area, $c(x,t)$ is the bacterial count, D is a longitudinal dispersion coeficient, k is a first order disappearance rate, and $c_L(x)$ is the bacterial count of lateral inflow (which may include CSO, stormwater and/or dry weather loads). the model presumes no storage; hence Eq. B.1 is solved at each time step by successively adding the lateral inflows to the upstream river flow to obtain the river flow at each segment. Eq. B.2 is solved with an explicit finite difference scheme using upwind differencing for advection. Boundary conditions for Eq. B.2 specify no dispersive flux across either the upstream (Watertown) or downstream (Charles River) dams.

B.2 Model Segmentation and Time Step

The Charler River Basin is divided into 118 segments of equal volume, identical to those used in the previous 1990 MWRA CSO Facilities Plan. Because the upstream reaches are relatively shallow and narrow, their segments are relatively long in comparison to the downstream seqments. The original reason for choosing equal volume segments, as expressed in the previous 1990 MWRA CSO Facilities Plan, was to allow the model to be run using values of the Courant number (Cu) close to one. Cu is defined as

$$Cu = uDt/Dx = QDt/DV \qquad (B.3)$$

where u = Q/A is the river velocity, Dt is the time step, Dx is the segment length, and DV is the segment volume. The ostensible advantage of having Cu = 1, in turn, is that it minimizes numerical diffusion. For an upwind differencing scheme, the numerical diffusion coefficient (D_n) is given by (Roache, 1982)

$$D_n = (uDx/2) * (1 - Cu) \qquad (B.4)$$

For the present calculations, the idea of trying to maintain Cu = 1 was abandoned for three reasons:

1) During storms tributary flows can be substantial, causing the river flow to increase with distance downstream. Unless the grid cell volume were to change dynamically, the Courant number would necessarily vary, causing large temporal and spatial variations of D_n.

2) Requiring Cu = 1 places an upper limit on the amount of input dispersion D_i which can be used in an explicit model. In order to provide numerical stability in an explicit scheme,

$$D_i Dt/Dx^2 < 0.5 \qquad (B.5)$$

which, combined with Eq. B.3, translates to

$$D_i < uDx/2 = QDV/2A^2 \qquad (B.6)$$

In other words, by requiring Cu = 1 in an explicit model, we are limited to a maximum effective (input plus numerical) diffusion coefficient of $uDx/2 = QDV/2A^2$. Conversely, with an arbitrary (small) value of Cu, the effective value of dispersion is equal to the input value (which is unrestricted) plus the numerical value, which for small Cu is approximately $uDx/2 = QDV/2A^2$. Thus, for small Cu, the minimum value of the effective dispersion coefficient is $QDV/2A^2$ which is the maximum value under the constraint of Cu =1. For the Charles River Basin as discretized, the numerical dispersion coefficient ($QDV/2A^{2}$) ranges from about 30 m^2/s upstream to about 0.1 m^2/s downstream. As discussed below, the physical dispersion coefficient is expected to be of order 10 m^2/s, which can only be obtained (at least in the downstream portions) by relaxing the constraint of Cu = 1.

3) Finally, as seen from Eq. B.3, choosing Cu = 1 requires that the time step be inversely proportional to flow rate. This results in large and variable values of Dt (several hours). The variable time step adds a degree of complexity when Charles River model output must be interpolated in time to provide input to the downstream Boston Harbor model at constant 62 minute time steps or to provide comparisons with measured concentrations in the river.

B.3 Calibration

Calibration involved determined optimal values of k and D through comparison of simulated fecal coliform counts with corresponding measurements. **Fig. B.1** shows the pollutant source locations and **Fig. B.2** shows the receiving water quality sampling locations used for the Charles River model calibration. **Fig. B.3** shows receptor locations used in the baseline assessment scenarios described in Section D. Before this stage of calibration could be performed, however, it was necessary to estimate the magnitude of lateral dry weather loadings.

B.3.1 Dry Weather Loads Unlike wet weather loads associated with stormwater and CSOs, dry weather loads have neither been measured nor modeled in a comprehensive manner. Therefore dry weather loads were calculated by matching simulated bacterial counts computed without any wet weather loading (i.e, no stormwater or CSO loads and only base loads from the Charles River upstream) to measured dry weather counts measured by the MWRA. These dry weather data consisted of the geometric means of historical fecal coliform counts collected over the period 1989-1993 at five locations within the basin. Fig. **B.4** shows the geometric mean counts at the five locations (along with the 95% confidence estimates of the geometric means), connected by linear interpolation. By inverting Eq. B.2, and using the same numerical discretization, values of the product $q_L c_L$ at each of the 118 model segments can be determined for any values of k, D and dry weather flow rate by matching simulated concentrations to dry weather measurements. Assuming steady state conditions, constant dispersion and negligible inflow rate q_L in comparison with the upstream dry weather flow Q_{dw},

$$q_L c_L = kAc_{dw} + Q_{dw}(\partial c_{dw}/\partial x) - D\partial(A\partial c_{dw}/\partial x)/\partial x \qquad \text{(B.7)}$$

Note that the effect of the calibrated dry weather loadings is to add the distribution of dry weather counts shown in Fig. B.4 to the counts computed in response to the wet weather inputs. Eq. B.7 was embedded in the code for use with future model calibration and simulation runs.

B.3.2 Coliform Disappearance and Longitudinal Dispersion The remaining calibration involved the two free model parameters: a first-order disappearance rate k and the longitudinal dispersion ceofficient, D. Calibration consisted of estimating optimal constant values of these two parameters, consistent with ranges suggested by theoretical analysis (D) and prior studies reported in the literature (k). Hence the first step was to identifiy acceptable ranges for these parameters.

Bacterial disappearance is a function of a number of factors including sunlight, temperature and salinity (Mancini, 1978; Fujioka et. aL, 1981). Of these, sunlight is the most important, with values of k during the day higher by an order of magnitude than those during the night (Bell, Munro and Powell, 1992). If bacterial concentrations are being simulated for several days, a daily average value is appropriate and literature indicates daily average values of k in the range of 0.5 to 2 d^{-1} (Mancini, 1978). By comparison, the calibrated value of k for the July 1988 storm used in the previous 1990 MWRA CSO Facilities Plan was 1.5 d^{-1} (CDM, 1989b).

Following Fischer et al (1979), the value of longitudinal dispersion can be expected to be about 10 m^2/s in the upstream reaches of the Charles River (before the river widens substantially at the B.U. Bridge). Below this point, contaminant concentrations many not be mixed completely across the river, making it difficult to analysis longitudinal dispersion theoretically. However, extrapolating from field measurements reported in CH_2M-Hill (1990), one could expect to find roughly similar values of longitudinal dispersion in the dowstream portions. Values of D used in the previous 1990 MWRA CSO Facilities Plan are not relevant here because, as indicated above, they were limited by numerical stability constraints to values considerably less than the expected physical values. It should also be noted that the value of D is expected to be somewhat less important than the value of k in regulating fecal coliform counts in the Chalres River.

Values of k and D were chosen by calibration to data collected during two storms: October 30, 1993 and November 28, 1993. In both cases, upstream loads (at Watertown Dam) and lateral inflows from a total of 16 treated and untreated CSO and stormwater discharges were provided from the results of storm event model simulations. All input data were averaged over 62 minute intervals (the same interval of one-twelfth of a tidal period used in the downstream harbor model) and the model was run with a time step consistent with Eq. B.5. Simulations were continued for eight tidal cycles or a little over four days. Initial conditions and dry weather loadings were provided by the dry weather data discussed above.

Simulations were compared with measurements collected after the two storms. For the storm of October 1993, measurements were collected at eight sites at up to five times (see **Figs B.2** and **B.7**) and for the November 1993 storm, measurements were collected at nine sites at up to seven times (see **Figs. B.2** and **B.8**). In cases where duplicate samples or both near surface and near bottom samples (denoted respectively by o and x in **Figs. B.7** and **B.8**) were collected, these were arithmetically averaged and treated as a single measurement. Thus a total N of about 40 samples for the first storm and 60 samples for the second storm were available for comparison. Calibration consisted of computing the root-mean-square-log (RMSL) error associated with each of the N measurements. The RMSL error is defined as:

$$\text{RMSL Error} = [\, (1/N) \textstyle\sum_i (\log c_i^s - \log c_i^m)^2 \,]^{1/2} \qquad \text{(B.8)}$$

where $\log c_i^s$ is the $\log_{10}$ of the ith simulated count and $\log c_i^m$ is the $\log_{10}$ of the ith measured count. RMSL errors as a function of k and D are shown in **Fig. B.5**, and **B.6** for the two storms. From **Fig. B.5** we conclude that the optimal values of k and D for the October 1993 storm are about 0.5 d^{-1} and 1

m^2/s. For the November 1993 storm **Fig. B.6** shows that the optimal values are about 1 d^{-1} and 5 m^2/s. We should note that the calibrated D corresponds to the input dispersion coefficient D_i discussed previously, and that the effective dispersion coefficient is given by the sum of Di and D_n. The effective dispersion coefficient falls within the same ballpark as the expected physical value of order 10 m^2/s for most of the river.

In order to arrive at a single pair of calibrated parameters, the data for the two storms were pooled, and global optimal values of k and D were sought, by minimizing the combined RMSL error. The optimal values are about $k = 0.8\ d^{-1}$ and $D = 4\ m^2/s$, and these values are used in future simulations. The RMSL error for this combination is about 0.3 which compares with a value of about 0.8 reported for the July 1988 storm used for calibration in the previous 1990 MWRA CSO Facilites Plan (CDM, 1989b). **Figs. B.7** and **B.8** show comparisons of measured and simulated concentrations along the Charles River using $k = 0.8$ d^{-1} and $D = 4\ m^2/s$, and Figs. **B.9** and **B.10** depict these comparisons in equivalence form.

Figs. B.11 and **B.12** plot the distributions of dry weather loads (q_Lc_L) for the two storms using the optimal values of k and D. In each case the solid line is a linear interpolation of model results using all 118 calculated loads, while the dashed line depicts model results filtered using a running average. The total dry weather loading (obtained by adding all the loads along the river) is between $4*10^8$ counts/s and $5*10^8$ counts/s for each storm. The loadings are almost the same because, as seen from Eq. B.7, the simulations differ only by the dry weather flow Q_{dw}, which is taken as the base flow rate at the beginning of each storm. For both storms the loading is substantial. If the dry weather concentrations being used are representative of current dry weather conditions, this analysis suggests that the swimming standard of 200 counts/100 ml will be violated even if all of the CSO and storm water inputs are eliminated. Thus it appears that the issue of dry weather inputs deserves further attention.

C Boston Harbor Model Description

C.1 Model, Grid and Time Step

Harbor modeling used the same two-dimensional, time-dependent models TEA and ELA used for previous 1990 MWRA CSO modeling (CDM, 1989a; Adams and Zhang, 1991). Hence there is no need for a detailed description. The modeling procedures were also similar except that the finite element grid has been refined considerably and the sources have been aggregated differently. Adams and Zhang (1991) defend the use of aggregate sources, arguing that model grids are generally too course to resolve individual sources. The current number of aggregate sources is similar to the previous modeling, but the aggregation has been modified based on the newer storm water hydraulics. The finite element grid, computed velocities on this grid, and source locations are shown in **Figs. C.1, C.2 and C.3**, respectively. **Table C. 1** summarizes the actual CSOs and stormwater areas contained in each aggregate source. Boundary loads from the Mystic and Neponset Rivers and aggregate shoreline loads were obtained from stormwater and CSO portions of SWMM model output, while Charles River loads were obtained from the Charles River QUAL2EXP model, described in Section B.1, using output from the last model segment which represents the Charles River Dam. Initial concentrations and loadings from the Nut Island Wastewater Treatment Plant were assumed to be zero for the calibration, based on reviews of MWRA receiving water sampling conducted during dry weather, and a review of plant effluent sampling results during the calibration storms. Deer Island Wastewater Treatment Plant loadings were considered in the calibrations, as discussed below. The model used a time step of 62 minutes (one twelfth of a tidal cycle) and simulations were continued for 96 times steps or a little over four days.

C.2 Calibration

The main model parameters to be calibrated were the bacterial disappearance rate k and the dispersion coefficient D. For reference, values of $D = 10\ m^2/s$ and $k = 2\ d^{-1}$ had been used in the previous 1990 MWRA CSO Facilities Plan based on calibration against data collected during a July 1988 storm (CDM, 1989b).

Calibration of the harbor model was conducted in a manner similar to that of the Charles River, except that data from different storms were used; for the harbor model, water quality data were collected for storms of November 3, 1992 and September 26, 1993. **Fig. C.4** shows the locations of the measurements and **Fig. C.5** shows receptor locations used in the baseline assessment scenarios described in Section E below.

Data for the two storms were collected six times during each event at some or all of the eleven stations identified with an RW designation on **Fig. C.4**. Where duplicate samples were collected or samples were collected both near the surface and near the bottom, these were arithmetically averaged and considered as a single measurement. For the November 1992 storm 10 locations were sampled so the total number of measurements N was 60; for the September 1993 storm nine stations were sampled so N was 54. For each storm, the model was run using CSO, stormwater and upstream riverine boundary loadings provided from the SWMM model simulations. In addition, treatment plant loadings were estimated using a correlation provided by the MWRA between fecal coliform counts and the concentration of residual chlorine measured at the treatment plant. Based on this correlation, the loadings from the Nut Island Waste Water Treatment Plant were negligible throughout the two storms and were omitted. However, the loadings from the Deer Island Waste Water Treatment Plant were substantial. Counts in the range of several hundred to more than one million per 100 mL were computed by Eq. C.1 during several hours of each simulation, and these were supported by high counts recorded in several grab samples collected during the storms. The high loadings have a significant effect on receiving water concentrations near Deer Island, but their influence diminishes with distance from the Deer Island Treatment Plant. Because these loadings were inferred (rather than measured), and because they will not be present under future conditions (when the new outfall to Massachusetts Bay is in place), caution was exercised in the comparison of measured and modeled concentrations at the two measurement locations (RW10 and RW11 shown in **Fig. C.4**) nearest the Deer Island outfall.

Many simulations were run using different combinations of k and D. Model results were compared with the N measurements, and the combinations of k and D producing the lowest value of the RMSL error were sought. In accordance with the above discussion, separate calibrations were conducted which included and omitted data from the two measurement locations nearest the Deer Island Outfall (RW10 for both storms and RW11 for the September 1993 storm). **Figs C.6** and **C.7** plot the RMSL errors for the two storms. The curves in each figure represent the RMSL error as a function of k for a given value of D. The curves have been fit to the indicated data using quadratic interpolation. For the November 1992 storm, **Fig. C.6** suggests that the optimal combination of k and D is about 1.6 d^{-1} and between 30 and 40 m^2/s, respectively, using either all stations or omitting RW10. For the September 1993 storm **Fig. C.7** suggests optimal values of about 2 d^{-1} and 10 to 20 m^2/s with all stations and about 2 d^{-1} and 10 m^2/s without RW10 and RW11. As it turns out, the optimal parameter combinations are not very sensitive to the inclusion/exlusion of data from RW10 and RW11, but the magnitude of the RMSL error is somewhat higher during the September 1993 storm when these data are included.

As with the Charles River analysis, the data for the two storms were pooled and the global optima computed using all of the data points; **Fig. C.8** suggests optimal values of k and D of about 1.8 d^{-1} and 20 m^2/s. These values were used in future simulations. **Fig. C.9** plots measured versus simulated concentrations for the two storms using data contained in **Tables C.2** and **C.3**. We note that the value of k is only slightly smaller than the value of 2 d^{-1} determined during the previous 1990 MWRA CSO Facilities Plan and a little more than two times larger than the value of 0.8 d^{-1} fit to the Charles River data. This is not surprising, because salt water is toxic to bacteria. The value of D of 20 m^2/s is a factor of two higher than the value of 10 m^2/s used in the previous 1990 MWRA CSO Facilities Plan. However the higher value is consistent with the value anticipated from an earlier calibration against Inner Harbor dye measurements (Adams, et al, 1993). It should also be pointed out that the values of RMSL error are not as sensitive to D as they are to k (see **Figs. C.6-C.8**). The RMSL error for the optimal combination of parameters is a little over 0.9 using all stations and a little less than 0.8 without Stations RW10 and RW11; these RMSL errors compare with a value of about 0.9 reported for the July 1988 storm used in the previous 1990 MWRA CSO Facilites Plan (CDM, 1989b).

D Simulations of Baseline Water Quality in the Charles River.

D.1 Conditions Tested

The receiving water models were used to evaluate fecal coliform concentrations in the Charles River and Boston Harbor for seven baseline assessment scenarios (runs) identified in **Table D.1** and summarized briefly below:

1) existing conditions (1992-93) driven by a 3-month design storm. Inputs for this run include treated and untreated CSOs, storm water, and upstream boundary (river) sources. For the Charles River, the run also includes initial dry weather concentrations and model generated dry weather loads.

2) future planned conditions (1997) driven by a 3-month design storm. This run is similar to Run 1 except that the CSO and stormwater loadings have been modified in accordance with proposed system modifications which include SOPs and Intermediate Projects planned to be completed by 1997.

3) future planned conditions (1997) driven by a 1-year design storm. This run is similar to Run 2 except that it uses a 1-year rather than 3-month design storm.

4) future planned conditions (1997) driven by a 3-month design storm considering loading from CSOs only. This run is similar to Run 2 except that the storm water, dry weather, and boundary loads, as well as the initial conditions, have been set to zero.

5) future planned conditions (1997) driven by a 1-year design storm considering loading from CSOs only. This run is similar to Run 4 except that it uses a 1-year rather than a 3-month storm.

6) future planned conditions (1997) driven by a 3-month design storm considering loading from storm water, initial and model-generated Charles River dry weather sources and upstream (river) sources. This is similar to Run 2 except that the CSO loadings have been set to zero. Thus Runs 4 and 6 are complements; output from Runs 4 plus 6 should equal that of Run 2.

7) future planned conditions (1997) driven by a 1-year design storm considering loading from storm water, initial and model-generated Charles River dry weather sources and upstream (river) sources. This is similar to Run 3 except that the CSO loadings have been set to zero. Thus Runs 5 and 7 are complements; output from Runs 5 plus 7 should equal the output of Run 3.

D.2 Baseline Results for the Charles River

Results of the Charles River simulations for the seven baseline scenarios are shown on the various parts (a through c) of **Figs. D.1** through **D.7**. Part a) of each figure plots simulated fecal coliform counts versus distance at times of 1, 2, 3 and 4 days after the start of the simulation. Note that the simulations were begun at the high tide which precedes the start of any wet weather loading. The locations identified by abbreviations on the distance axis include the Newton Yacht Club (NYC), Weld Boat House (WBH), Magazine Beach (MB), the MWRA Cottage Farm Treatment Facility (CF), the Boston University Sailing Pavilion (BU), Stony Brook (SB), and the Community Boat House (CBH). Part b) of each figure shows computed concentration versus time at five receptors along the river: the Newton Yacht Club, Weld Boat House, Magazine Beach, the BU Sailing Pavilion and the Community Boat House. The loadings for each scenario from each source to the Charles River are shown on parts c) of each figure. The location of sources and receptors along the river are shown in Figs. **B.1** and **B.3**. Note that NYC is upstream of all CSOs; WBH and MB are in the downstream portion of the upper Charles River Basin, while BU and CBH are in the lower Charles River Basin.

Clearly, the computed counts reflect the spatial and temporal distributions of loadings. In most cases this loading is dominated by the Stony Brook. And, not surprisingly, the average counts reflect the magnitude of the loadings. Thus results for future planned conditions with a 3-month design storm (Run 2) are only slightly lower than results for existing conditions with the same storm (Run 1); results for the 1-year design storm (Runs 3, 5 and 7) are greater than corresponding results for the 3-month design storm (Runs 2, 4 and 6); and the results for runs with CSO loading only (Run 4 and 5) plus the results for only non-CSO loading (Run 6 and 7) sum to give the results for the combined loads (Runs 2 and 3).

The horizontal dotted lines in parts a) and b) of **Figs. D.1** through **D.7** denote fecal coliform counts of 200 and 1000 counts/100mL which reflect water quality standards for swimming and boating, respectively. The number of hours of each simulation during which computed counts exceed these standards are tabulated in **Table D.2.** Note that the total simulation length is 99.4 hours. As explained above, the swimming standard of 200 counts/100 mL is predicted to be violated throughout most of the basin for all scenarios which include dry weather loadings (all but Runs 4 and 5 which only include CSO).

E Simulations of Baseline Water Quality for Boston Harbor

Results of the harbor simulations for the seven runs are shown in the various parts of **Fig. E.1** through **E.7**. These figures correspond to the same seven baseline assessment scenarios identified in **Table D.1** and described in Section D. Part a) of each figure plots the spatial distribution of simulated fecal coliform counts for elapsed times of 1, 2, 3 and 4 days following the start of the simulation. The time origin for these simulations is the same as for the Charles River runs: i.e., simulations begin at the high tide immediately preceding the beginning of any wet weather load. In each display, contours of 1, 14, 88, 200 and 1000 counts/100 ml are indicated. Part b) of each figure shows time series output at each of 17 receptors in the harbor. Receptor locations were chosen to represent a combination of water uses including boating, swimming and shellfishing. The receptor locations are shown in **Fig. C.5**. Part c) of each figure plots the fecal coliform loads versus time for the 17 aggregate sources to the harbor. The source locations are shown in **Fig. C.3.**

As expected from previous modeling (CDM, 1989a; Adams and Zhang, 1991) counts are highest near the largest sources (e.g., the Upper Inner Harbor, Fort Point Channel, and Neponset River) and, like the Charles River results, the average counts reflect the loadings. Thus results for future planned conditions with a 3-month storm (Run 2) are only slightly lower than results for existing conditions with the same storm (Run 1); results for the 1-year storm (Runs 3, 5 and 7) are greater than corresponding results for the 3-month storm (Runs 2, 4 and 6); and the results for runs with CSO loading only (Run 4 and 5) plus the results for only non-CSO loading (Run 6 and 7) sum to give the results for the combined loads (Runs 2 and 3).

Table E.1 plots the number of hours during each simulation in which the concentration thresholds of 14, 88, 200 and 1000 counts/100 mL are exceeded. In contrast with the Charles River, bacterial disappearance and dispersion reduce the counts over time such that boating, swimming and shellfishing standards are all eventually met for each scenario.

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Fig. E.7c Harbor Fecal Coliform Loadings versus Time for Each Source--Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

Location	Source	Tributary CSOs
Upper Mystic River	Group 1	SOM007,SOM007A
Mystic/Chelsea Confluence	Group 2	MWR025, BOS017
	Group 3	CHE002, CHE003, CHE004, BOS013, BOS014, BOS015
Lower Inner Harbor	Group 4	BOS003, BOS004, BOS005, BOS006, BOS007
Upper Inner Harbor	Group 5	BOS009, BOS010, BOS012, BOS019
	Group 6	BOS049, BOS052, MWR023, BOS028, SOM009, SOM010
	Group 7	BOS057, BOS058, BOS060
Ft. Pt. Channel	Group 8	BOS062, BOS064, BOS065, BOS068, BOS070, BOS072, BOS073
Res. Channel	Group 9	BOS076, BOS078, BOS079, BOS080
North Dorch. Bay	Group 10	BOS081, BOS082, BOS083, BOS084, BOS085, BOS086, BOS087
South Dorch. Bay	Group 11	BOS088, BOS089, BOS090
Nep. River	Group 12	BOS093, BOS095
Constitution Beach	MWR207	MWR207
Winthrop	WIN001	WIN001

Table C.1 Aggregate Sources

Run	Storm	Conditions	Sources
1	3-mo	existing	all
2	3-mo	future planned	all
3	1-yr	future planned	all
4	3-mo	future planned	CSO only
5	1-yr	future planned	CSO only
6	3-mo	future planned	non-CSO
7	1-yr	future planned	non-CSO

Table D.1 Summary of Baseline Assessment Scenarios

Simulation	Location	Hours of Violation	
		FC>200	FC>1000
Existing Conditions 3 month design storm All sources	Newton Y.C.	99.4	35.2
	Weld B.H.	99.4	64.2
	Magazine Beach	99.4	58.0
	B.U. Sailing	99.4	70.4
	Community B.H.	99.4	41.4
Future Conditions 3 month design storm All sources	Newton Y.C.	99.4	35.2
	Weld B.H.	99.4	64.2
	Magazine Beach	99.3	56.9
	B.U. Sailing	99.4	67.3
	Community B.H.	99.4	34.2
Future Conditions 1 year design storm All sources	Newton Y.C.	99.4	34.2
	Weld B.H.	99.3	71.4
	Magazine Beach	99.4	76.6
	B.U. Sailing	99.4	82.8
	Community B.H.	99.4	79.7
Future Conditions 3 month design storm CSO sources only	Newton Y.C.	0.0	0.0
	Weld B.H.	0.0	0.0
	Magazine Beach	0.0	0.0
	B.U. Sailing	52.8	17.6
	Community B.H.	26.9	0.0
Future Conditions 1 year design storm CSO sources only	Newton Y.C.	0.0	0.0
	Weld B.H.	51.7	26.9
	Magazine Beach	57.9	9.3
	B.U. Sailing	82.8	49.7
	Community B.H.	80.7	35.2
Future Conditions 3 month design storm non-CSO sources	Newton Y.C.	99.3	35.2
	Weld B.H.	99.4	64.2
	Magazine Beach	99.4	56.9
	B.U. Sailing	99.4	61.1
	Community B.H.	99.4	0.0
Future Conditions 1 year design storm non-CSO sources	Newton Y.C.	99.3	33.1
	Weld B.H.	99.4	68.3
	Magazine Beach	99.4	74.5
	B.U. Sailing	99.4	73.5
	Community B.H.	99.4	43.5

Table D.2 Hours of Violation to Water Quality Standards in Simulation for Charles River Receptors. The simulation period was 99.36 hours. FC means Fecal Coliform Count per 100 mL.

Simulation	Location	Hours of Violation			
		Shellfish		Beach	Boating
		FC>14	FC>88	FC>200	FC>1000
Existing Conditions 3 month design storm All sources	Mystic River	73.5	46.6	35.2	0.0
	Chelsea Creek	71.4	45.5	32.0	1.0
	Charles R. Mouth	76.6	47.6	32.1	0.0
	Ft.Pt. Channel Mouth	72.5	49.7	40.4	11.4
	Middle Lower Harbor	68.3	47.6	36.2	0.0
	Reserved Channel	54.8	24.8	7.2	0.0
	Ship Channel	1.0	0.0	0.0	0.0
	Airport Shellfish	0.0	0.0	0.0	0.0
	Constitution Beach	23.8	0.0	0.0	0.0
	Const. B. Shellfish	24.8	0.0	0.0	0.0
	Pleasure Bay	44.5	8.3	0.0	0.0
	City Point Beach	52.8	23.8	9.3	0.0
	Carson Beach	52.8	29.0	22.8	2.1
	Malibu Beach	78.6	42.4	33.1	3.1
	Tenean Beach	84.9	46.6	37.3	14.5
	Squantum (West)	55.9	20.7	3.1	0.0
	Squantum (East)	33.1	0.0	0.0	0.0

Table E.1a Hours of Violation to Water Quality Standards in Simulation for Boston Harbor Receptors-- Existing Conditions, All Sources. The simulation period was 99.36 hours. FC means Fecal Coliform Count per 100 mL.

Simulation	Location	Hours of Violation			
		Shellfish		Beach	Boating
		FC>14	FC>88	FC>200	FC>1000
Future Conditions 3 month design storm All sources	Mystic River	69.3	41.4	27.9	0.0
	Chelsea Creek	68.2	40.3	27.9	0.0
	Charles R. Mouth	70.4	40.4	20.7	0.0
	Ft.Pt. Channel Mouth	65.2	41.4	29.0	0.0
	Middle Lower Harbor	63.2	37.3	16.6	0.0
	Reserved Channel	52.8	21.8	5.2	0.0
	Ship Channel	0.0	0.0	0.0	0.0
	Airport Shellfish	0.0	0.0	0.0	0.0
	Constitution Beach	23.8	0.0	0.0	0.0
	Const. B. Shellfish	24.8	0.0	0.0	0.0
	Pleasure Bay	42.4	6.2	0.0	0.0
	City Point Beach	50.7	21.7	9.3	0.0
	Carson Beach	49.7	29.0	20.7	0.0
	Malibu Beach	78.6	42.4	33.1	3.1
	Tenean Beach	84.9	44.5	37.3	14.5
	Squantum (West)	55.9	20.7	3.1	0.0
	Squantum (East)	31.0	0.0	0.0	0.0
Future Conditions 1 year design storm All sources	Mystic River	79.7	49.7	38.3	5.2
	Chelsea Creek	79.7	48.7	35.2	10.4
	Charles R. Mouth	83.9	50.8	37.3	0.0
	Ft.Pt. Channel Mouth	78.7	50.8	40.4	17.6
	Middle Lower Harbor	76.5	48.6	36.2	0.0
	Reserved Channel	64.2	35.2	23.8	0.0
	Ship Channel	9.3	0.0	0.0	0.0
	Airport Shellfish	8.3	0.0	0.0	0.0
	Constitution Beach	26.9	0.0	0.0	0.0
	Const. B. Shellfish	26.9	0.0	0.0	0.0
	Pleasure Bay	57.0	21.8	8.3	0.0
	City Point Beach	56.9	31.0	18.6	1.0
	Carson Beach	57.9	33.1	25.9	9.3
	Malibu Beach	80.8	46.6	36.2	17.6
	Tenean Beach	84.9	49.7	39.3	17.6
	Squantum (West)	64.2	31.1	14.5	0.0
	Squantum (East)	43.5	0.0	0.0	0.0

Table E.1b Hours of Violation to Water Quality Standards in Simulation for Boston Harbor Receptors-- Future Planned Conditions, All Sources. The simulation period was 99.36 hours. FC means Fecal Coliform Count per 100 mL.

Simulation	Location	Hours of Violation			
		Shellfish		Beach	Boating
		FC>14	FC>88	FC>200	FC>1000
Future Conditions 3 month design storm CSO sources only	Mystic River	45.5	6.2	0.0	0.0
	Chelsea Creek	46.5	10.3	1.0	0.0
	Charles R. Mouth	58.0	29.0	3.1	0.0
	Ft.Pt. Channel Mouth	60.0	38.3	27.9	0.0
	Middle Lower Harbor	58.0	35.2	8.3	0.0
	Reserved Channel	45.5	18.6	3.1	0.0
	Ship Channel	0.0	0.0	0.0	0.0
	Airport Shellfish	0.0	0.0	0.0	0.0
	Constitution Beach	0.0	0.0	0.0	0.0
	Const. B. Shellfish	0.0	0.0	0.0	0.0
	Pleasure Bay	14.5	0.0	0.0	0.0
	City Point Beach	22.8	2.1	0.0	0.0
	Carson Beach	25.8	10.3	3.1	0.0
	Malibu Beach	2.1	0.0	0.0	0.0
	Tenean Beach	12.4	0.0	0.0	0.0
	Squantum (West)	0.0	0.0	0.0	0.0
	Squantum (East)	0.0	0.0	0.0	0.0
Future Conditions 1 year design storm CSO sources only	Mystic River	61.1	32.1	17.6	0.0
	Chelsea Creek	63.2	34.2	21.8	2.1
	Charles R. Mouth	72.5	45.6	32.1	0.0
	Ft.Pt. Channel Mouth	69.3	46.5	37.2	15.5
	Middle Lower Harbor	66.2	41.4	35.2	0.0
	Reserved Channel	56.9	29.0	20.7	0.0
	Ship Channel	4.1	0.0	0.0	0.0
	Airport Shellfish	0.0	0.0	0.0	0.0
	Constitution Beach	0.0	0.0	0.0	0.0
	Const. B. Shellfish	0.0	0.0	0.0	0.0
	Pleasure Bay	42.4	9.3	0.0	0.0
	City Point Beach	42.4	16.5	9.3	0.0
	Carson Beach	42.4	24.8	15.5	4.1
	Malibu Beach	41.4	19.7	0.0	0.0
	Tenean Beach	42.5	22.8	13.5	0.0
	Squantum (West)	35.2	0.0	0.0	0.0
	Squantum (East)	5.2	0.0	0.0	0.0

Table E.1c Hours of Violation to Water Quality Standards in Simulation for Boston Harbor Receptors-- Future Planned Conditions, CSO Sources Only. The simulation period was 99.36 hours. FC means Fecal Coliform Count per 100 mL.

Simulation	Location	Hours of violation in simulation			
		Shellfish		Beach	Boating
		FC>14	FC>88	FC>200	FC>1000
Future Conditions 3 month design storm non-CSO sources	Mystic River	65.3	39.4	22.8	0.0
	Chelsea Creek	61.1	34.2	19.7	0.0
	Charles R. Mouth	57.9	18.6	0.0	0.0
	Ft.Pt. Channel Mouth	43.5	0.0	0.0	0.0
	Middle Lower Harbor	40.4	0.0	0.0	0.0
	Reserved Channel	21.7	0.0	0.0	0.0
	Ship Channel	0.0	0.0	0.0	0.0
	Airport Shellfish	0.0	0.0	0.0	0.0
	Constitution Beach	23.8	0.0	0.0	0.0
	Const. B. Shellfish	24.8	0.0	0.0	0.0
	Pleasure Bay	39.3	4.1	0.0	0.0
	City Point Beach	43.5	17.6	5.2	0.0
	Carson Beach	47.7	28.0	19.7	0.0
	Malibu Beach	77.6	42.4	33.1	3.1
	Tenean Beach	84.9	43.5	37.3	12.4
	Squantum (West)	54.9	20.7	3.1	0.0
	Squantum (East)	30.0	0.0	0.0	0.0
Future Conditions 1 year design storm non-CSO sources	Mystic River	71.5	42.5	34.2	0.0
	Chelsea Creek	69.3	41.4	29.0	0.0
	Charles R. Mouth	67.3	26.9	4.1	0.0
	Ft.Pt. Channel Mouth	53.8	18.6	0.0	0.0
	Middle Lower Harbor	50.7	9.3	0.0	0.0
	Reserved Channel	27.9	0.0	0.0	0.0
	Ship Channel	0.0	0.0	0.0	0.0
	Airport Shellfish	8.3	0.0	0.0	0.0
	Constitution Beach	26.9	0.0	0.0	0.0
	Const. B. Shellfish	26.9	0.0	0.0	0.0
	Pleasure Bay	45.5	9.3	0.0	0.0
	City Point Beach	50.7	25.9	10.4	0.0
	Carson Beach	51.8	29.0	20.7	1.0
	Malibu Beach	77.7	45.6	34.2	16.6
	Tenean Beach	84.9	45.6	37.3	16.6
	Squantum (West)	56.9	23.8	6.2	0.0
	Squantum (East)	38.3	0.0	0.0	0.0

Table E.1d Hours of Violation to Water Quality Standards in Simulation for Boston Harbor Receptors-- Future Planned Conditions, non-CSO Sources. The simulation period was 99.36 hours. FC means Fecal Coliform Count per 100 mL.

Figures

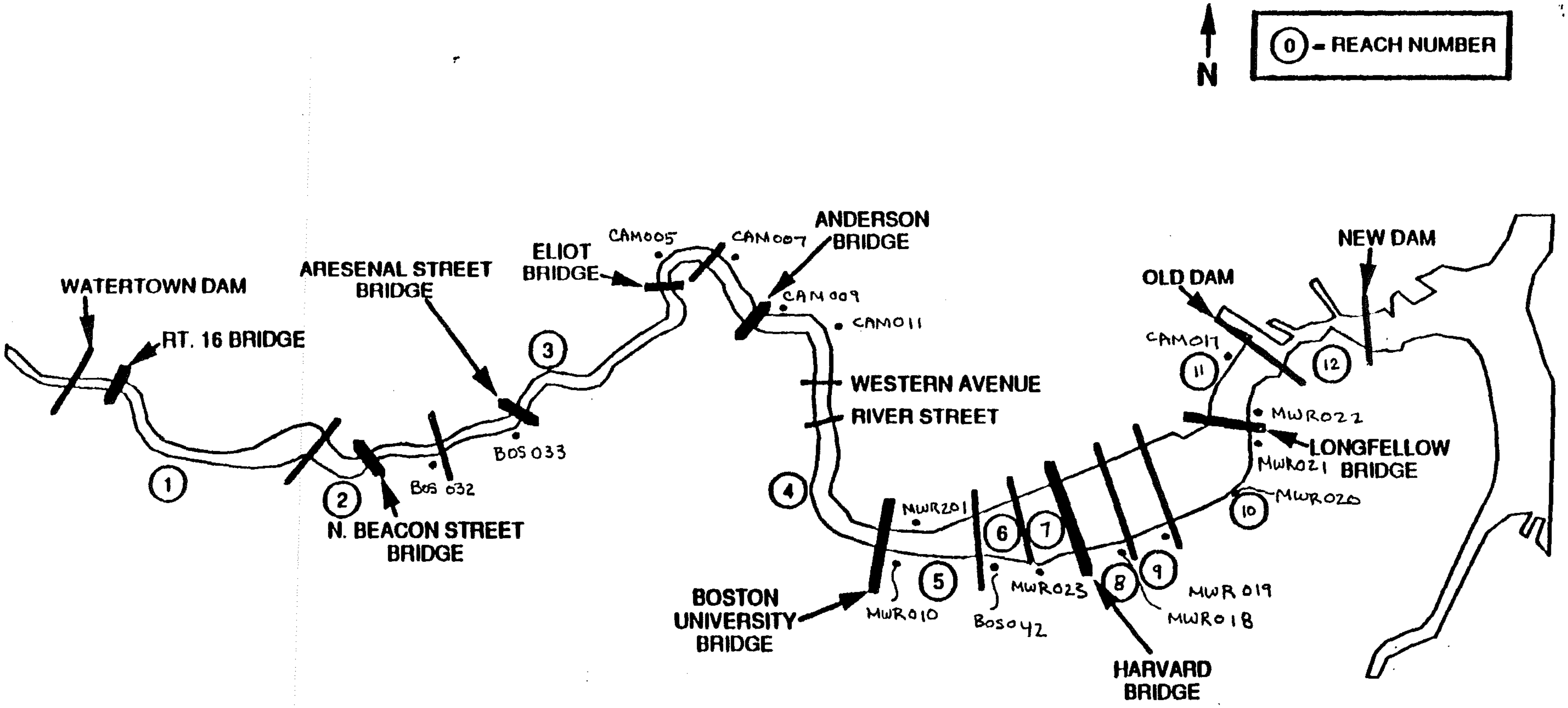


Fig. B.1 Charles River--Pollutant Source Loading Locations

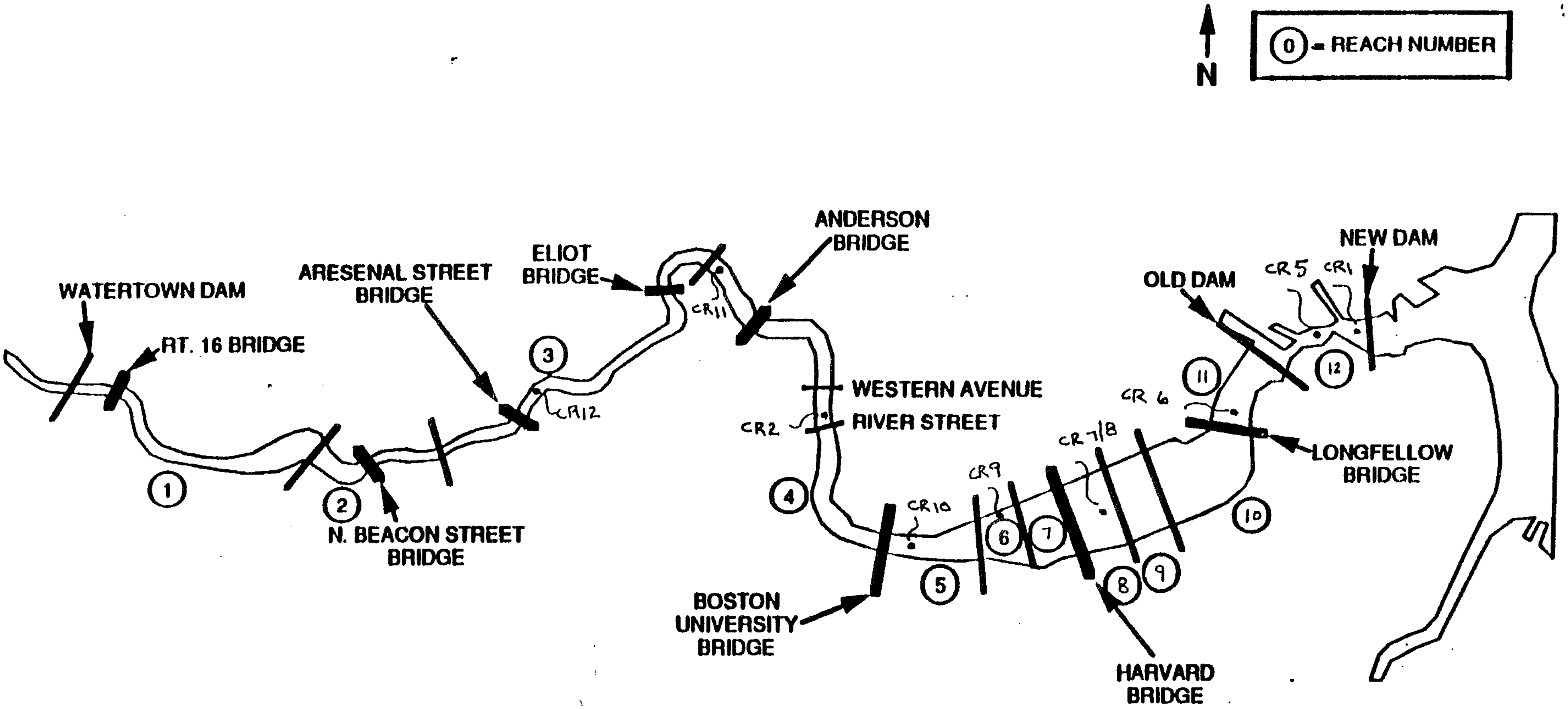


Fig. B.2 Charles River--Receiving Water Quality Sampling Locations for Model Calibration

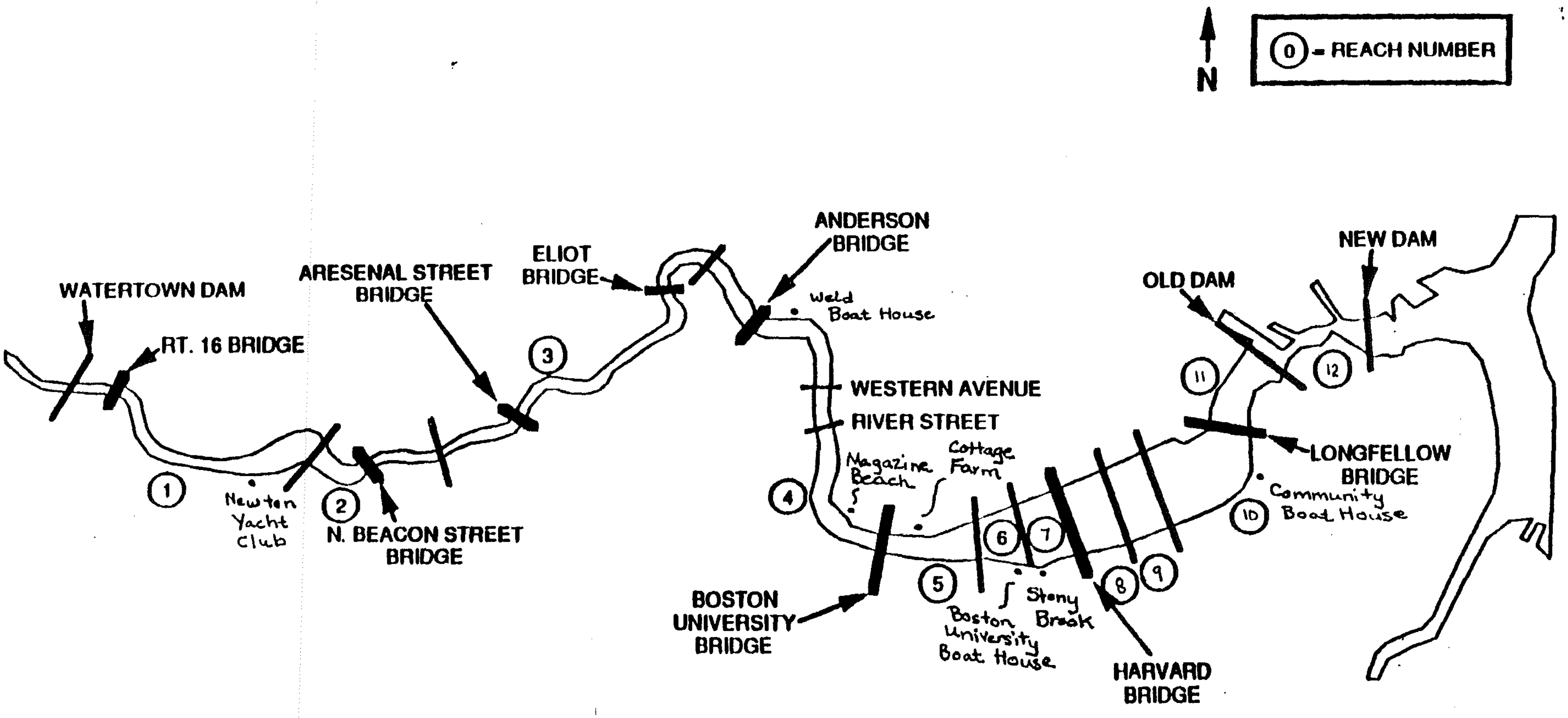


Fig. B.3 Charles River--Receptor Locations

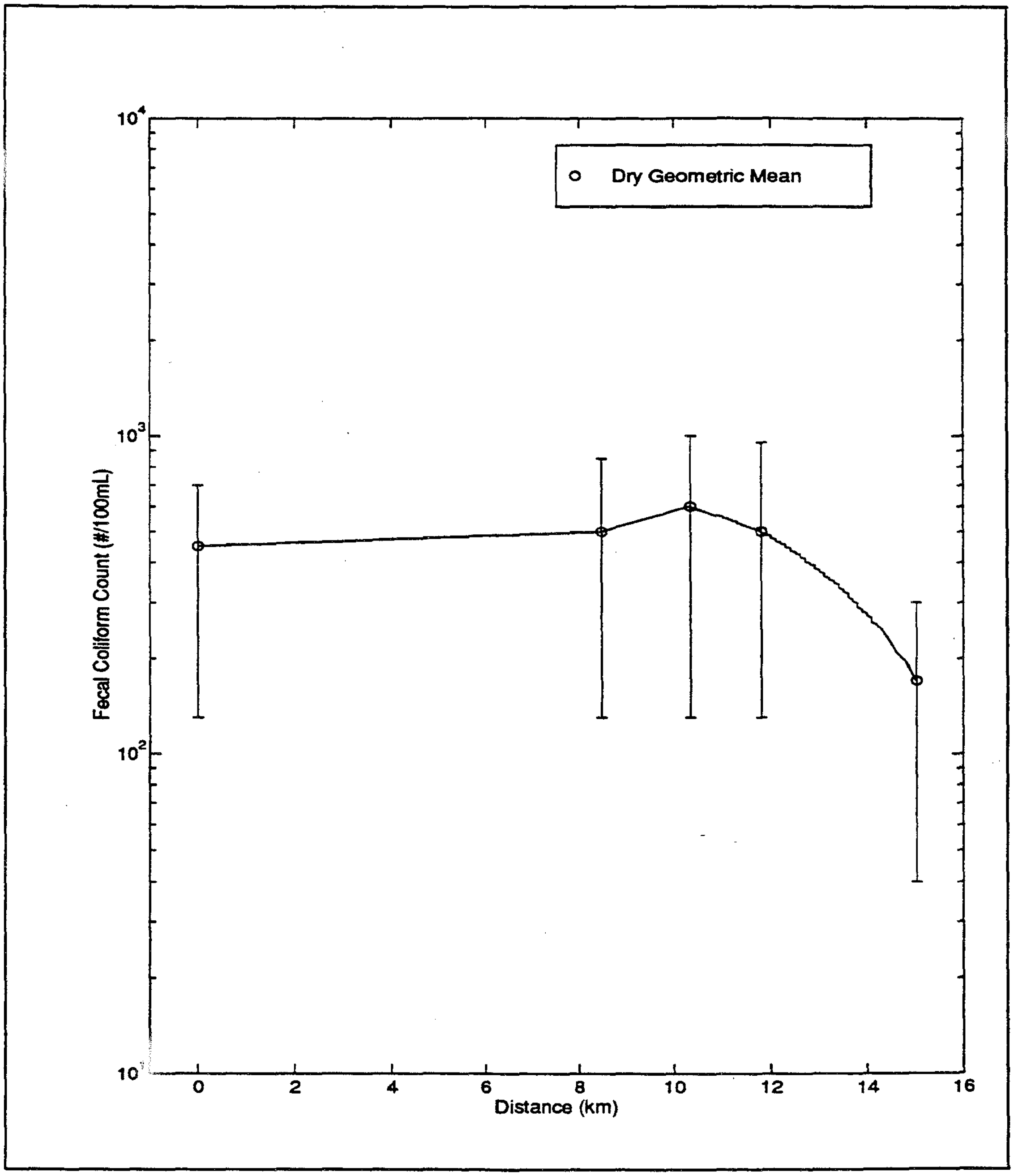


Fig. B.4 Charles River–Dry Weather Fecal Coliform Counts vs. Distance. Bars indicate 95% confidence intervals.

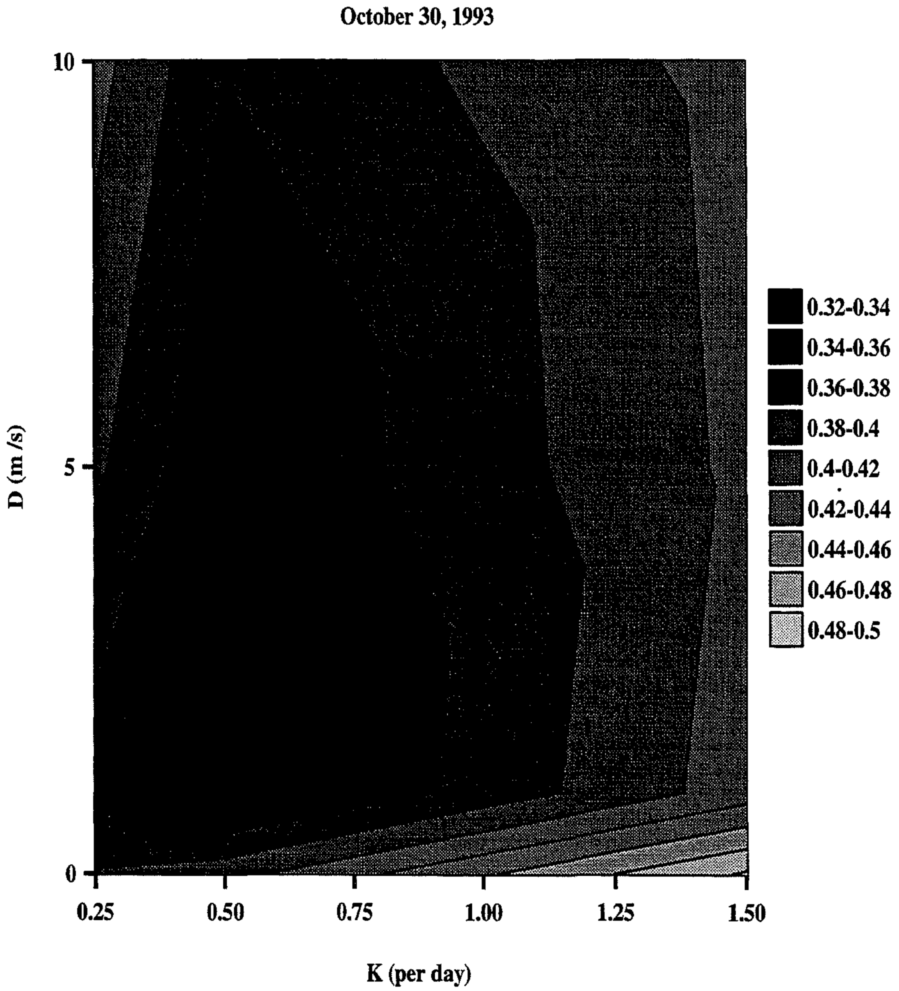


Fig. B.5 Charles River–RMSL Error Contours, October 30, 1993 Storm

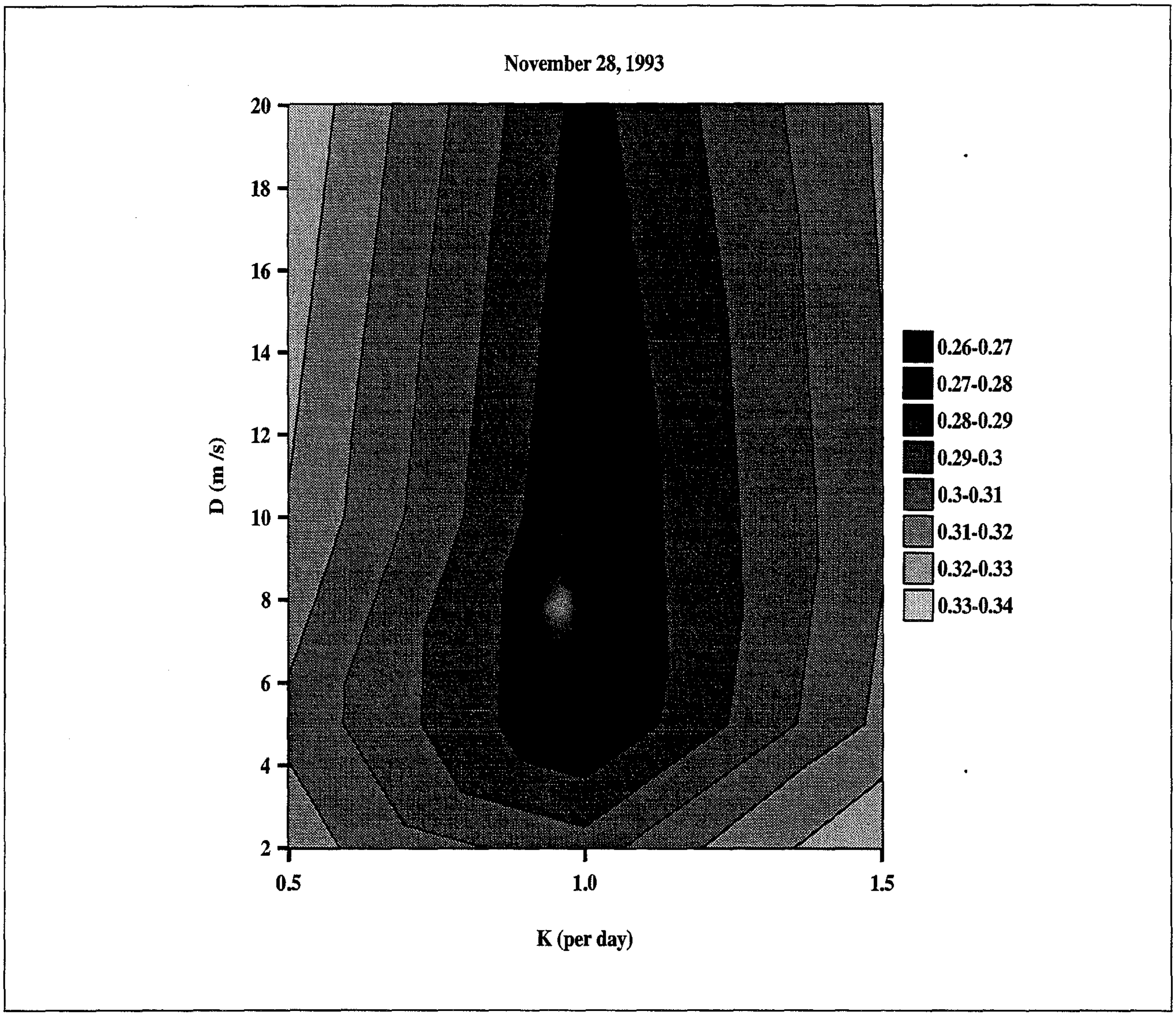


Fig. B.6 Charles River–RMSL Error Contours, November 28, 1993 Storm

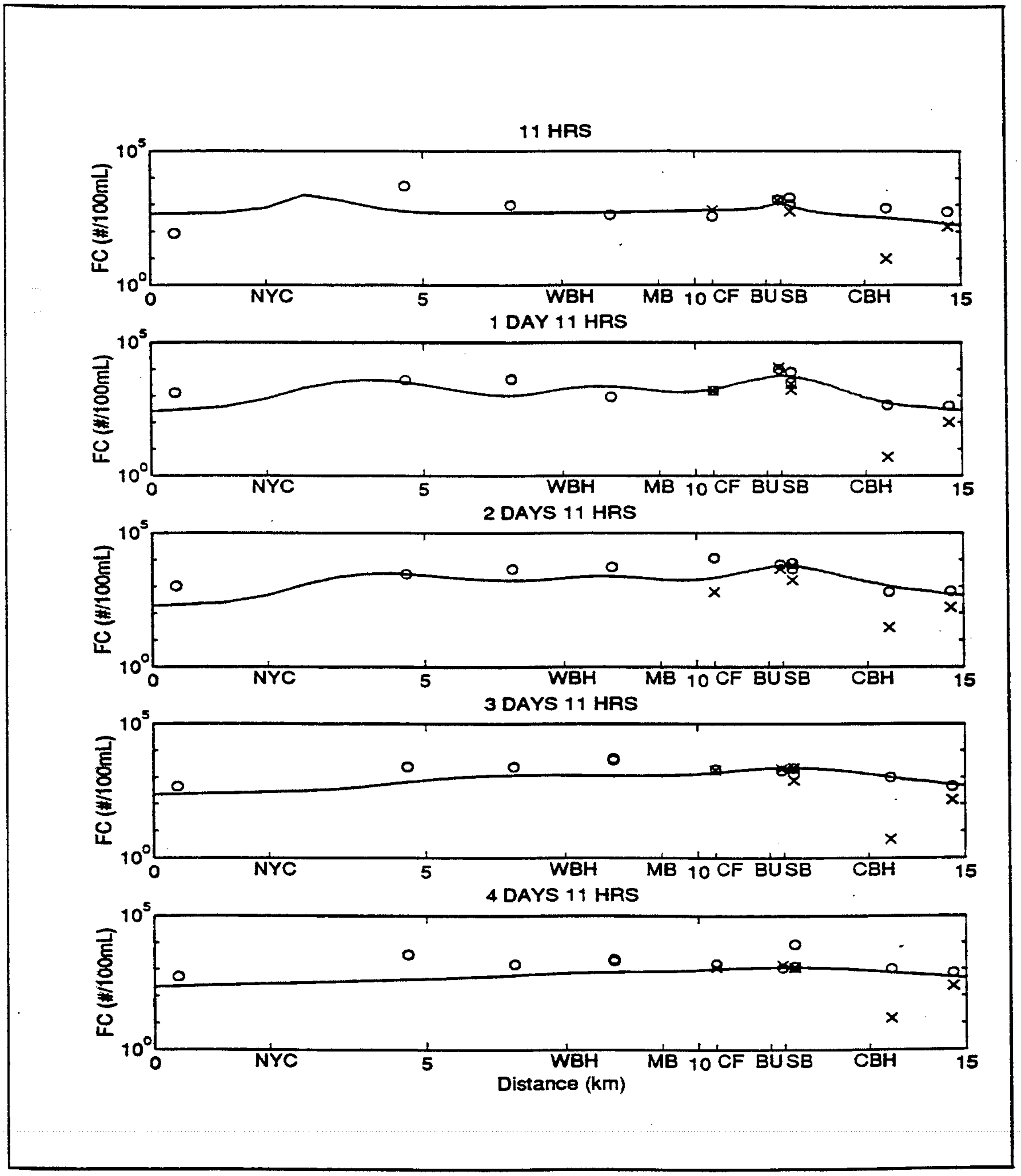


Fig. B.7 Charles River–Measured and Modeled Fecal Coliform Counts vs. Distance, October 30, 1993 Storm

Legend

○ Surface Sample
× Bottom Sample
—— Model Simulation

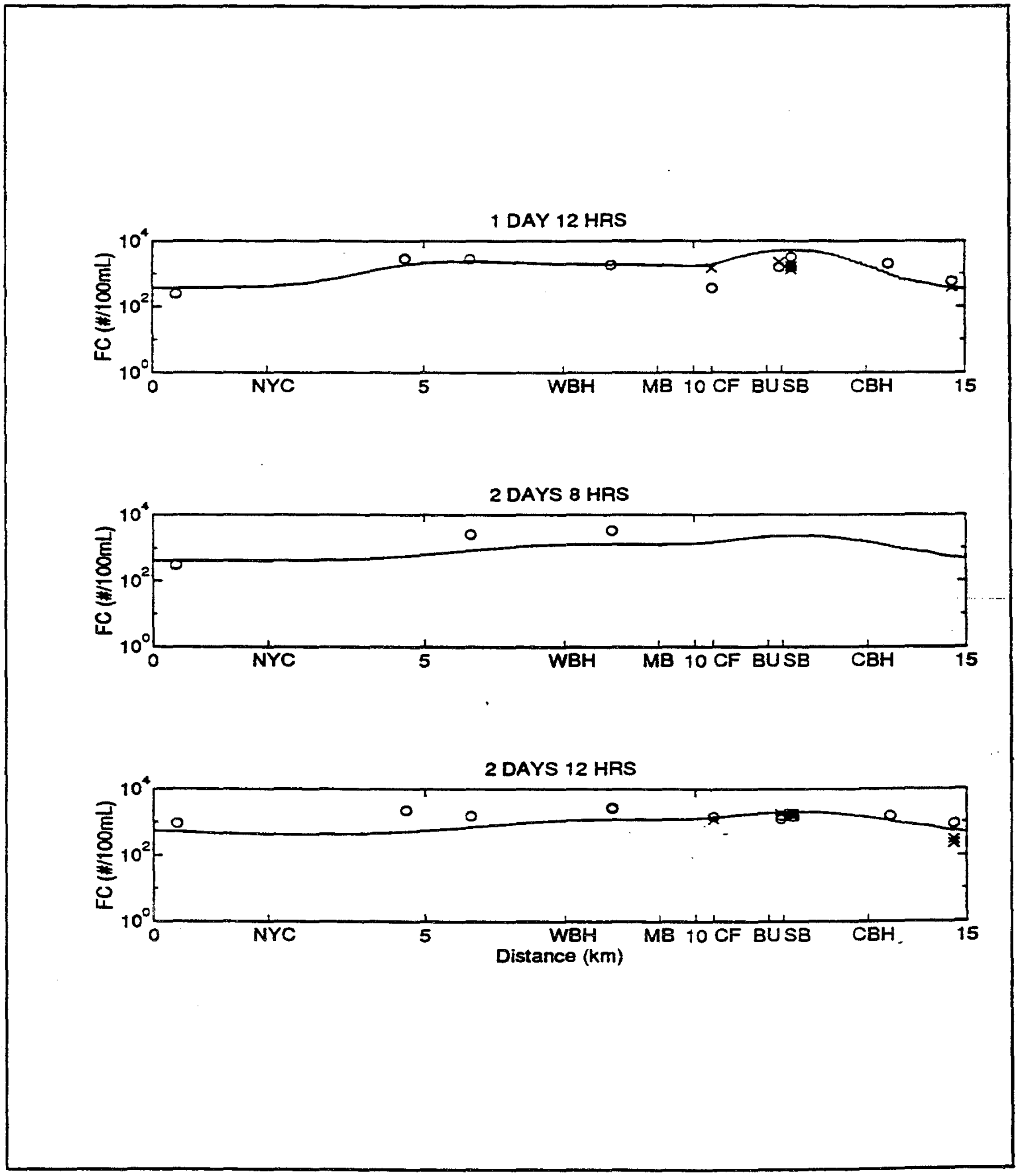


Fig. B.8a Charles River–Measured and Modeled Fecal Coliform Counts vs. Distance, November 28, 1993 Storm

Legend

○ Surface Sample
× Bottom Sample
—— Model Simulation

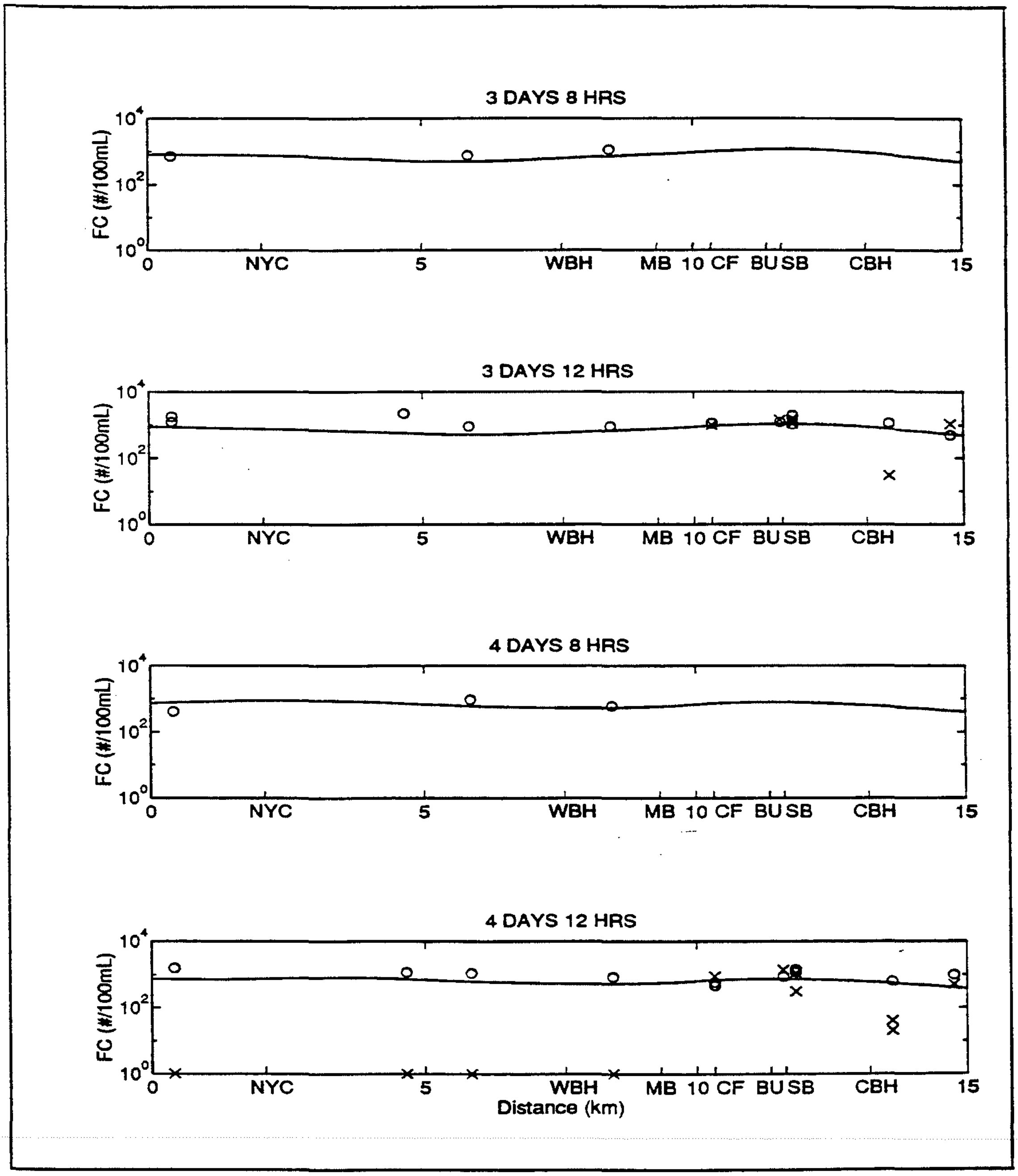


Fig. B.8b Charles River–Measured and Modeled Fecal Coliform Counts vs. Distance, November 28, 1993 Storm

Legend

○ Surface Sample
× Bottom Sample
—— Model Simulation

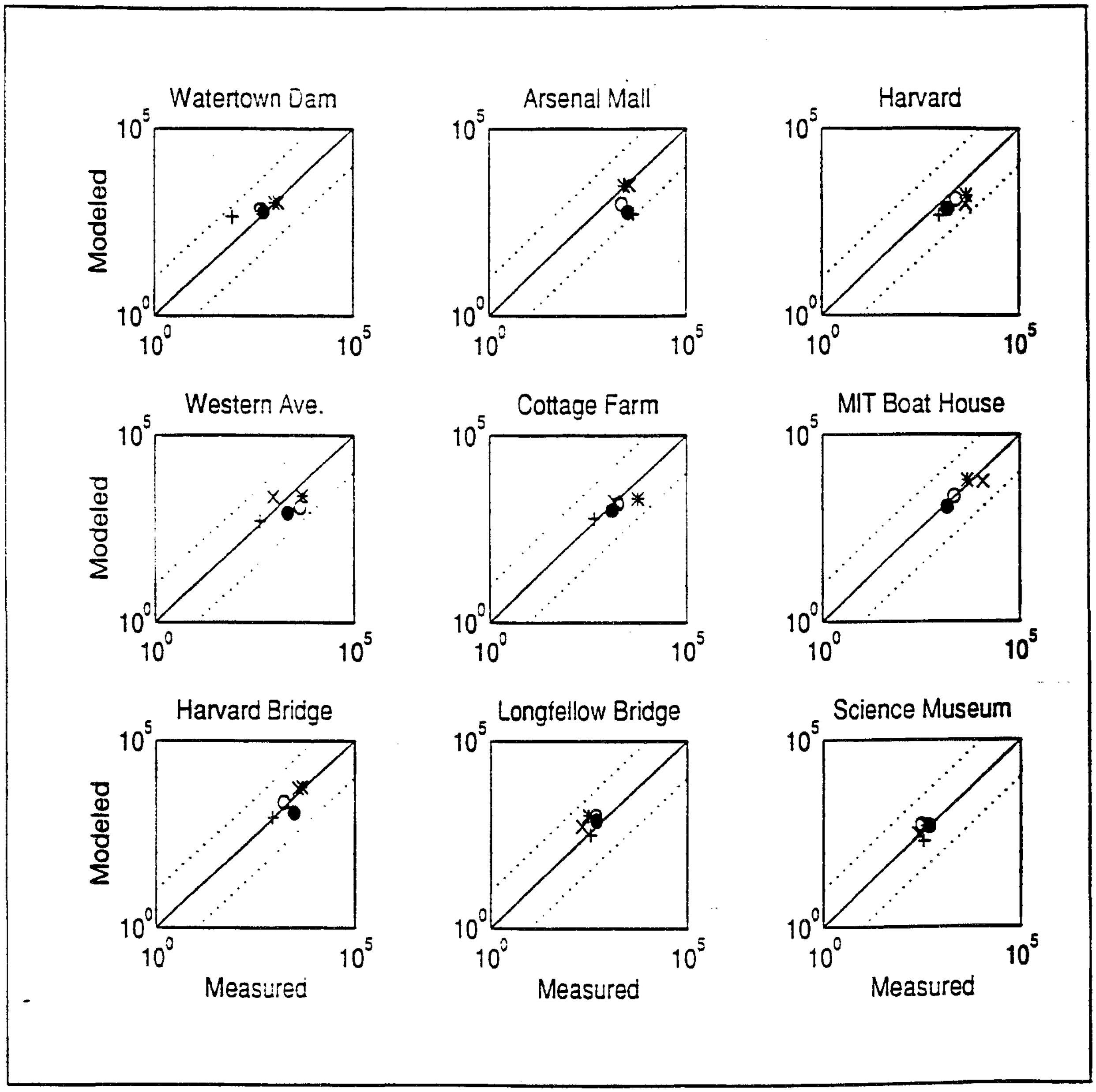


Fig. B.9 Charles River–Measured vs. Modeled Fecal Coliform Count per 100mL, October 30, 1993 Storm. The dotted line indicates a difference of one order of magnitude.

Legend

+ 11 Hours
× 35 Hours
✳ 59 Hours
○ 83 Hours
● 107 Hours

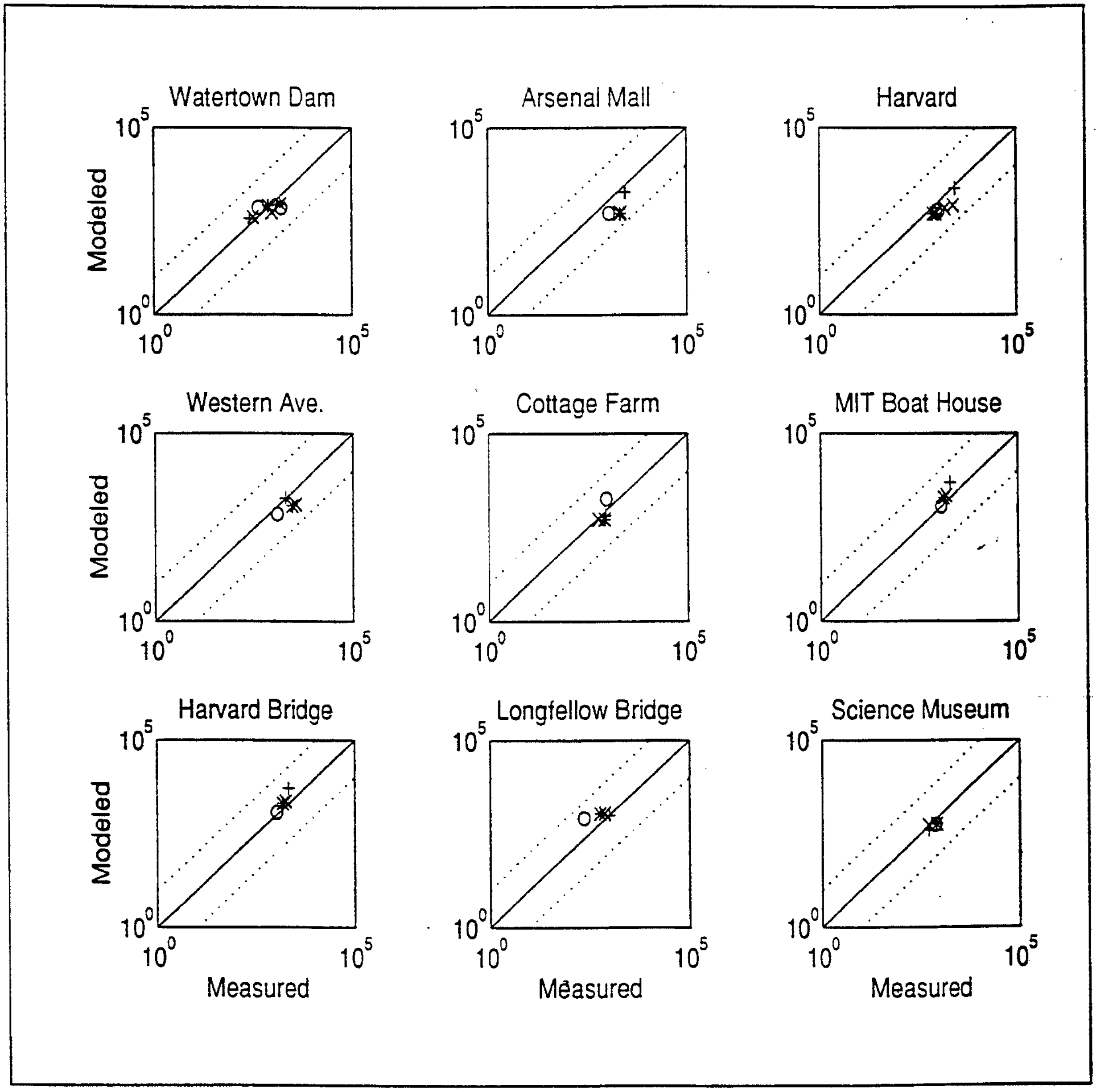


Fig. B.10 Charles River–Measured vs. Modeled Fecal Coliform Count per 100mL, November 28, 1993 Storm. The dotted line indicates a difference of one order of magnitude.

Legend

+ 36 Hours
× 56/60 Hours
∗ 80/84 Hours
○ 104/108 Hours

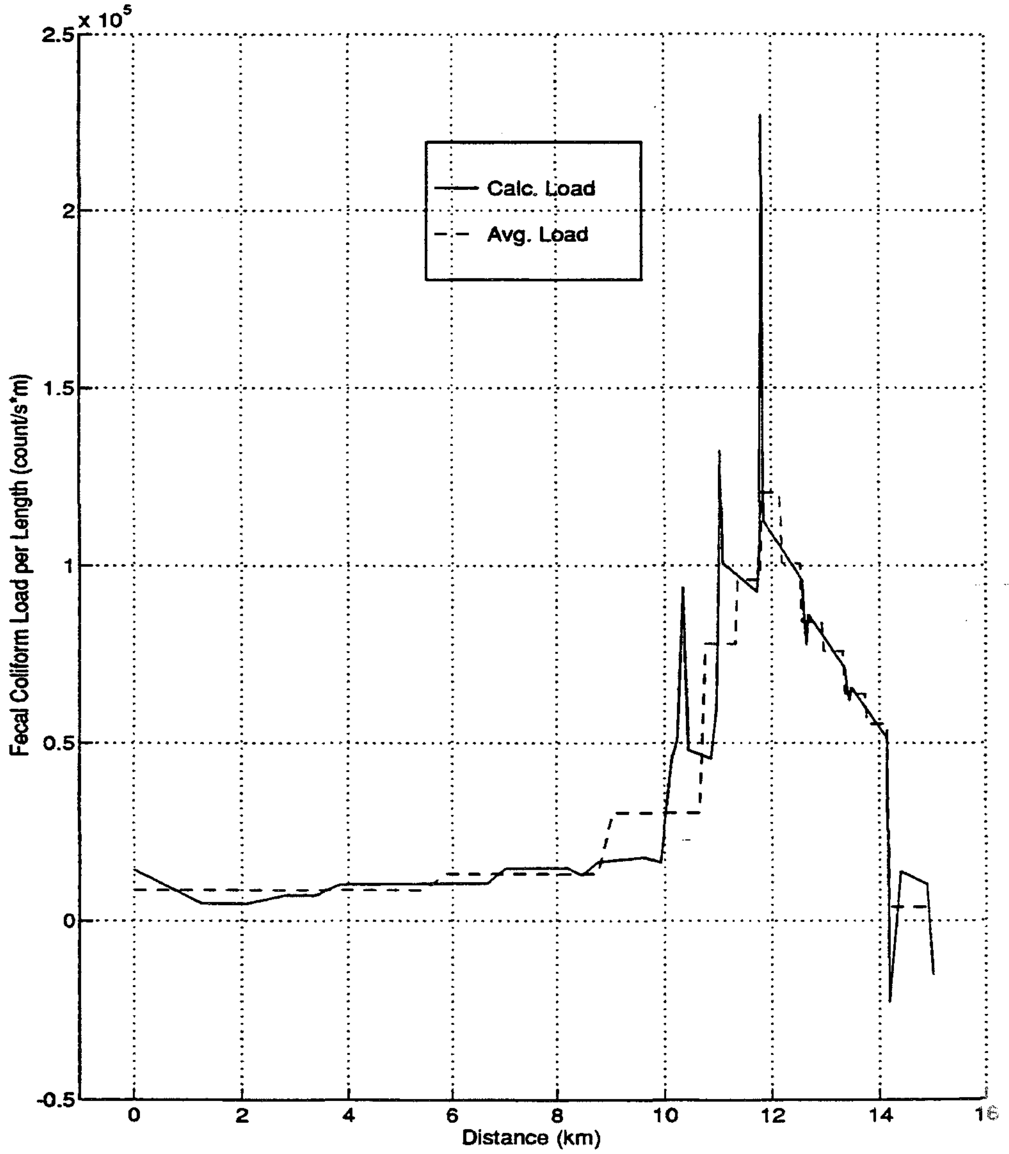


Fig. B.11 Charles River–Distribution of Dry Weather Loads, October 30, 1993 Storm

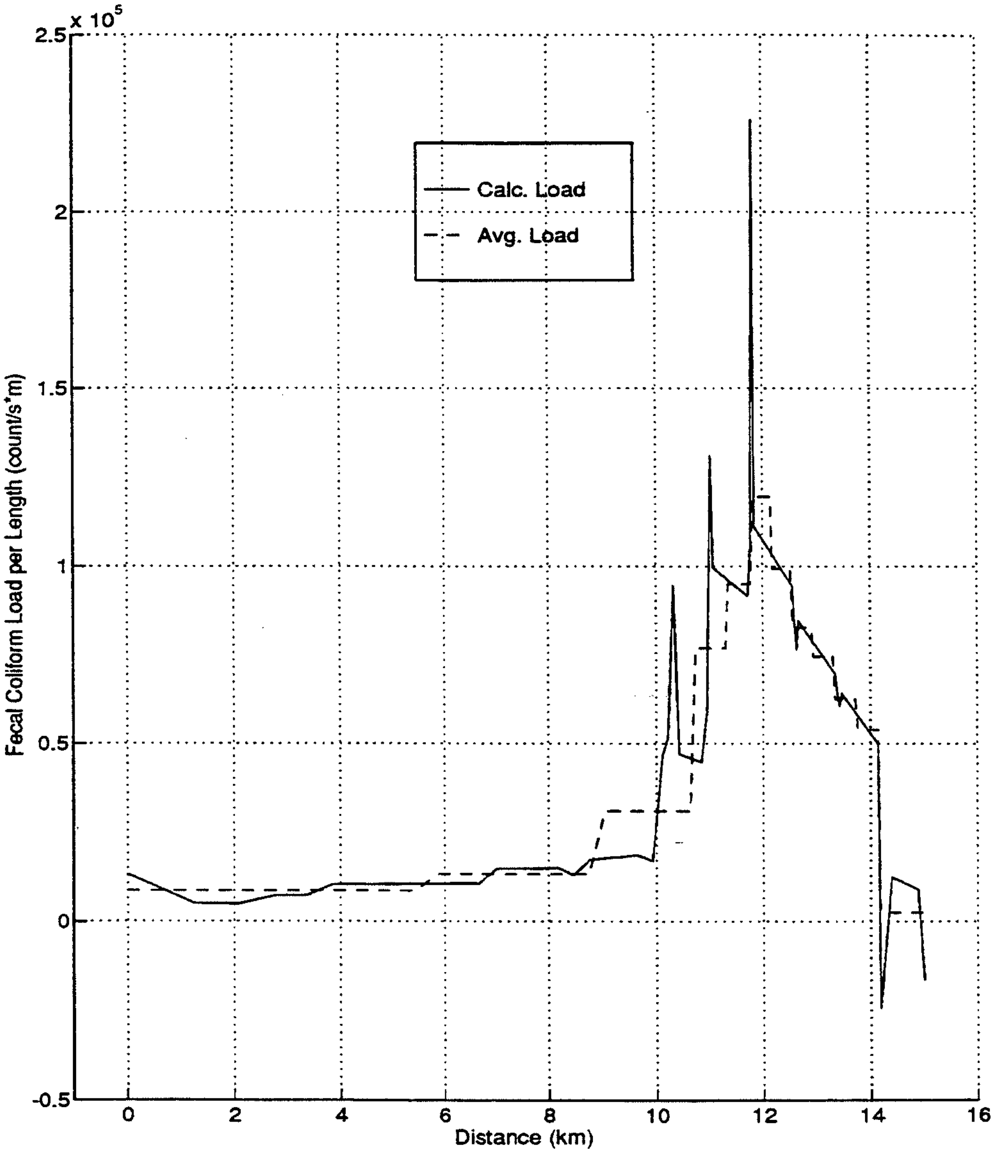


Fig. B.12 Charles River–Distribution of Dry Weather Loads, November 28, 1993 Storm

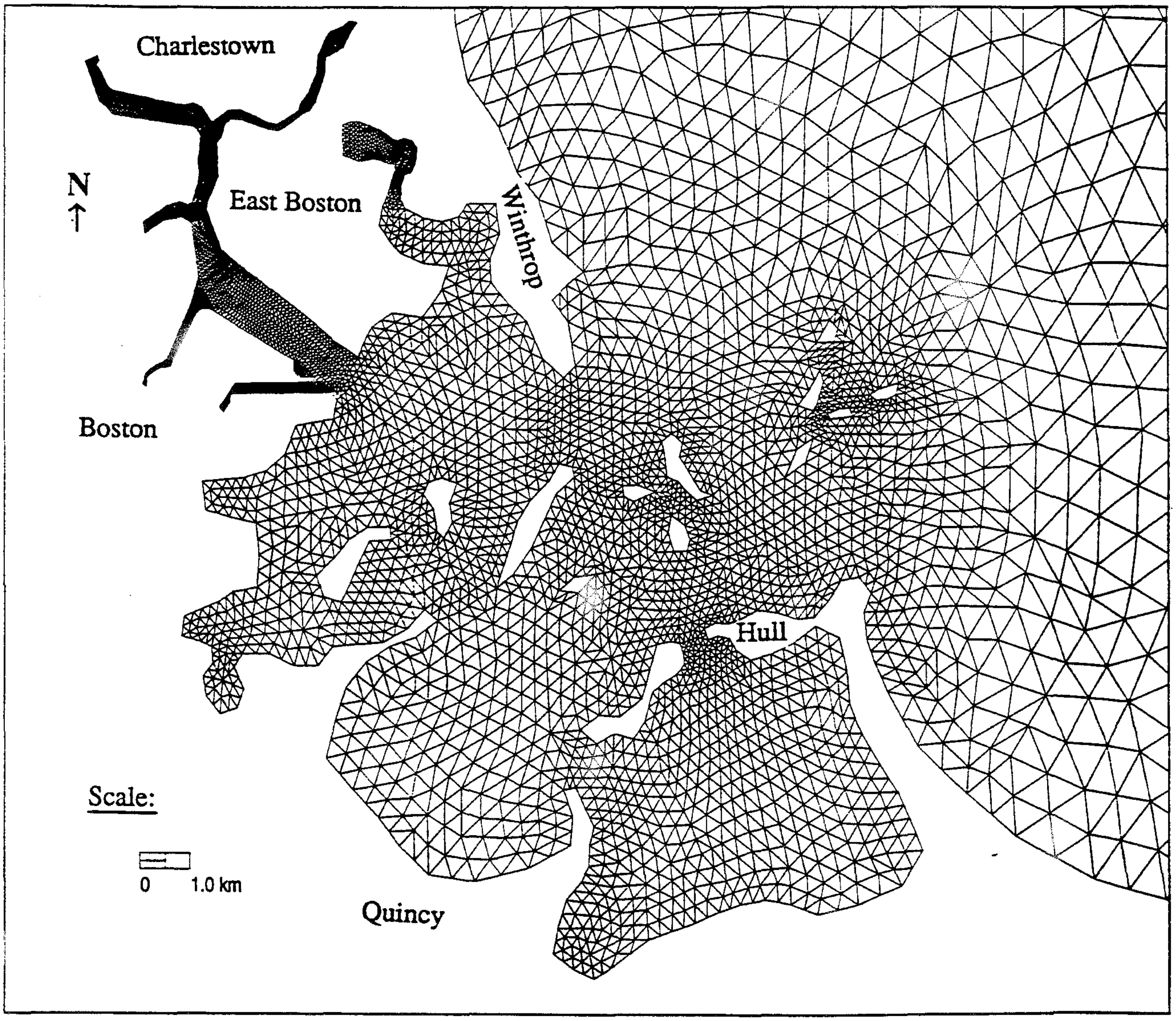


Fig. C.1a Boston Harbor–Finite Element Grid (Large Scale).

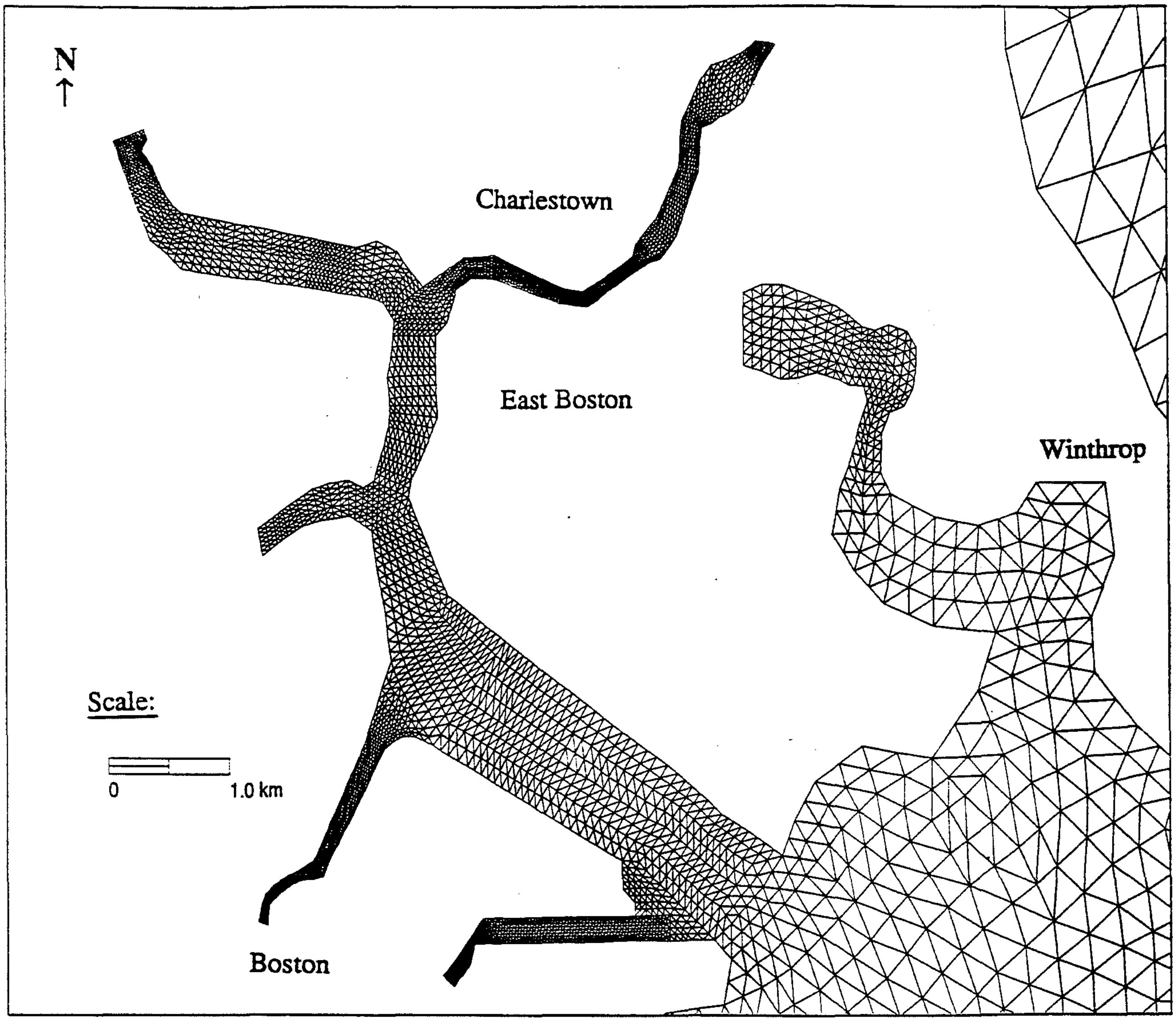


Fig. C.1b Boston Harbor–Finite Element Grid (Small Scale).

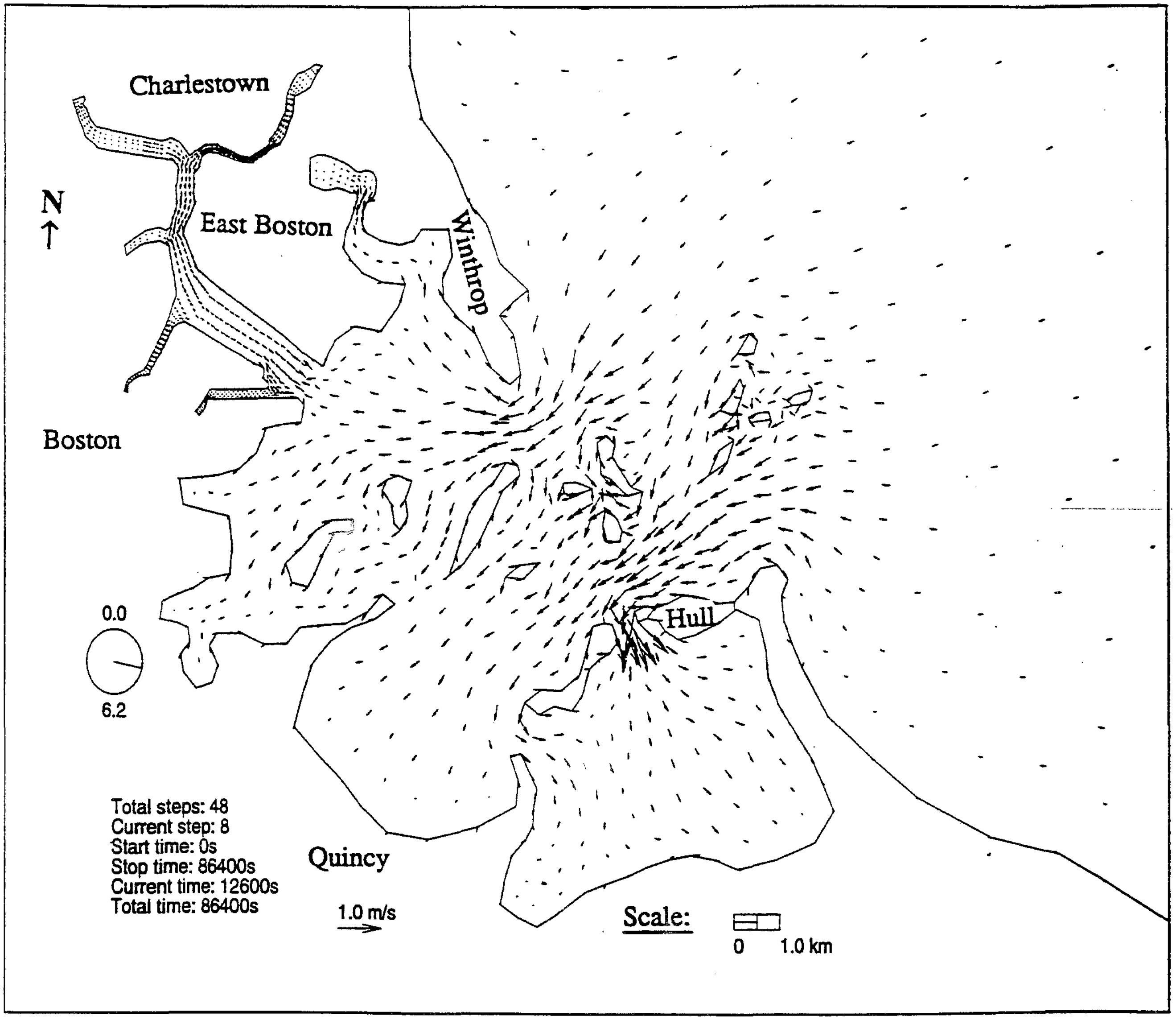


Fig. C.2a Boston Harbor–Current Velocities at Flood Tide (Large Scale).

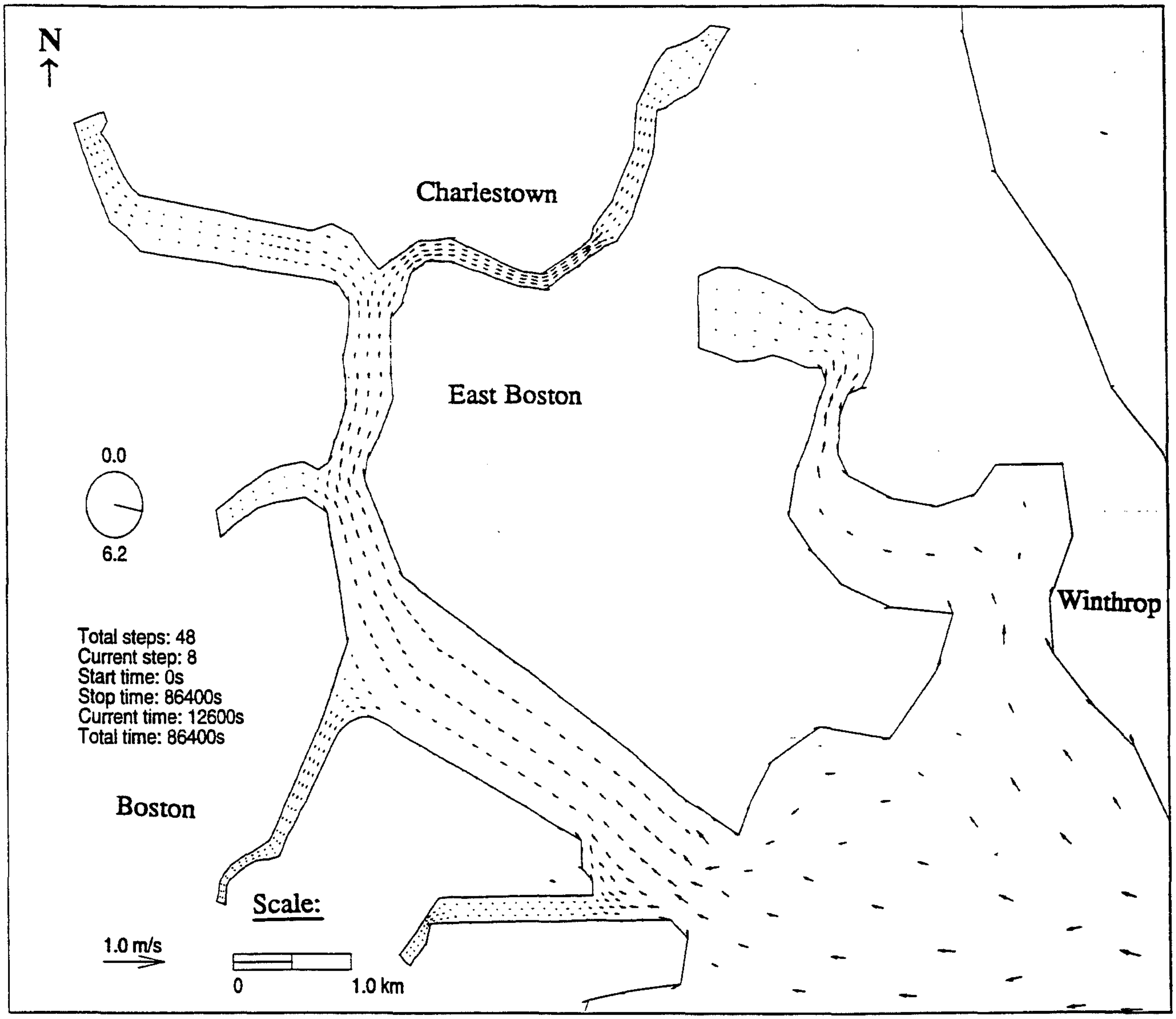


Fig. C.2b Boston Harbor–Current Velocities at Flood Tide (Small Scale).

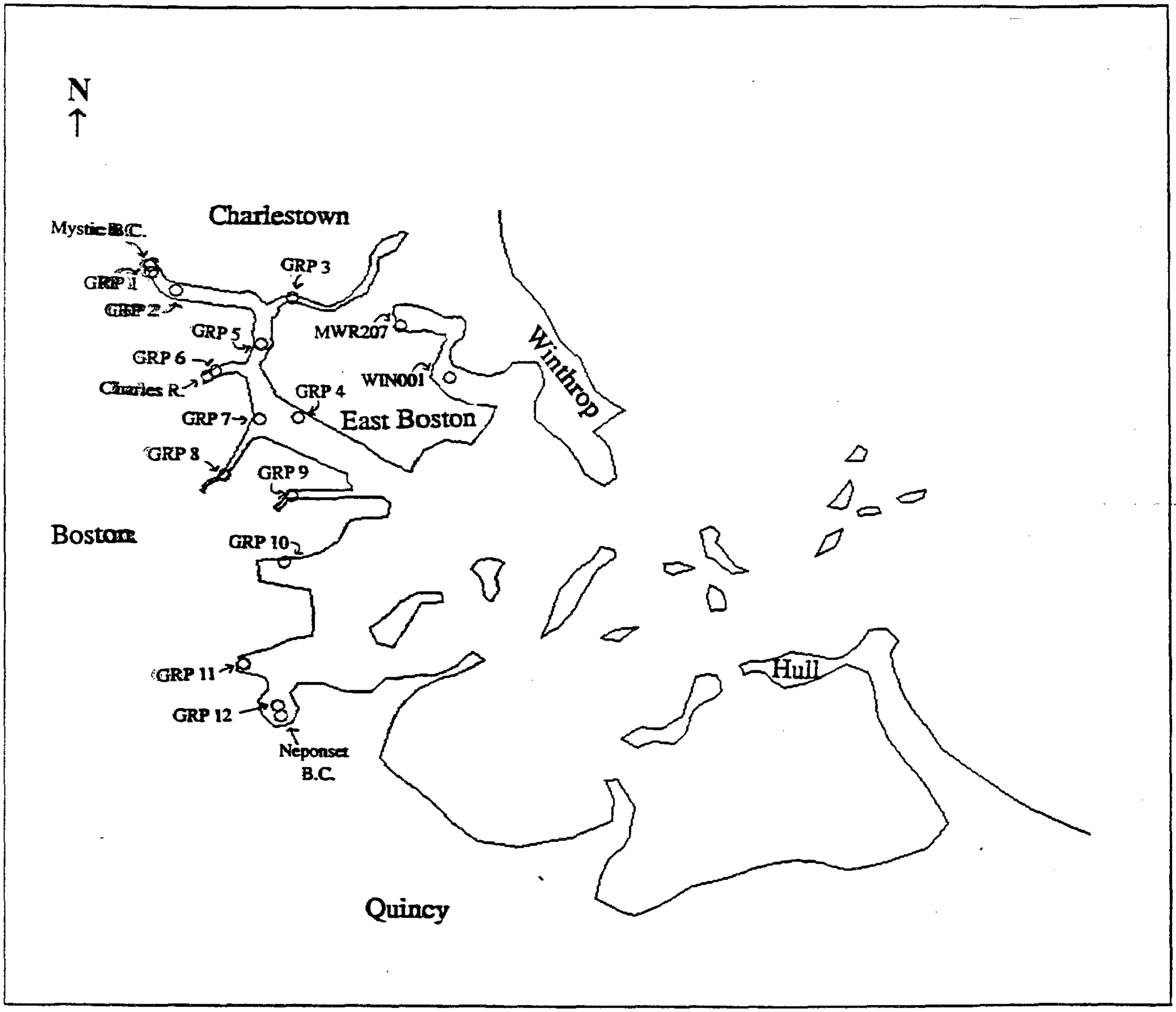


Fig. C.3 Boston Harbor–Aggregated Model Pollutant Source Loading Locations.

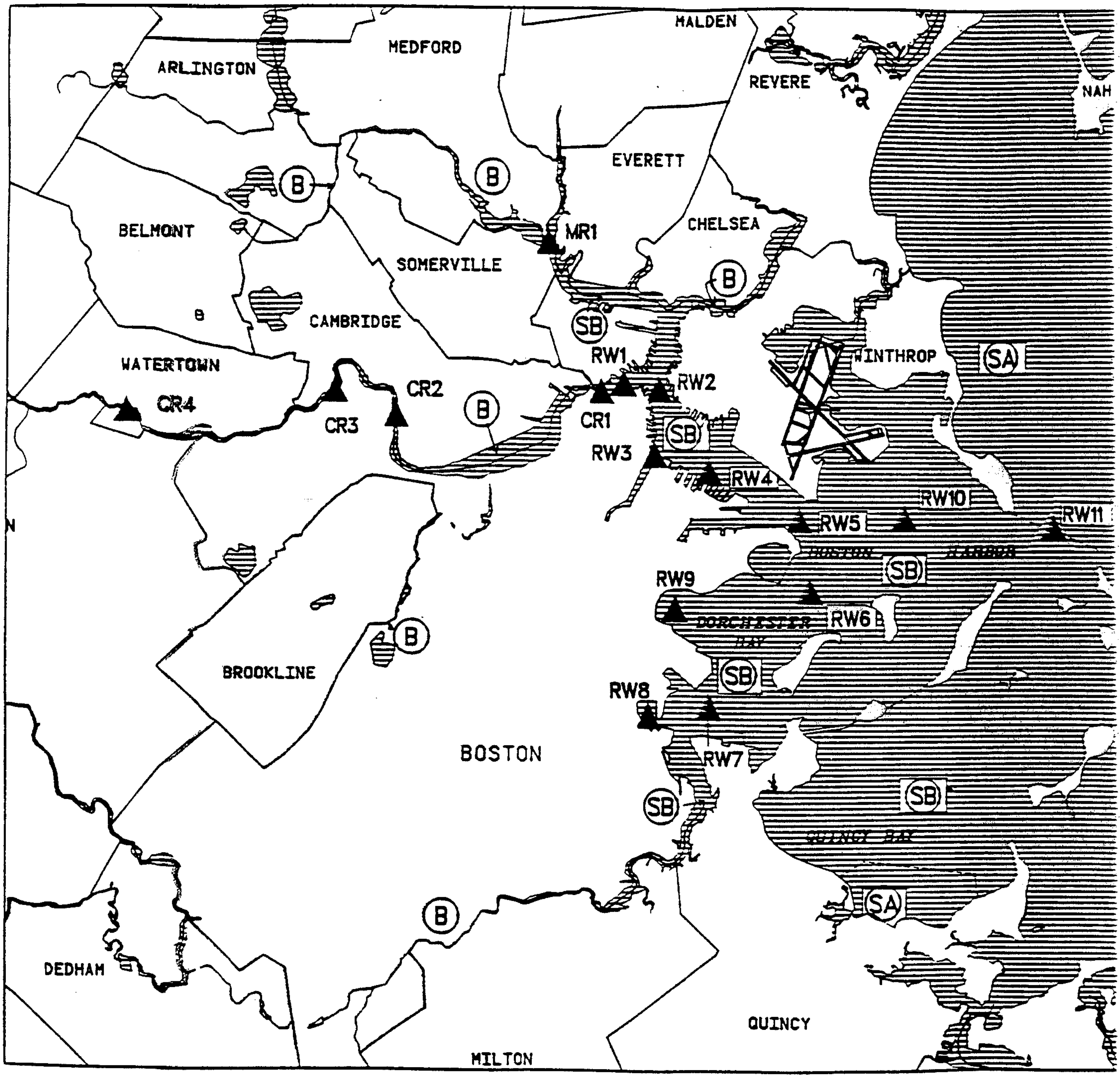


Figure C.4 Boston Harbor Water Quality Sampling Location Used for Model Calibration

Legend:

▲ Sampling Location

Ⓑ Mass. Dept. of Environmental Protection Water Body Quality Standard

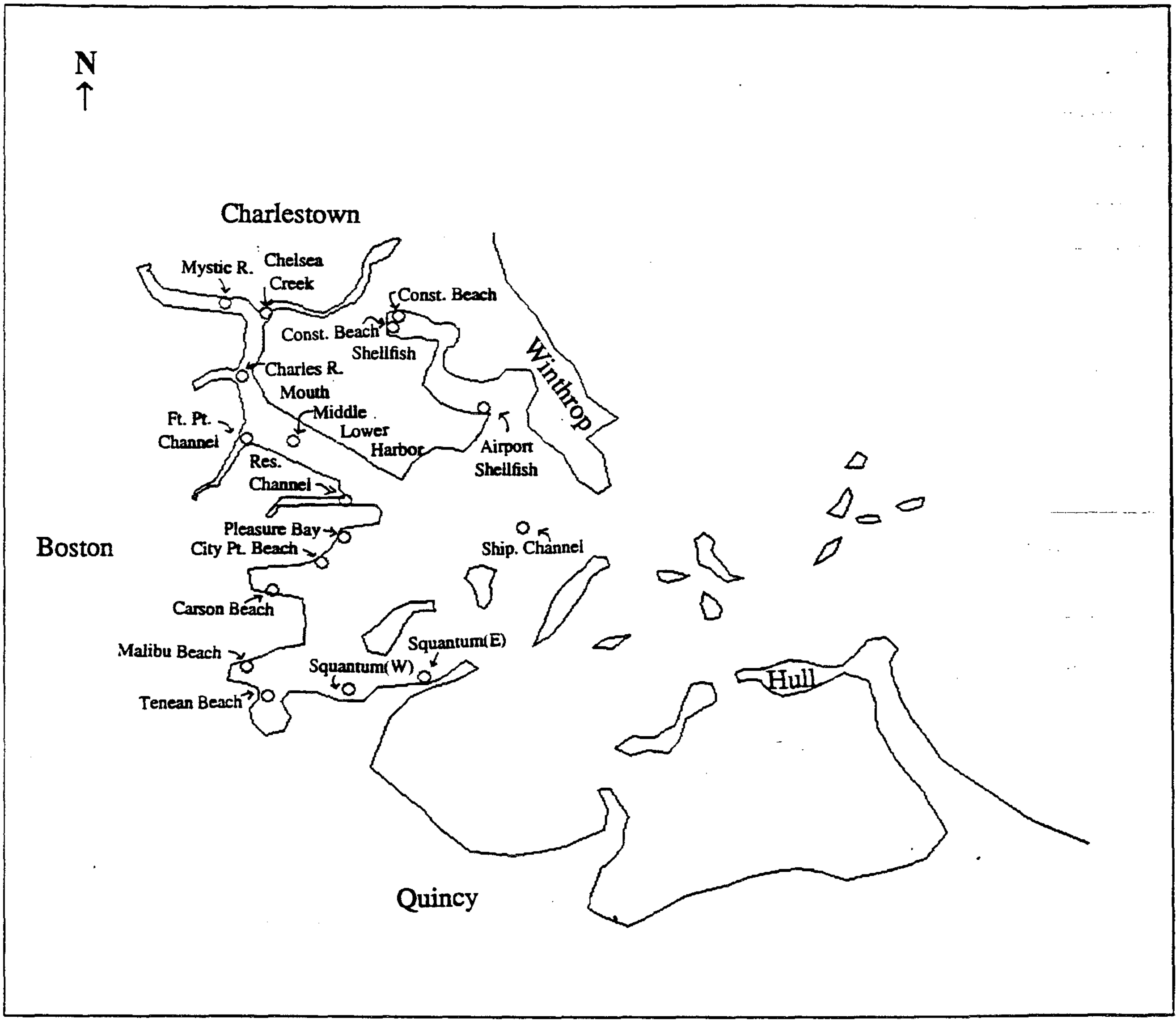


Fig. C.5 Boston Harbor–Receptor Locations

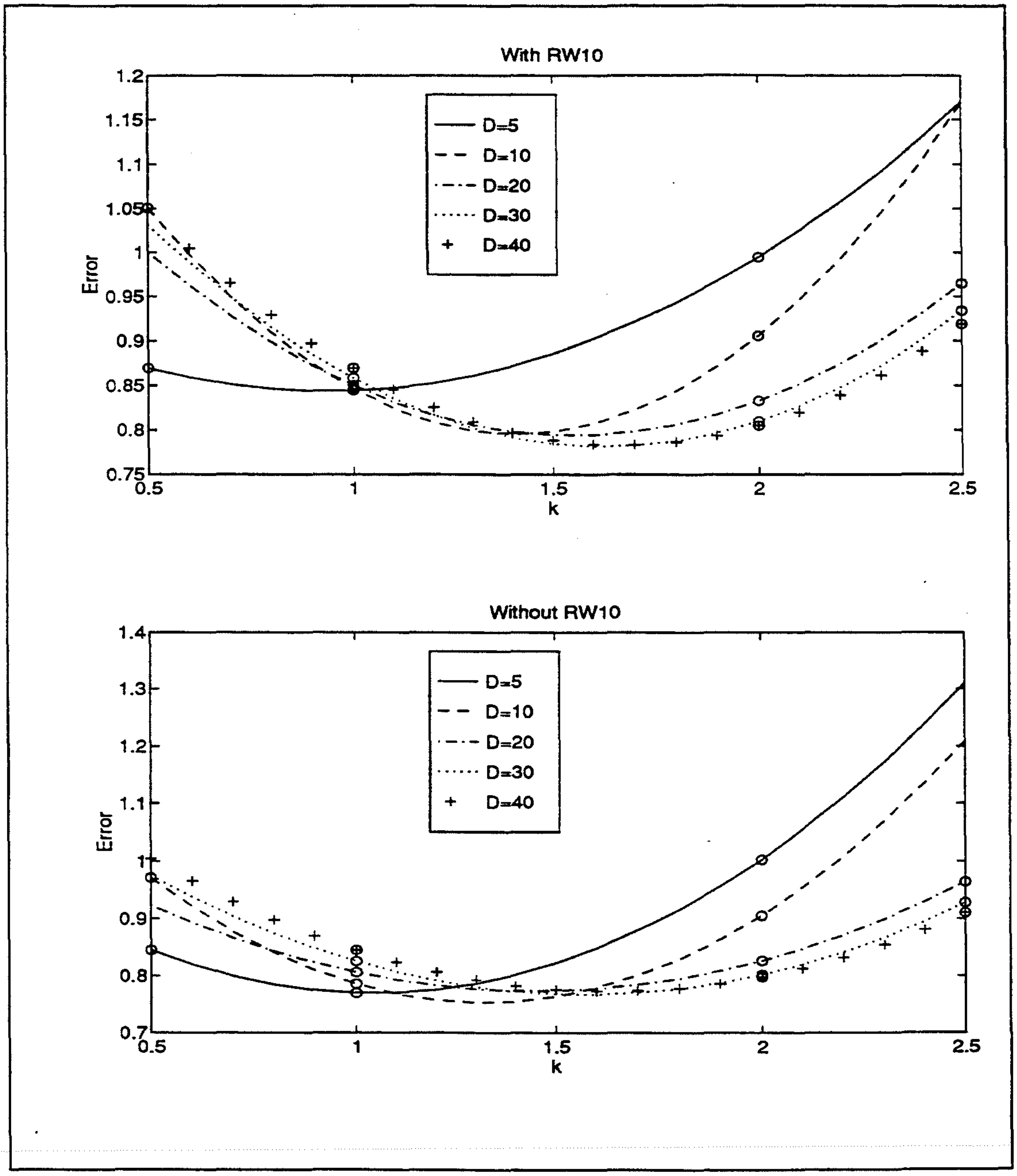


Fig. C.6 Boston Harbor–RMSL Errors, November 3, 1992 Storm. Circles mark the values of k for which runs were made.

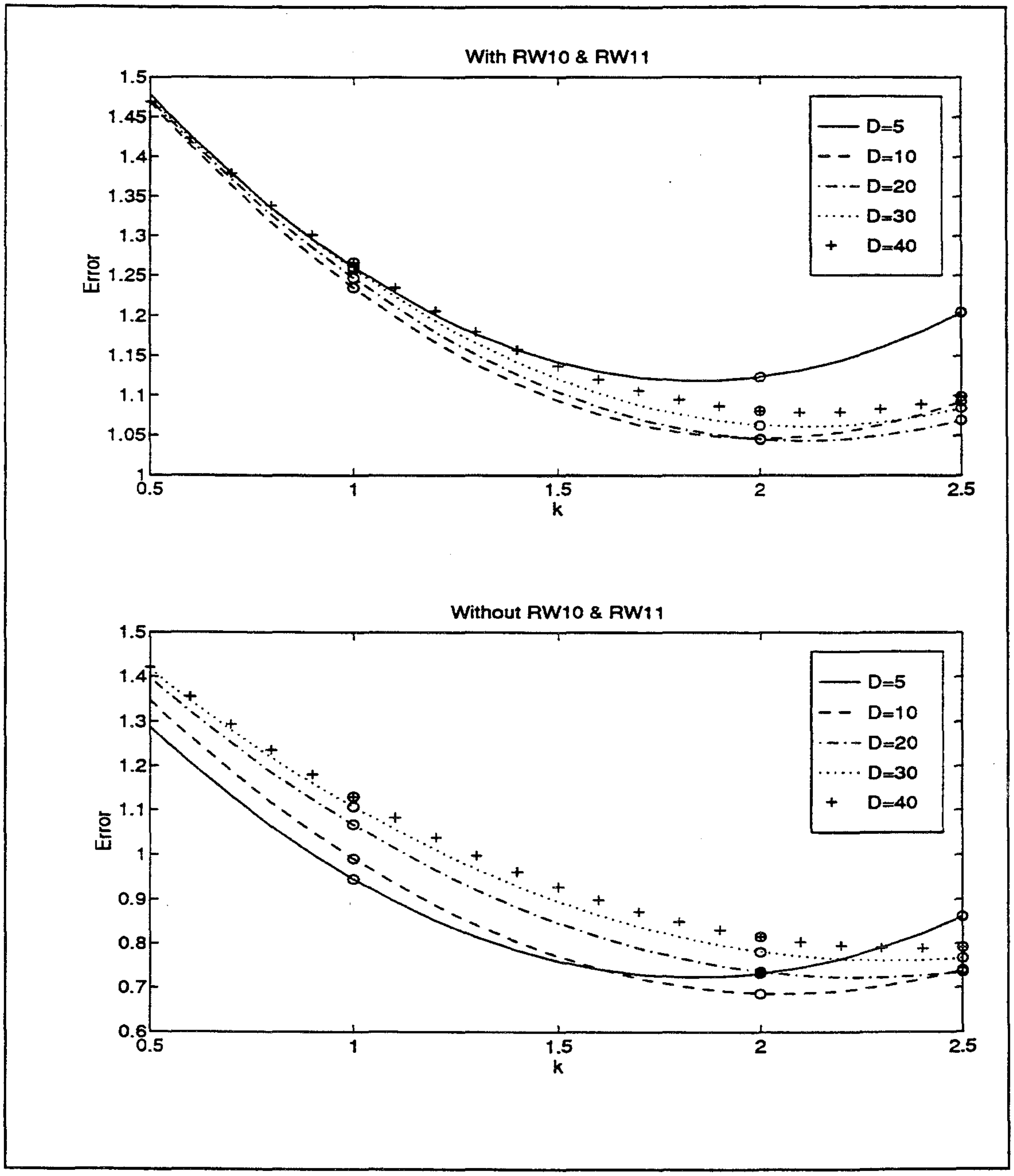


Fig. C.7 Boston Harbor–RMSL Errors, September 26, 1993 Storm. Circles mark the values of k for which runs were made.

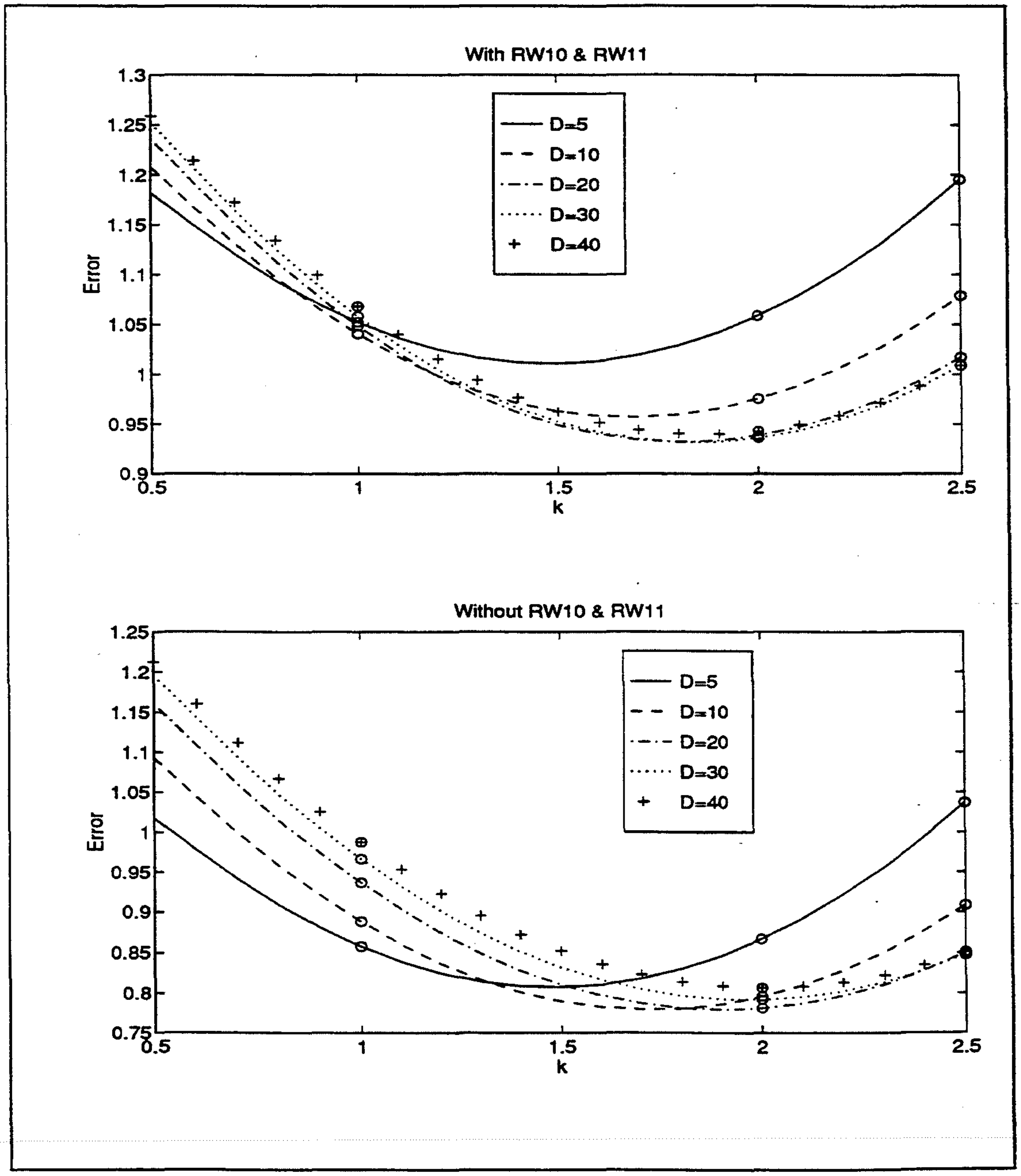


Fig. C.8 Boston Harbor–RMSL Errors, Average of November 3, 1992 and September 26, 1993 Storms. Circles mark the values of k for which runs were made.

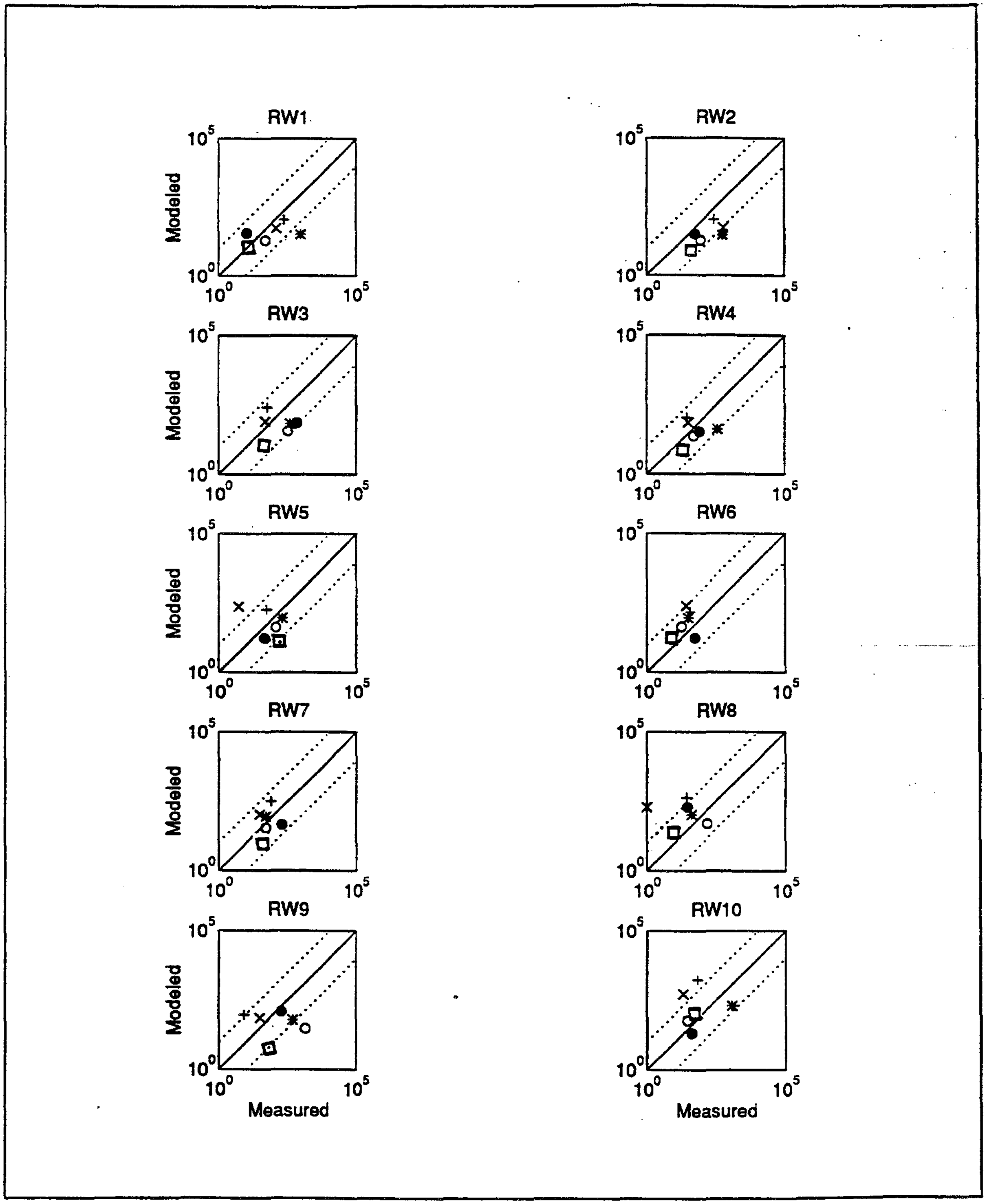


Fig. C.9a Boston Harbor–Measured vs. Modeled Fecal Coliform Count per 100mL, November 3, 1992 Storm. The dotted line indicates a difference of one order of magnitude.

Legend

+ 22 Hours
× 36 Hours
✱ 46 Hours
○ 61 Hours
● 72 Hours
□ 108 Hours

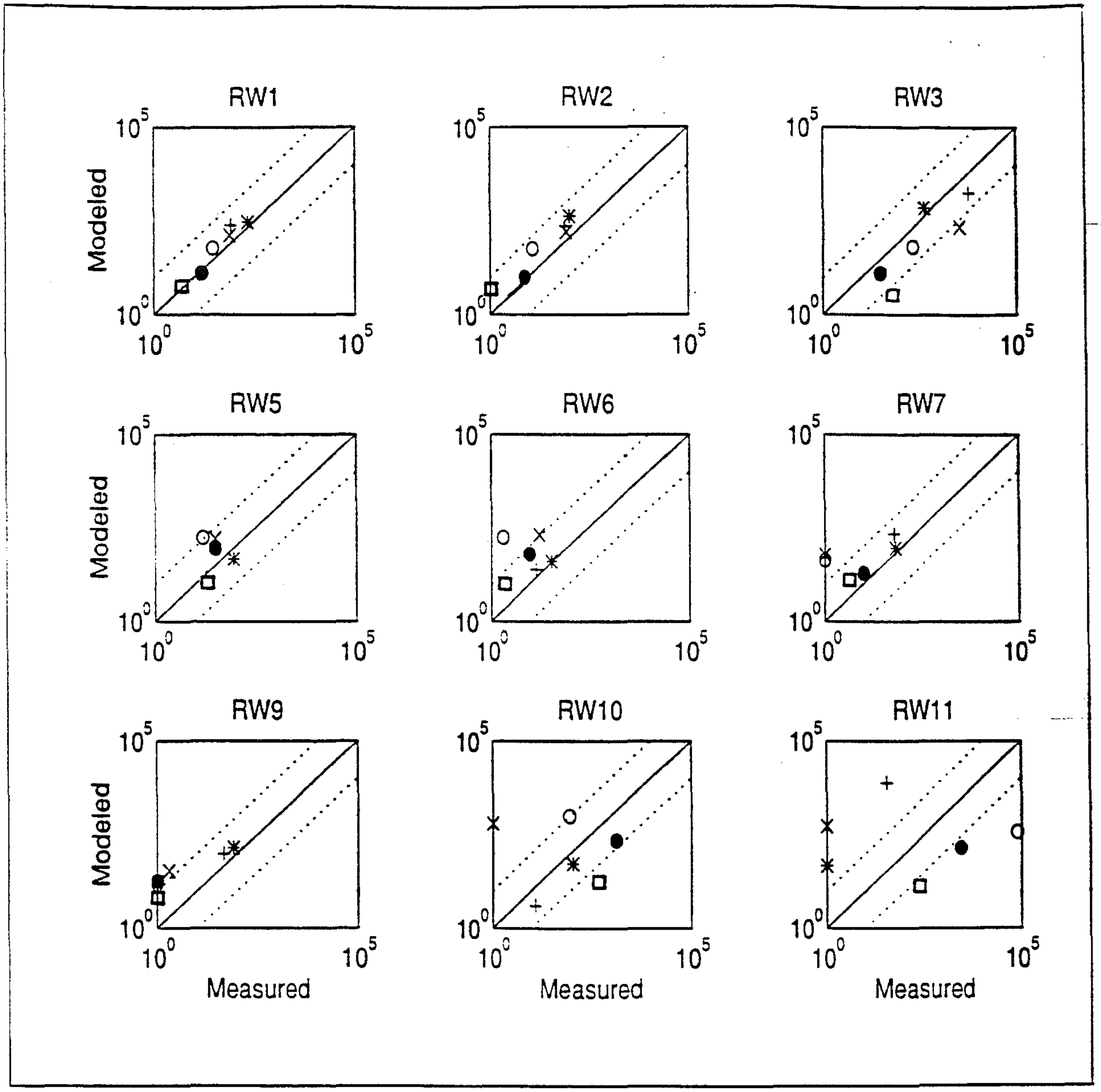


Fig. C.9b Boston Harbor–Measured vs. Modeled Fecal Coliform Count per 100mL, September 26, 1993 Storm. The dotted line indicates a difference of one order of magnitude.

Legend

+	17 Hours
×	34 Hours
✳	58 Hours
○	84 Hours
●	109 Hours
□	134 Hours

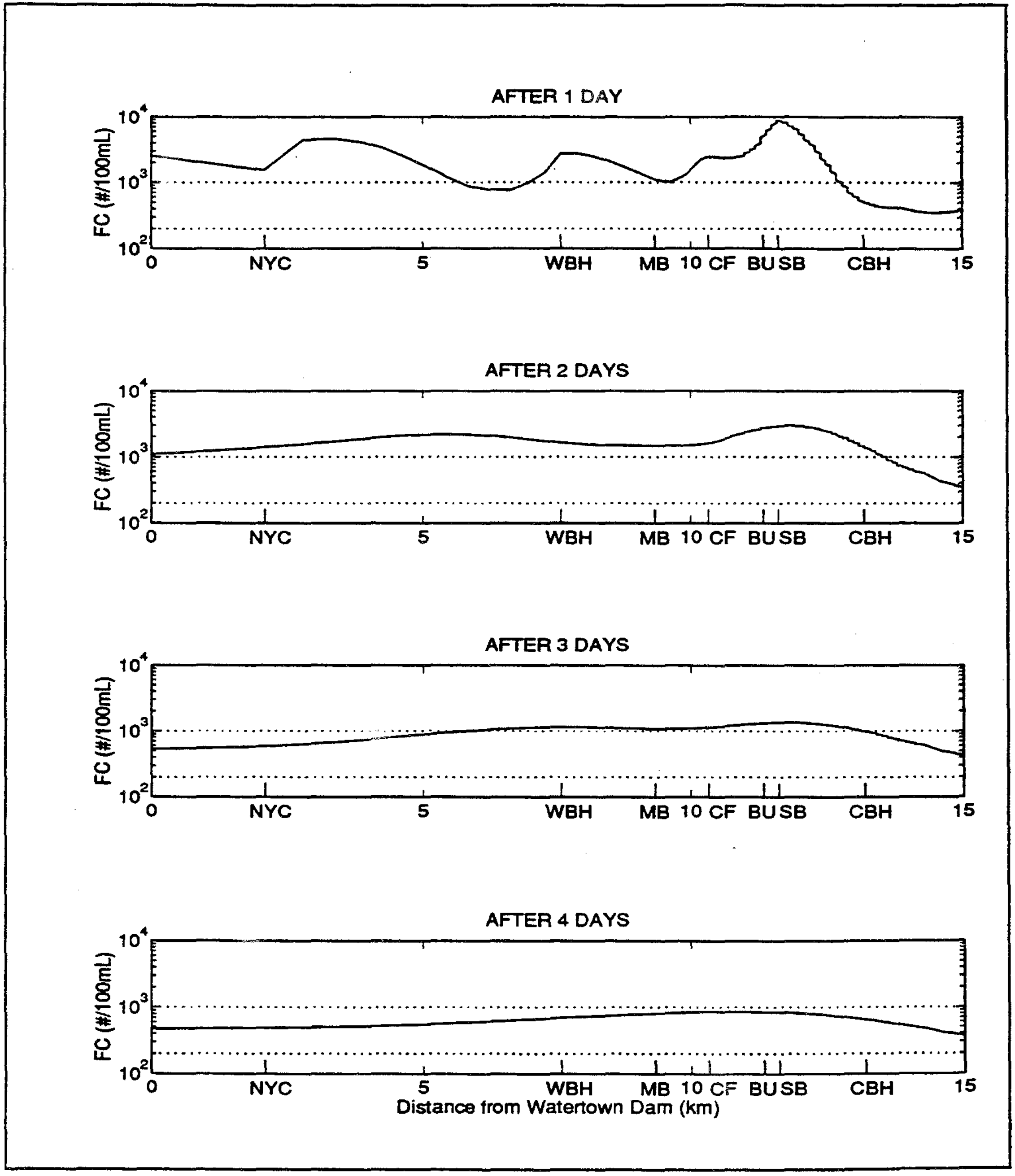


Fig. D.1a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 1: Existing conditions, 3-month design storm, all sources.

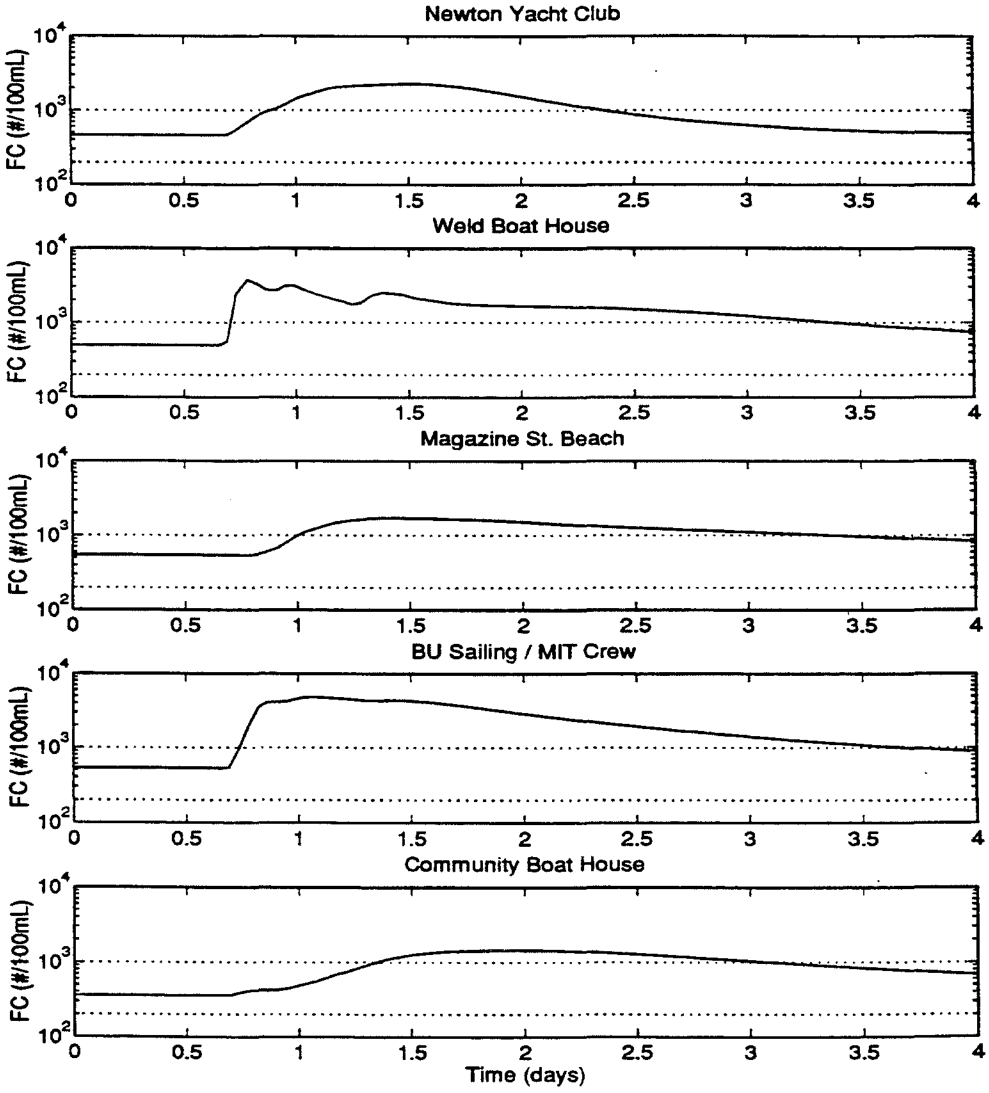


Fig. D.1b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 1: Existing conditions, 3-month design storm, all sources.

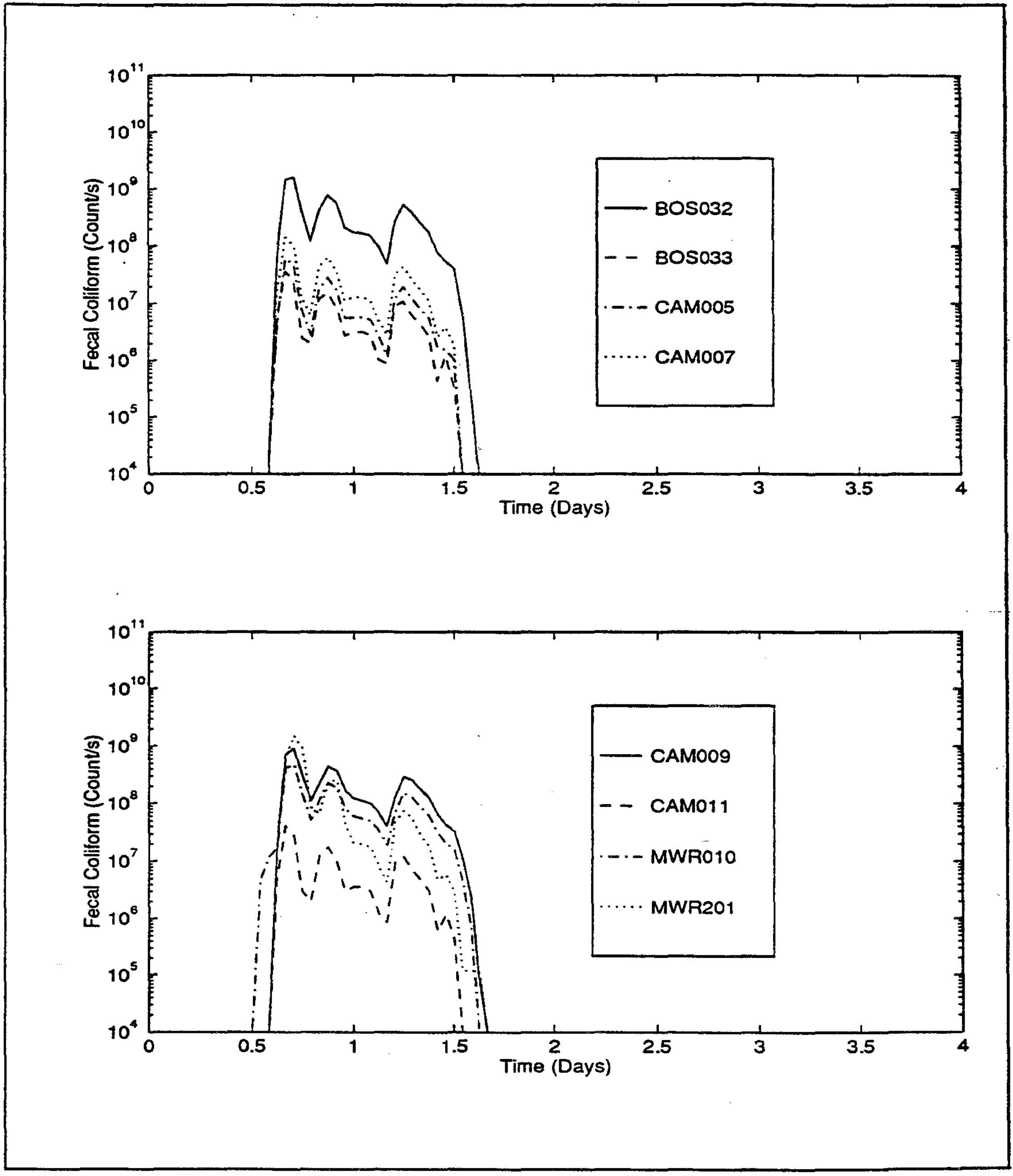


Fig. D.1c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 1: Existing conditions, 3-month design storm, all sources.

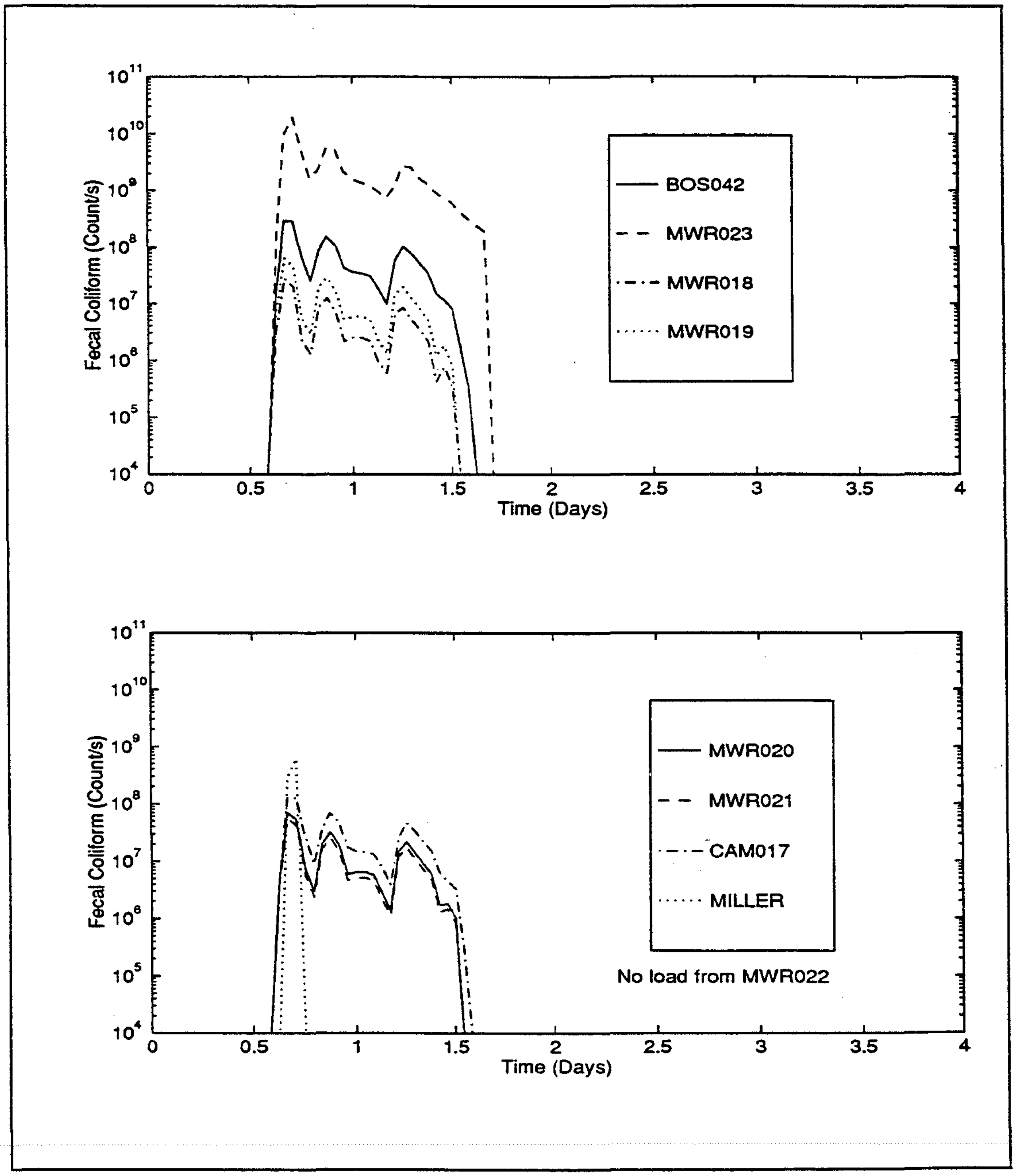


Fig. D.1c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 1: Existing conditions, 3-month design storm, all sources.

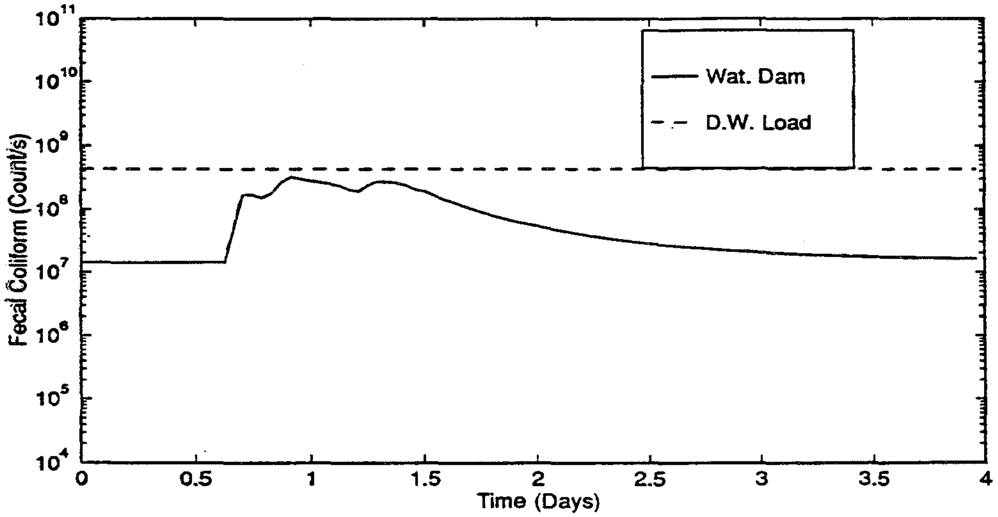


Fig. D.1c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 1: Existing conditions, 3-month design storm, all sources.

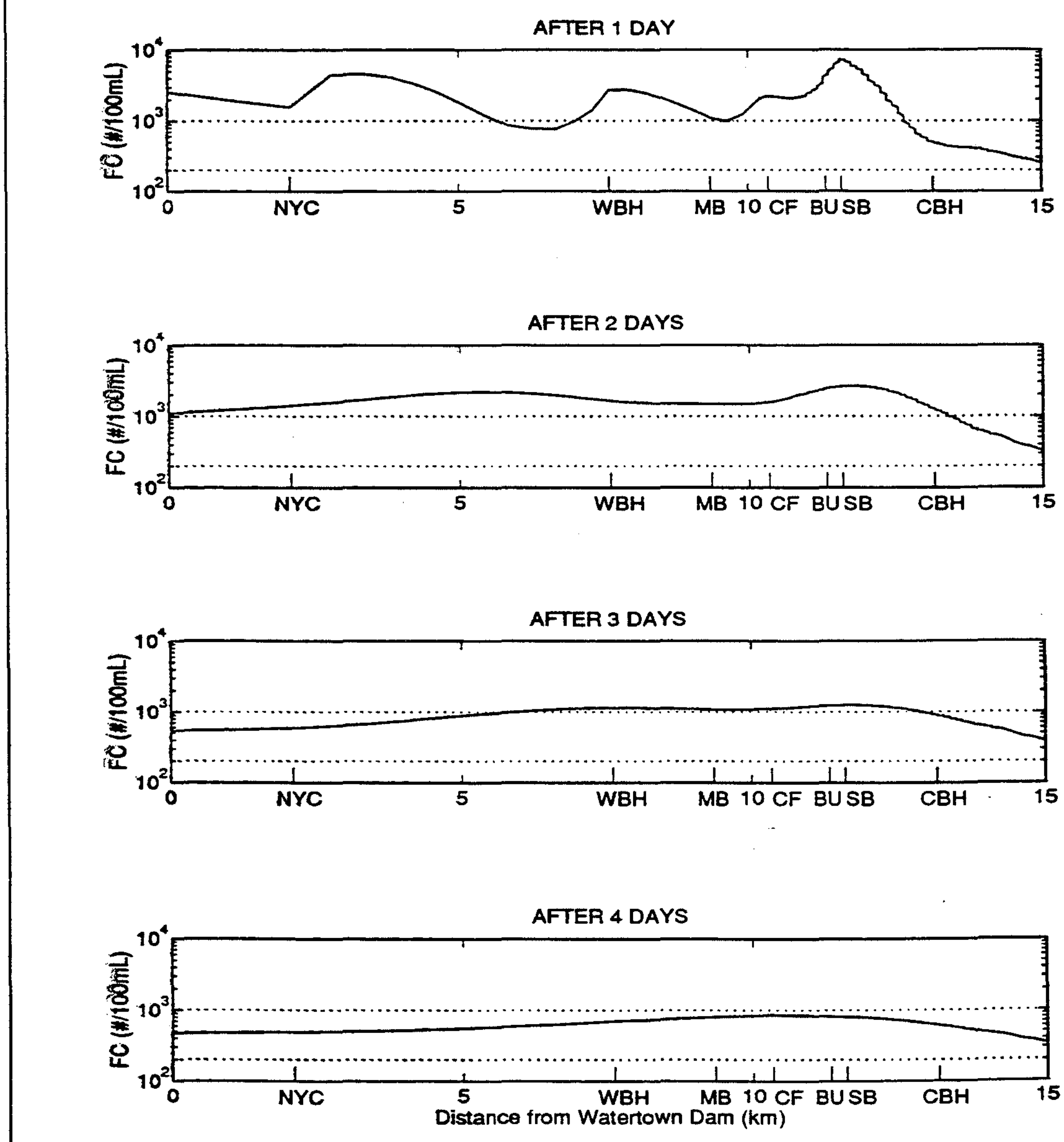


Fig. D.2a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 2: Future planned conditions, 3-month design storm, all sources.

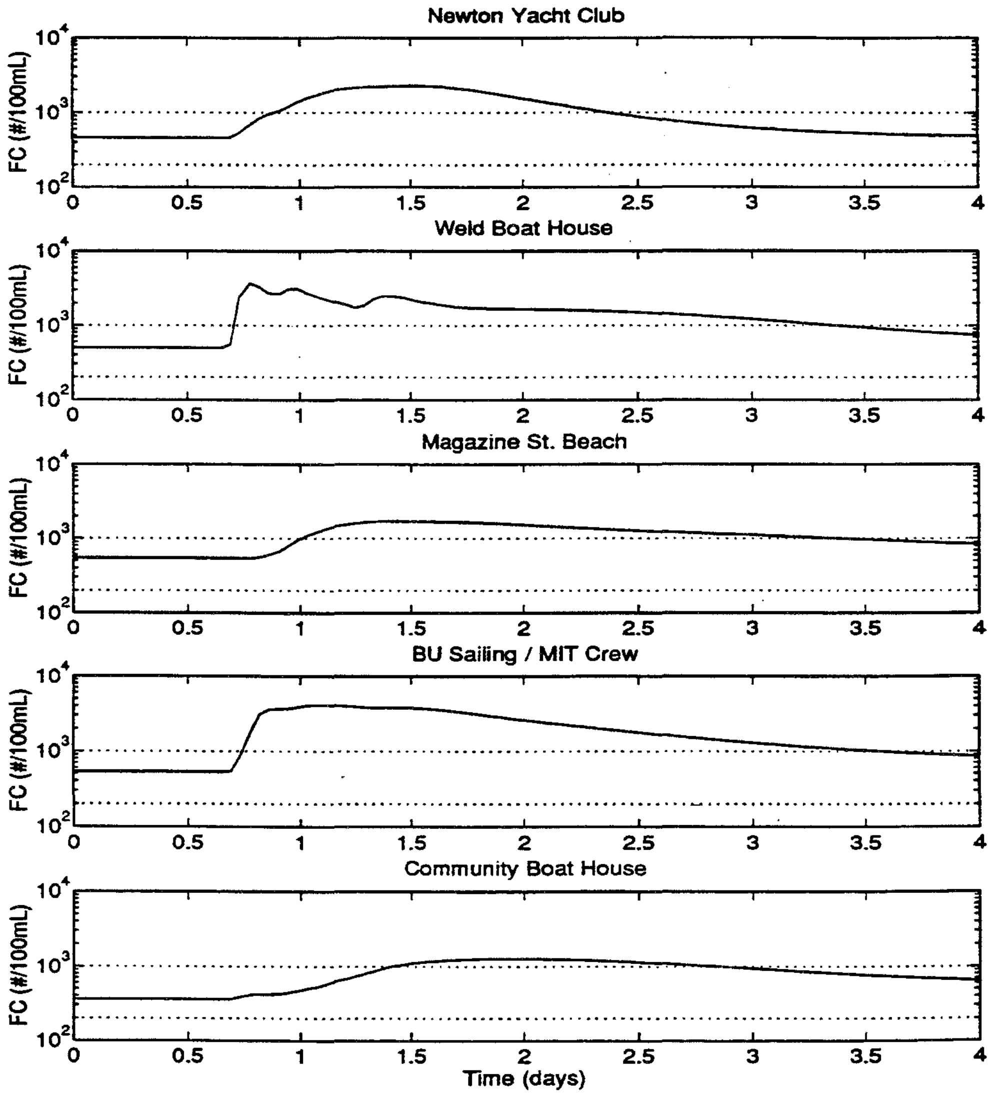


Fig. D.2b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 2: Future planned conditions, 3-month design storm, all sources.

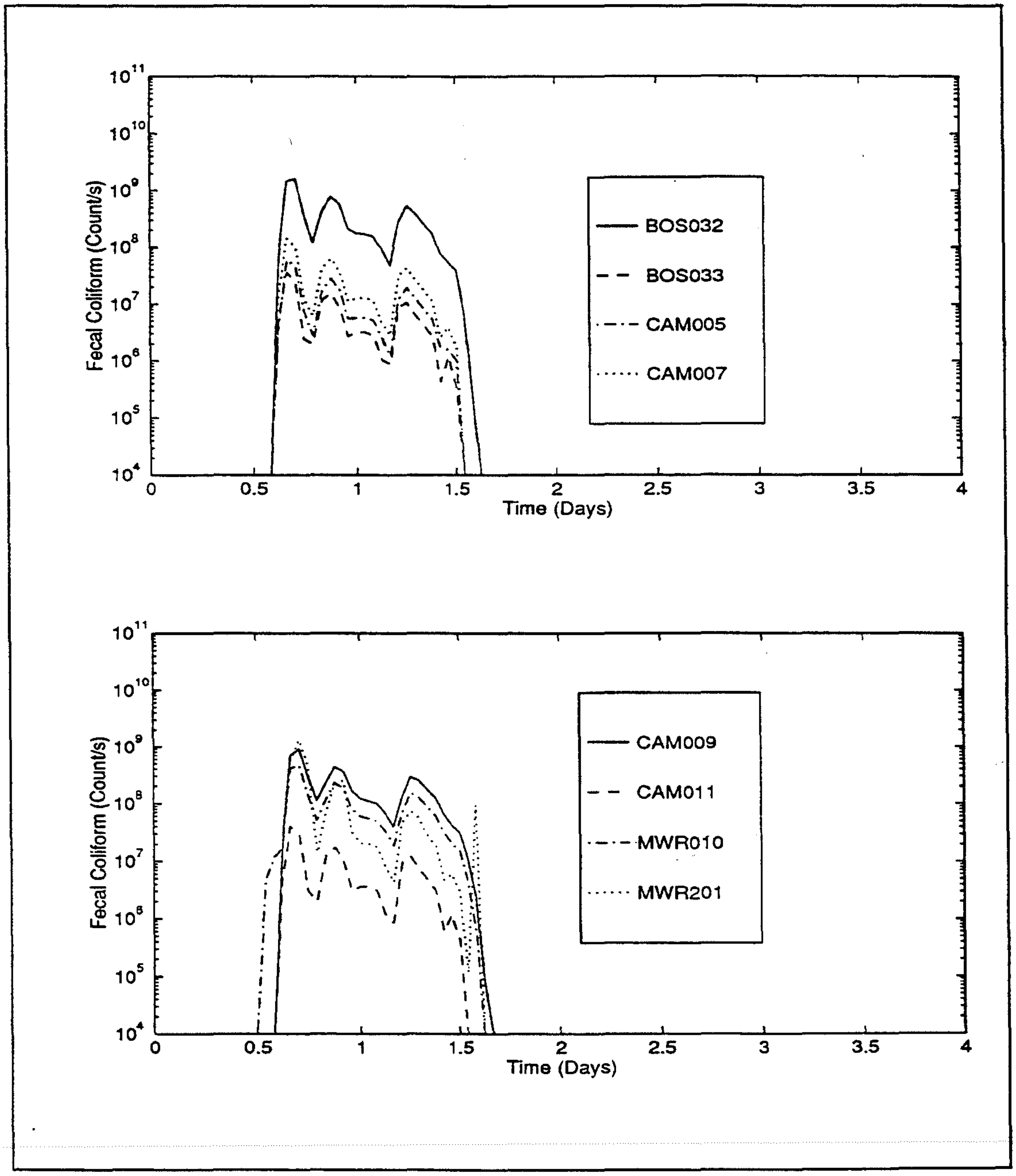


Fig. D.2c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 2: Future planned conditions, 3-month design storm, all sources.

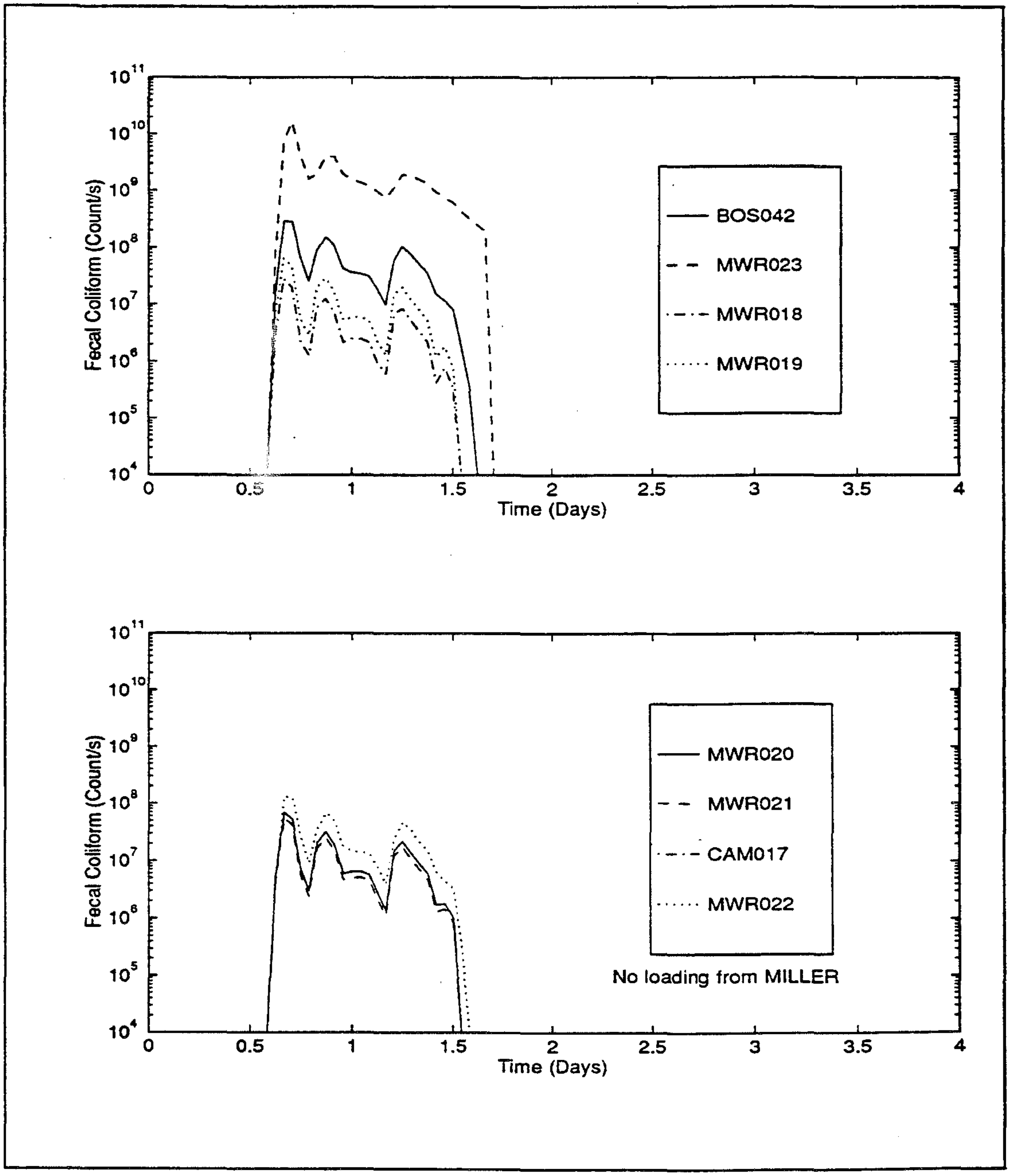


Fig. D.2c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 2: Future planned conditions, 3-month design storm, all sources.

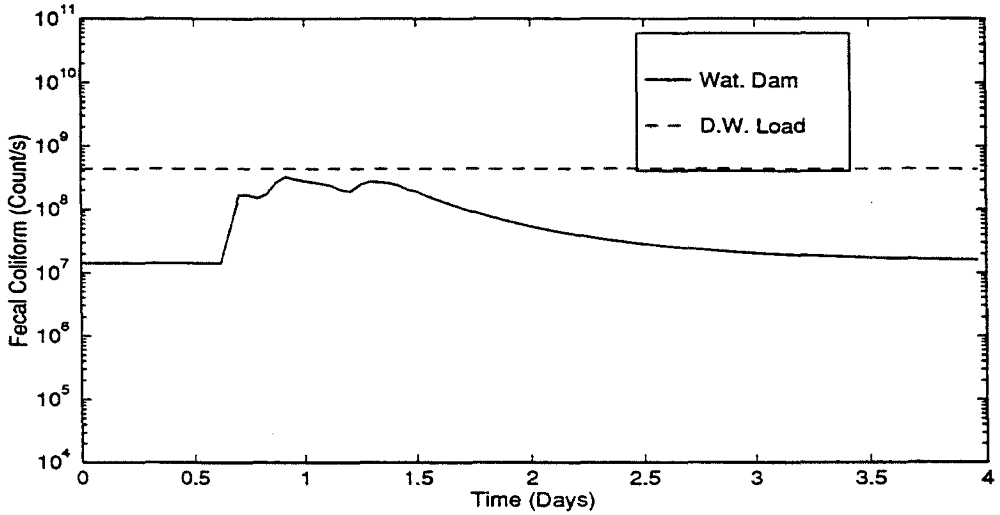


Fig. D.2c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 2: Future planned conditions, 3-month design storm, all sources.

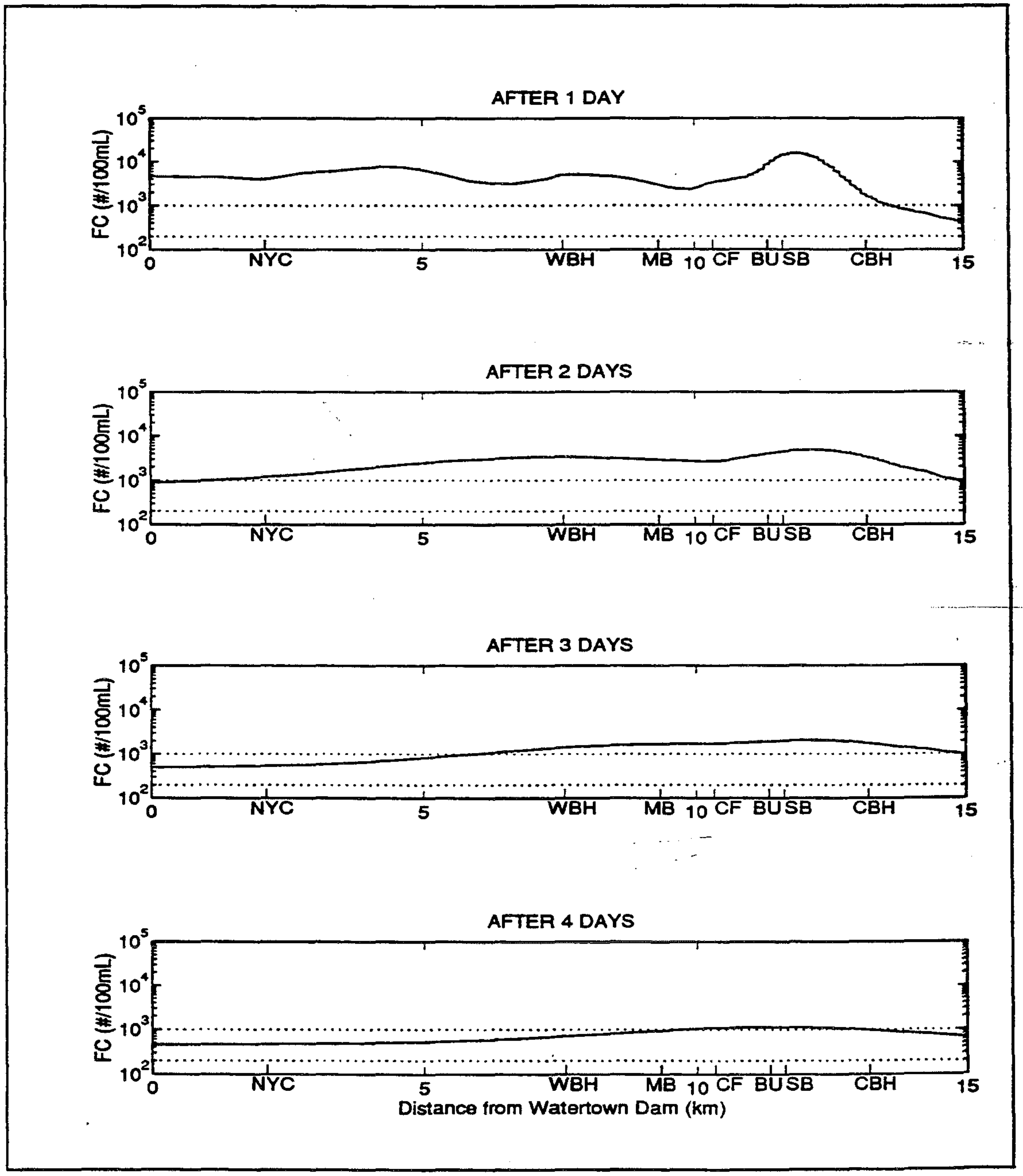


Fig. D.3a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 3: Future planned conditions, 1-year design storm, all sources.

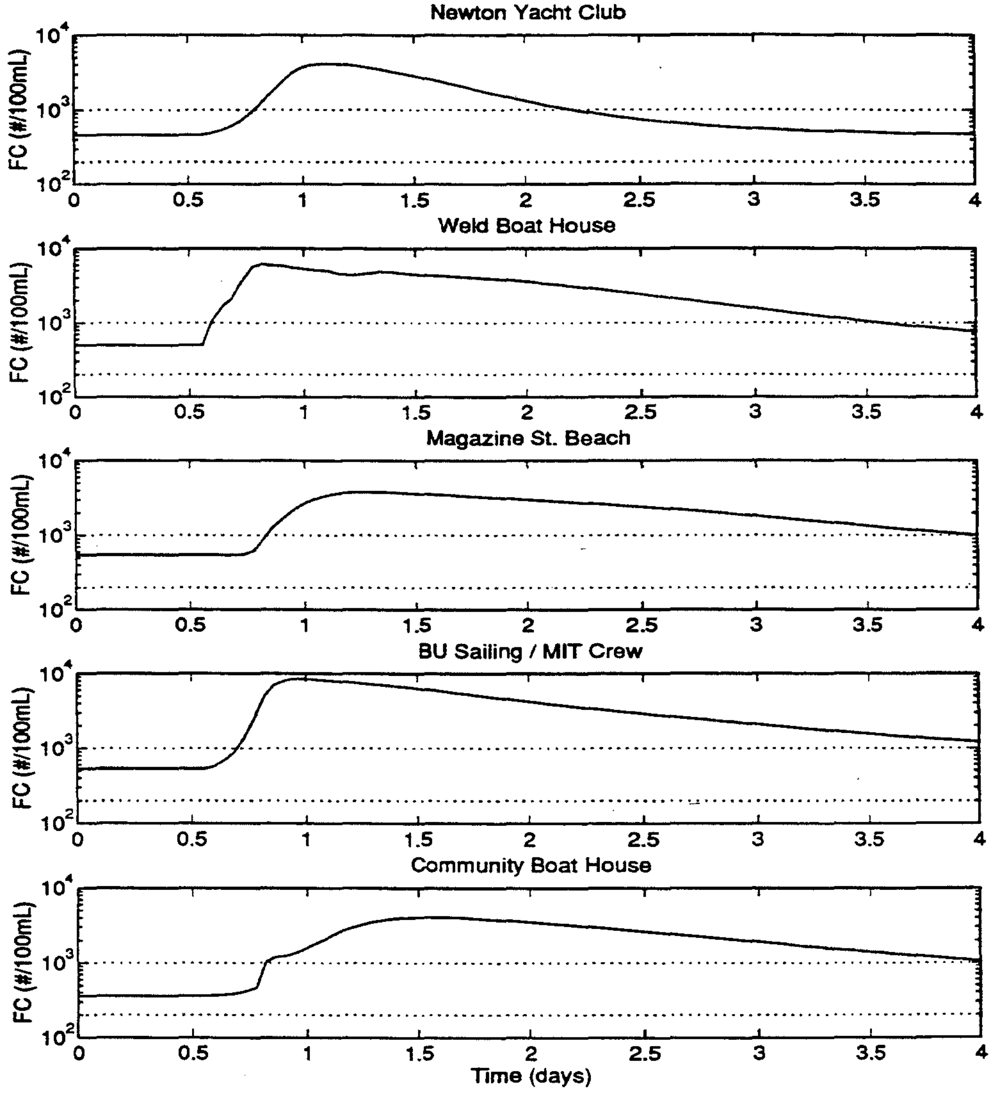


Fig. D.3b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 3: Future planned conditions, 1-year design storm, all sources.

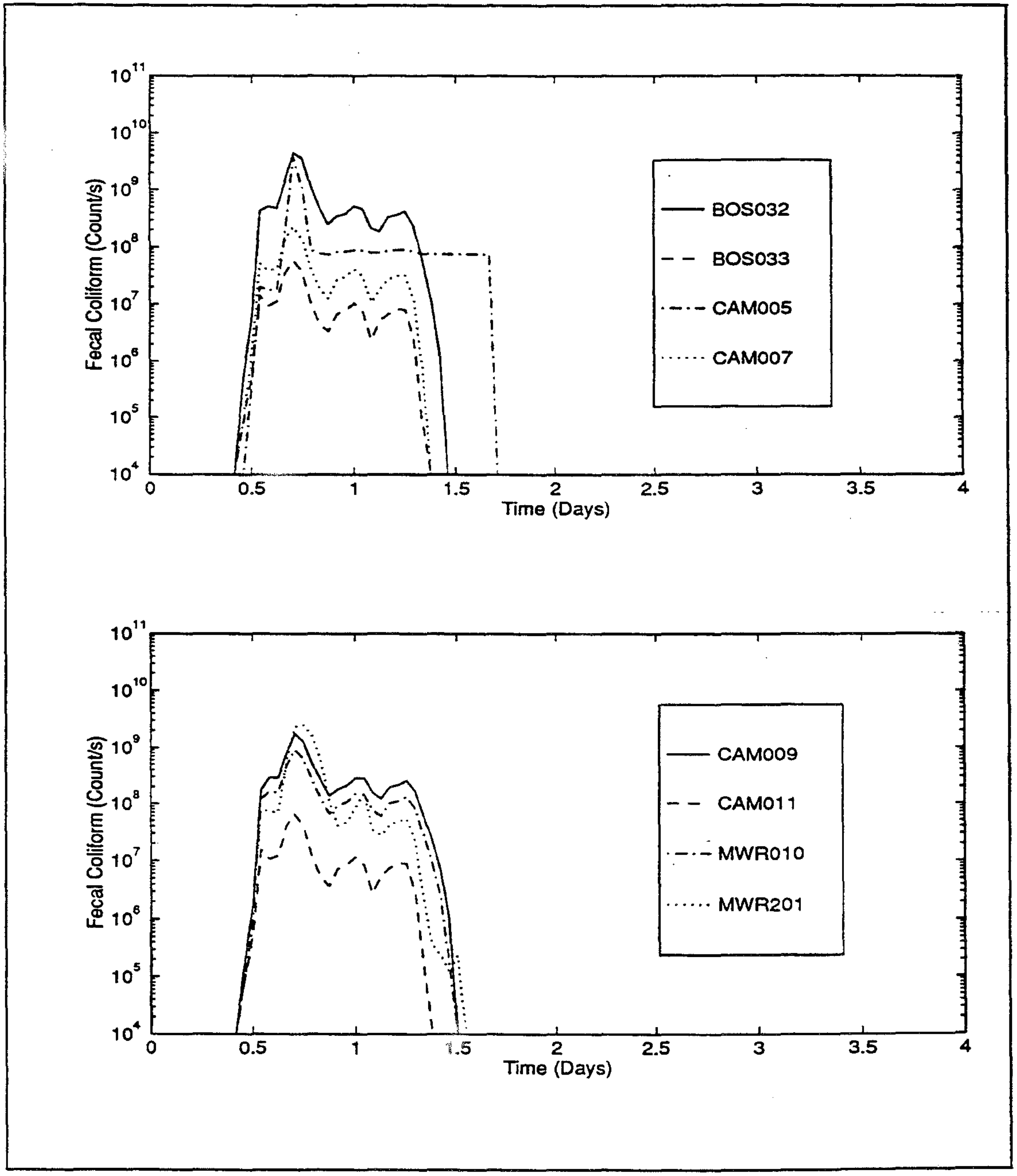


Fig. D.3c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 3: Future planned conditions, 1-year design storm, all sources.

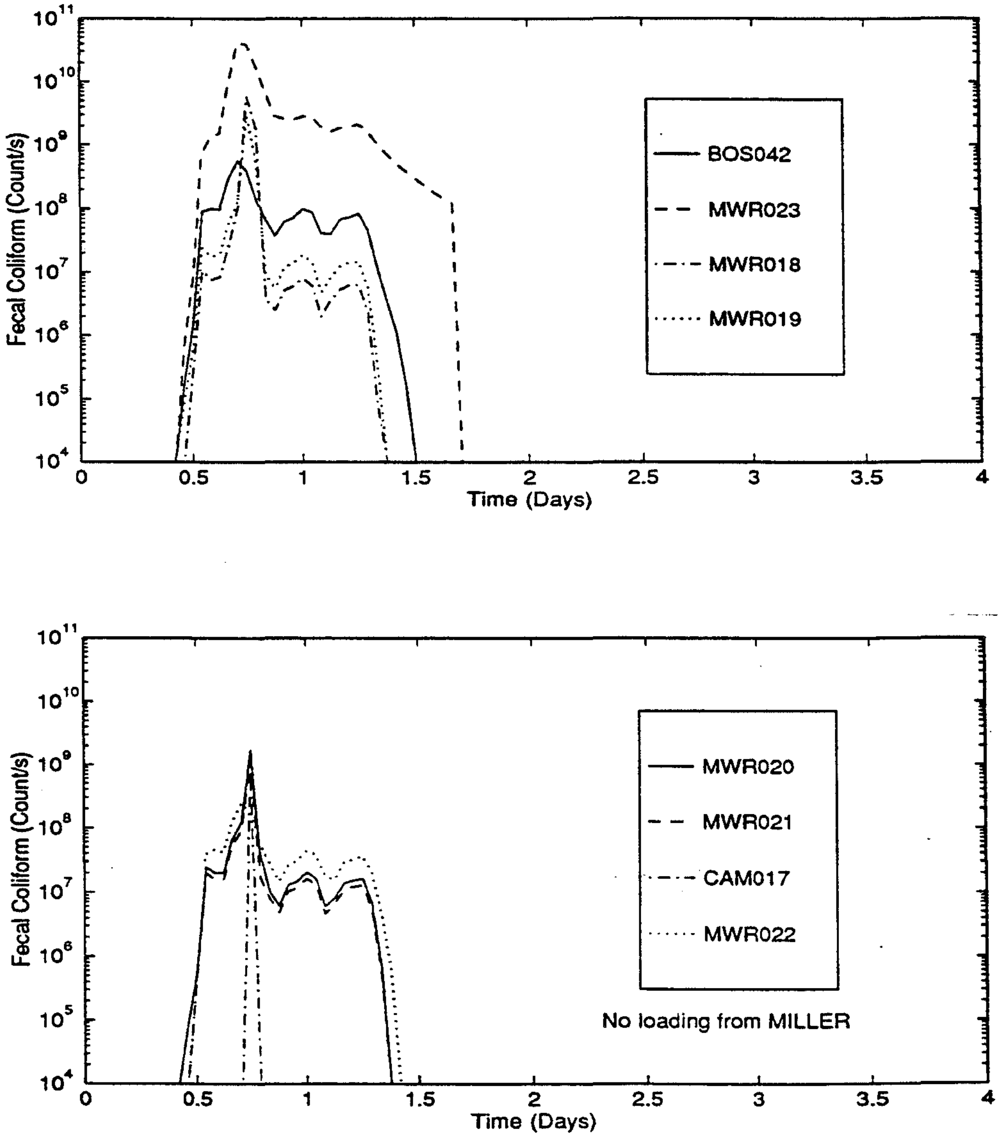


Fig. D.3c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 3: Future planned conditions, 1-year design storm, all sources.

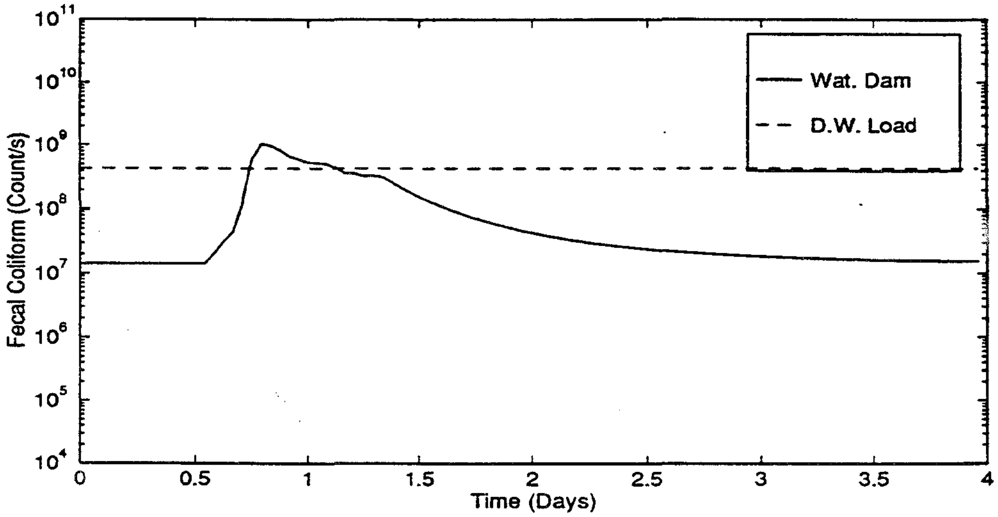


Fig. D.3c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 3: Future planned conditions, 1-year design storm, all sources.

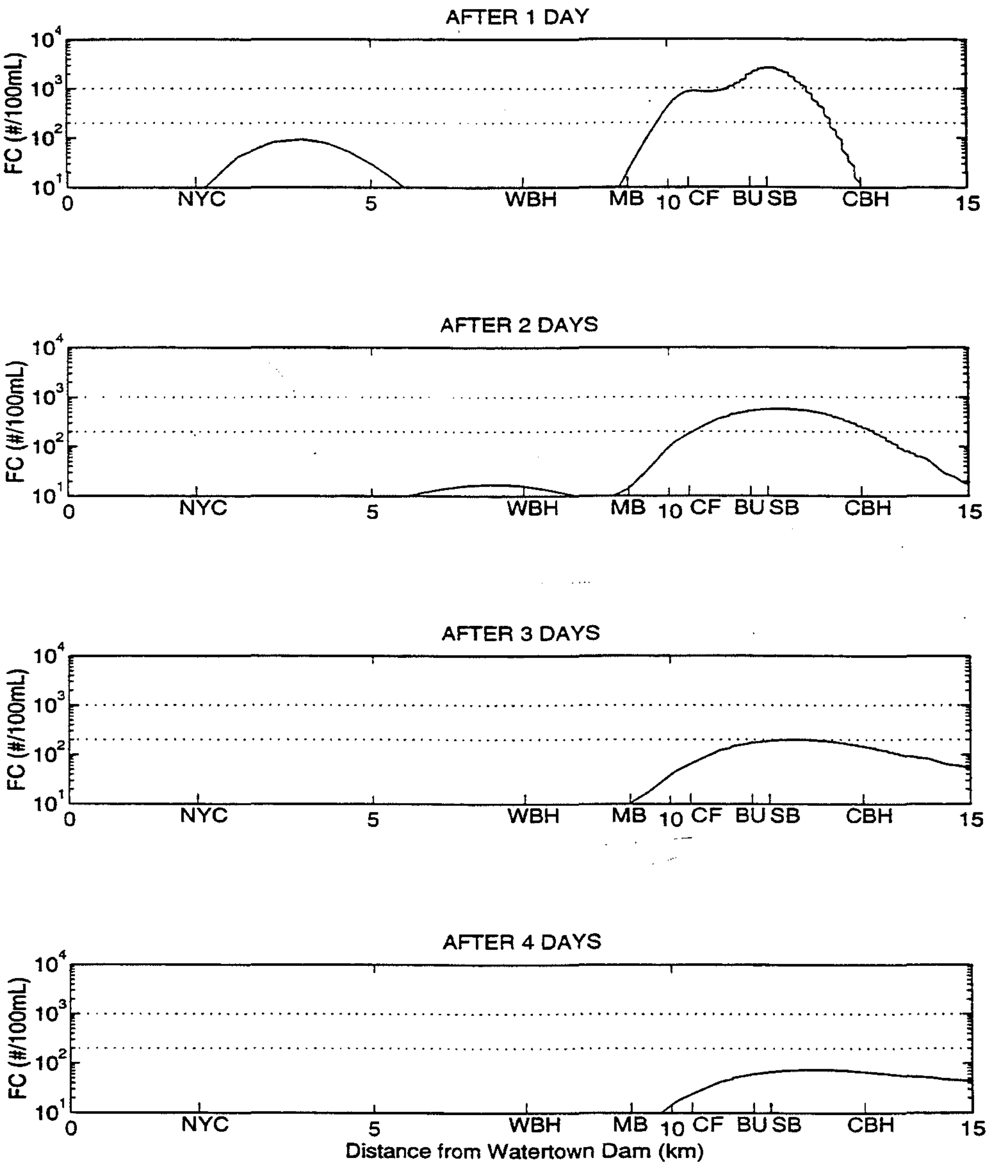


Fig. D.4a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

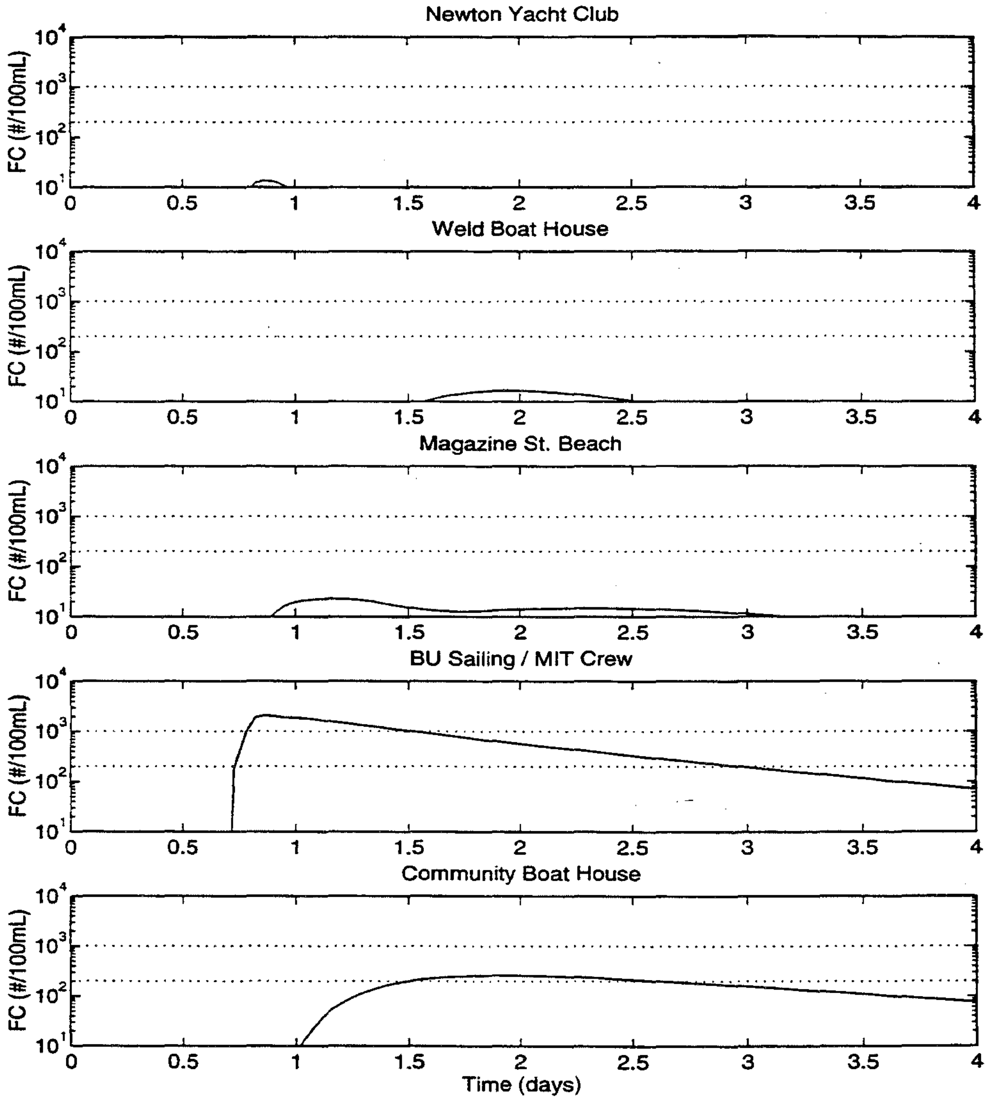


Fig. D.4b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

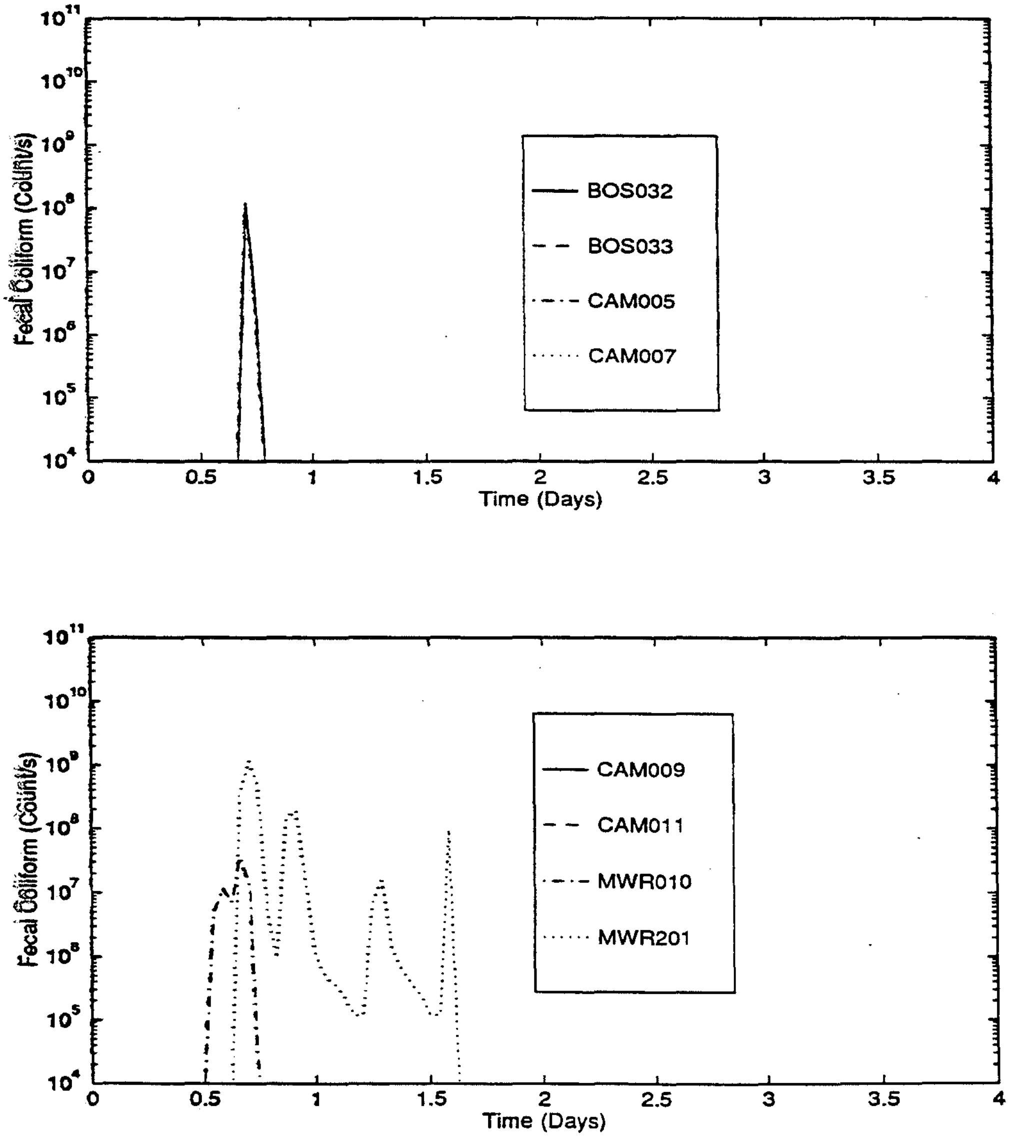


Fig. D.4c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

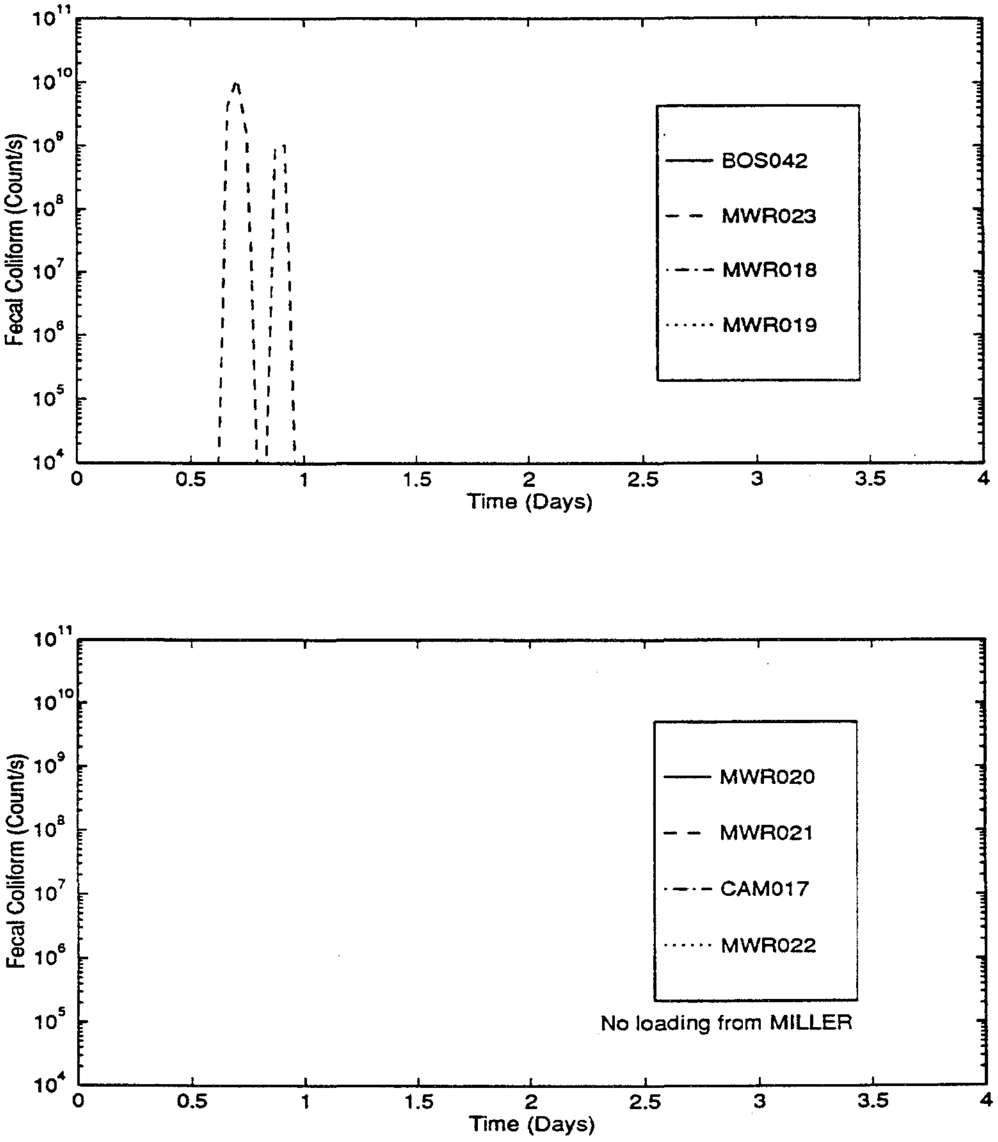


Fig. D.4c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

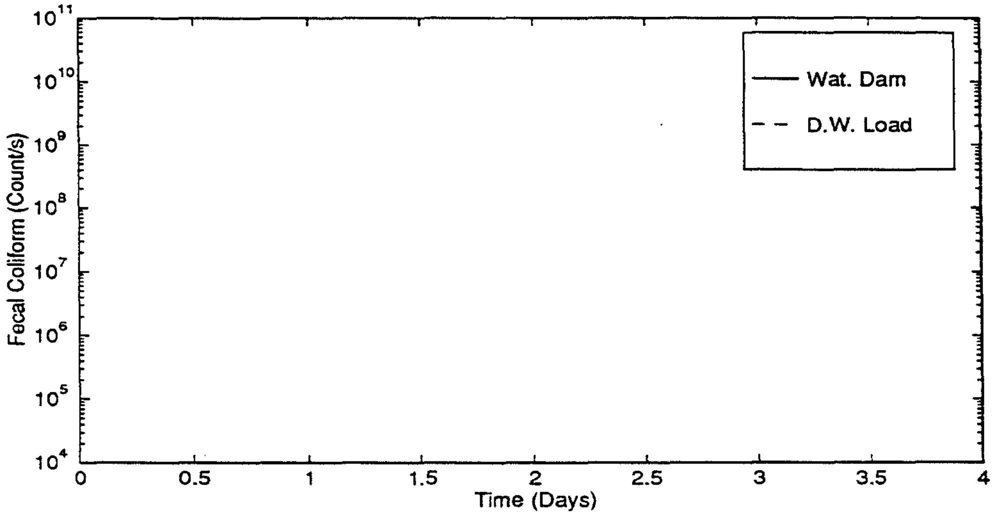


Fig. D.4c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

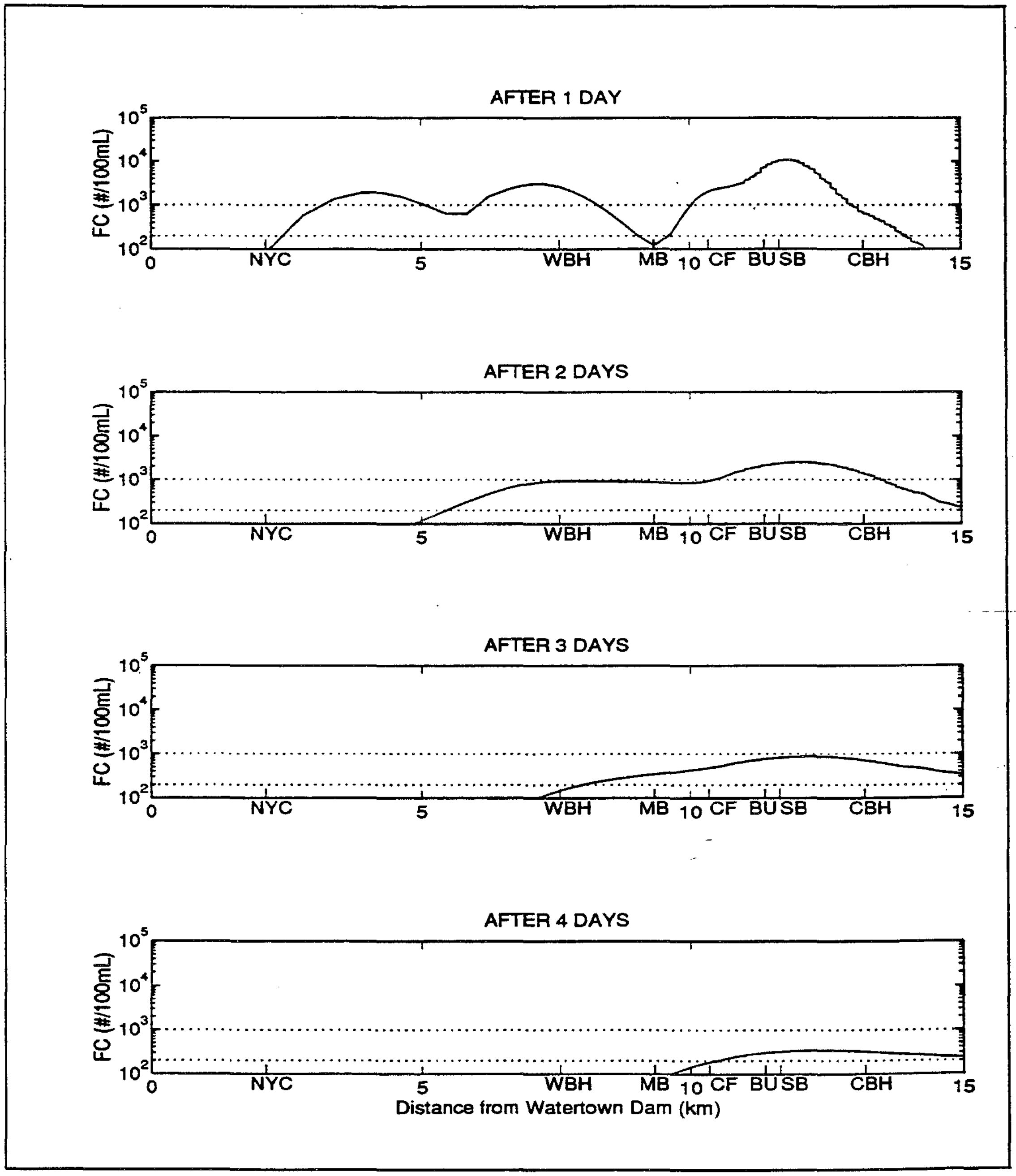


Fig. D.5a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

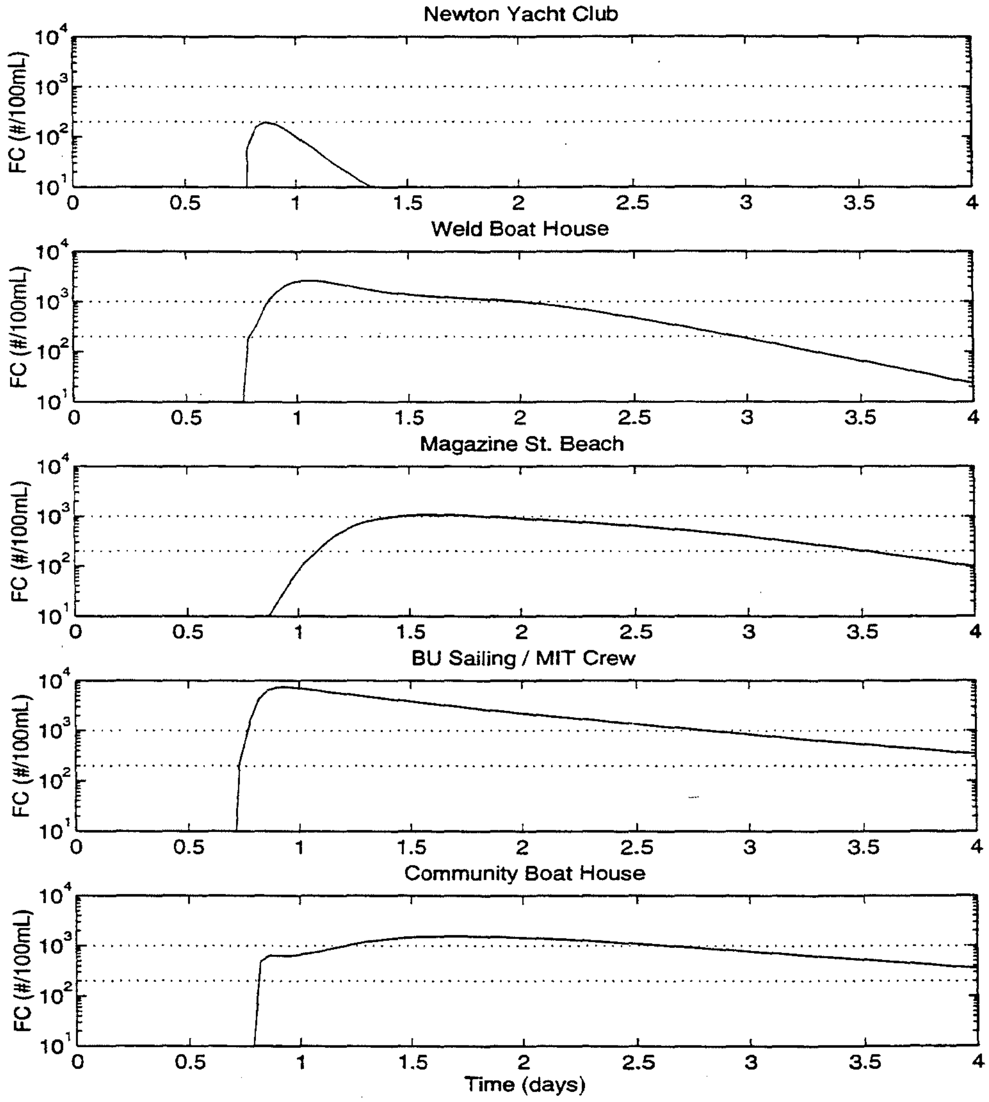


Fig. D.5b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

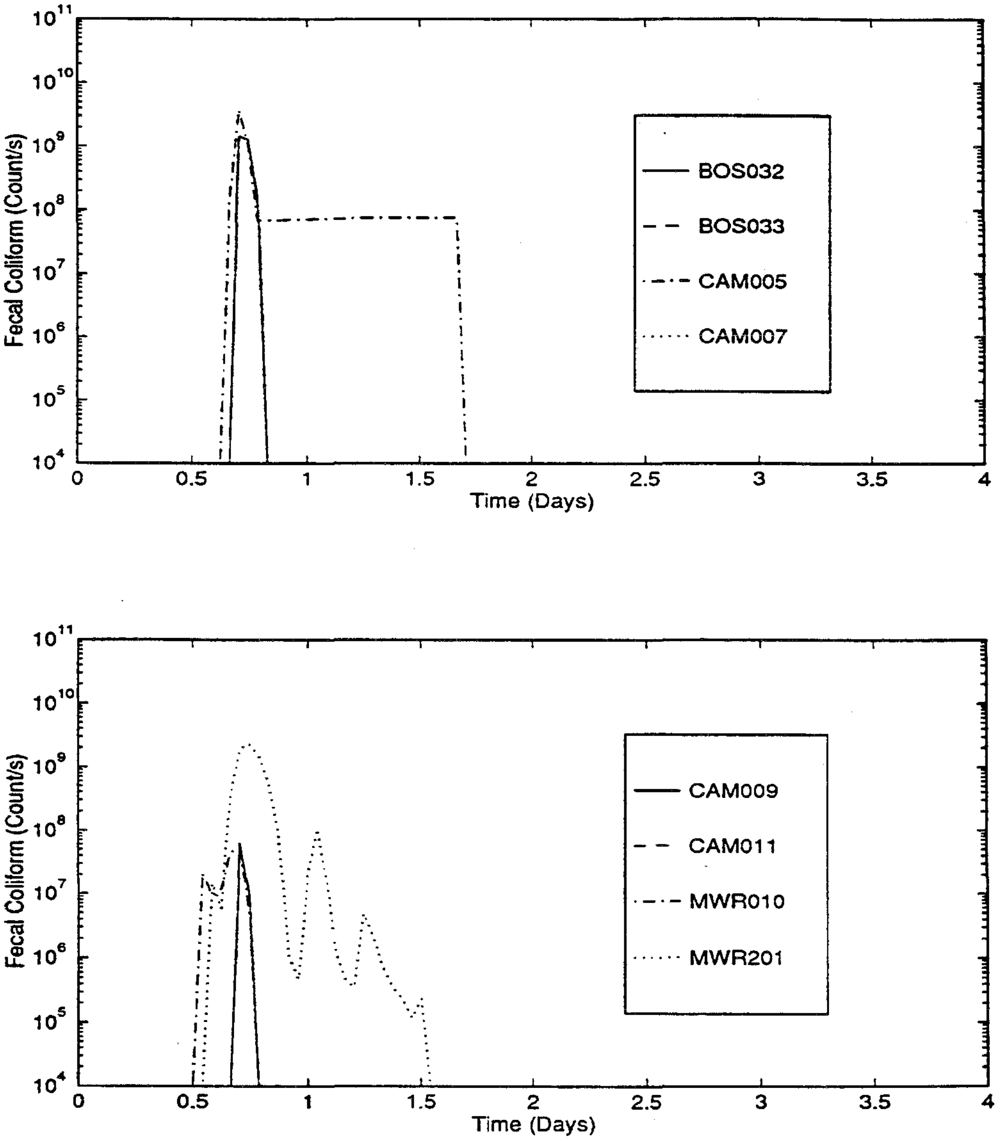


Fig. D.5c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

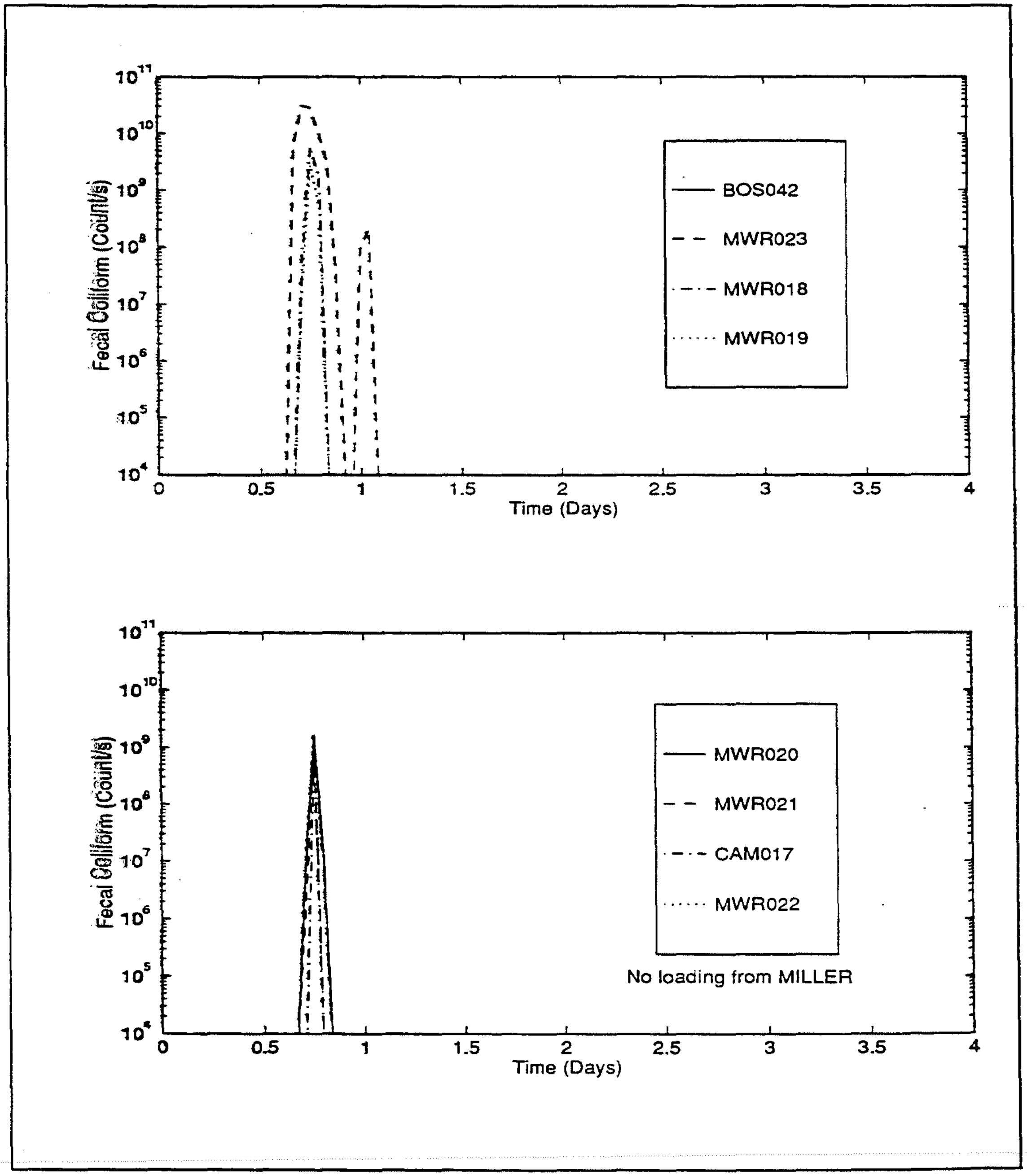


Fig. D.5c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

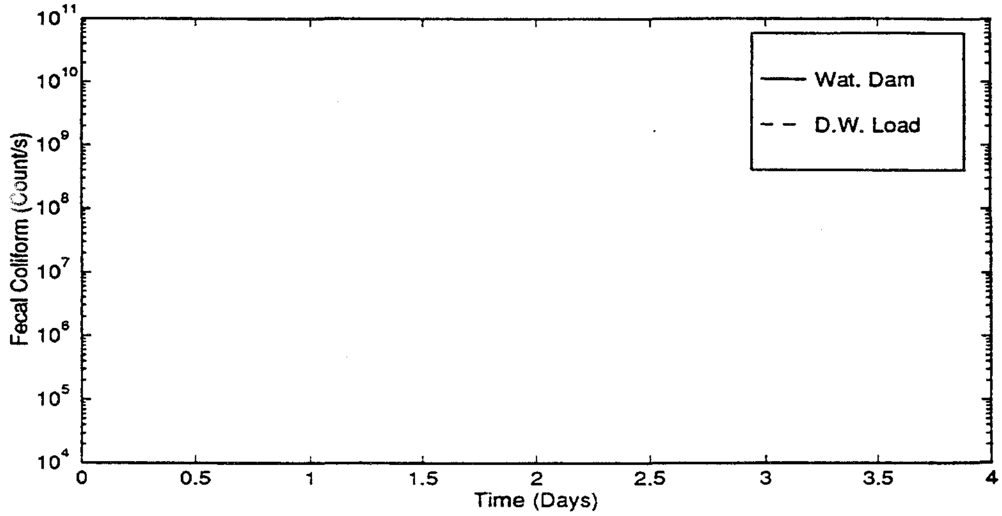


Fig. D.5c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

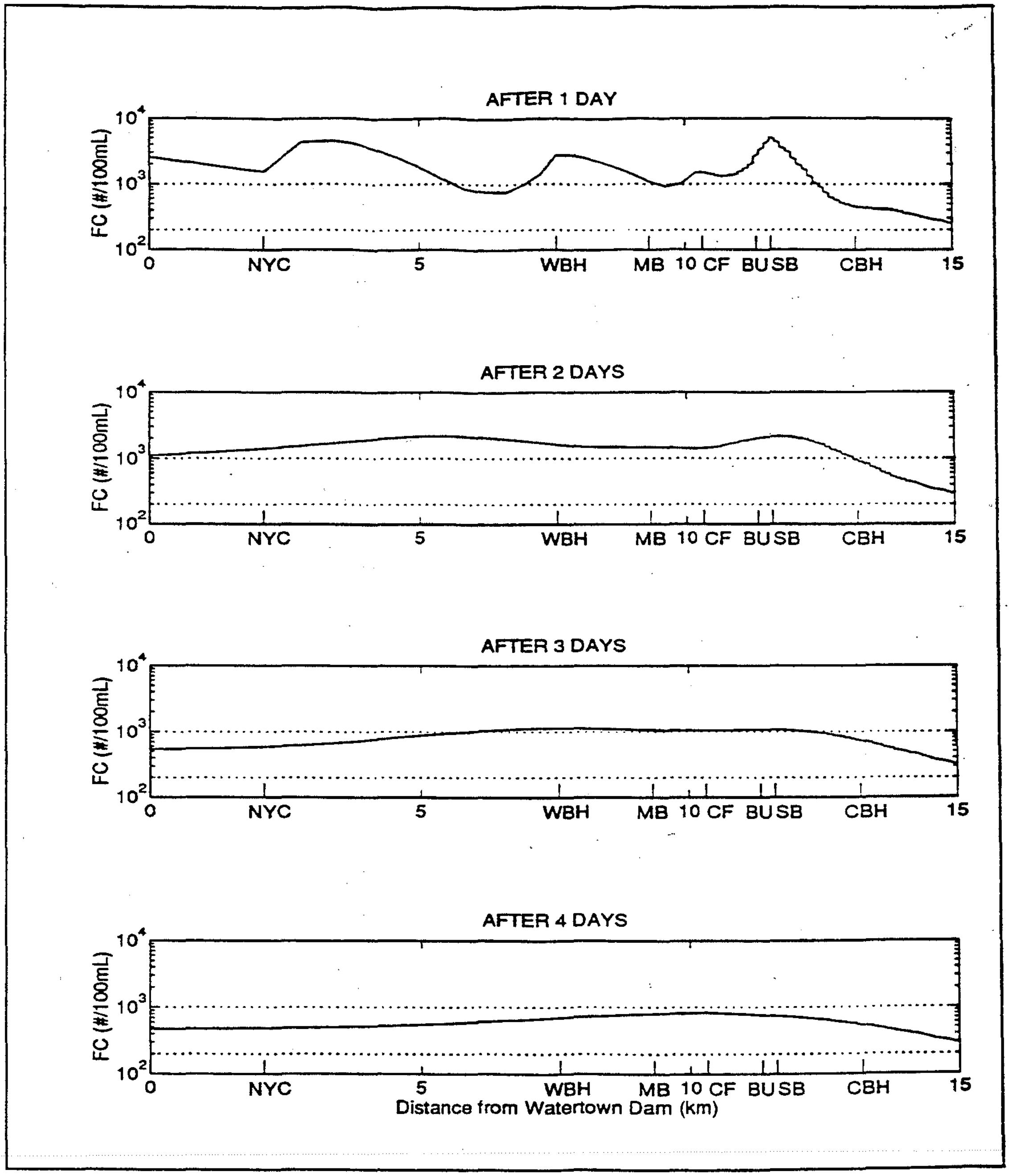


Fig. D.6a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

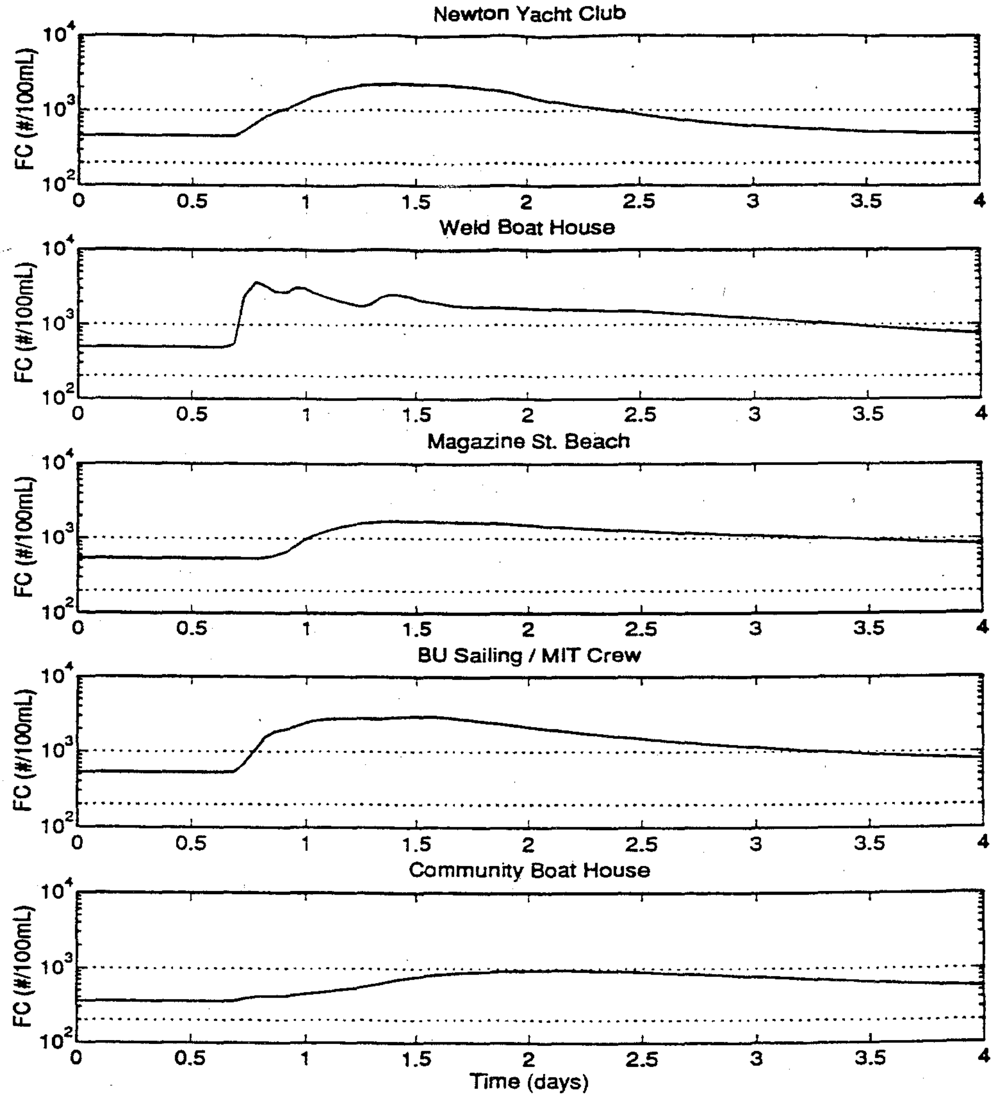


Fig. D.6b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

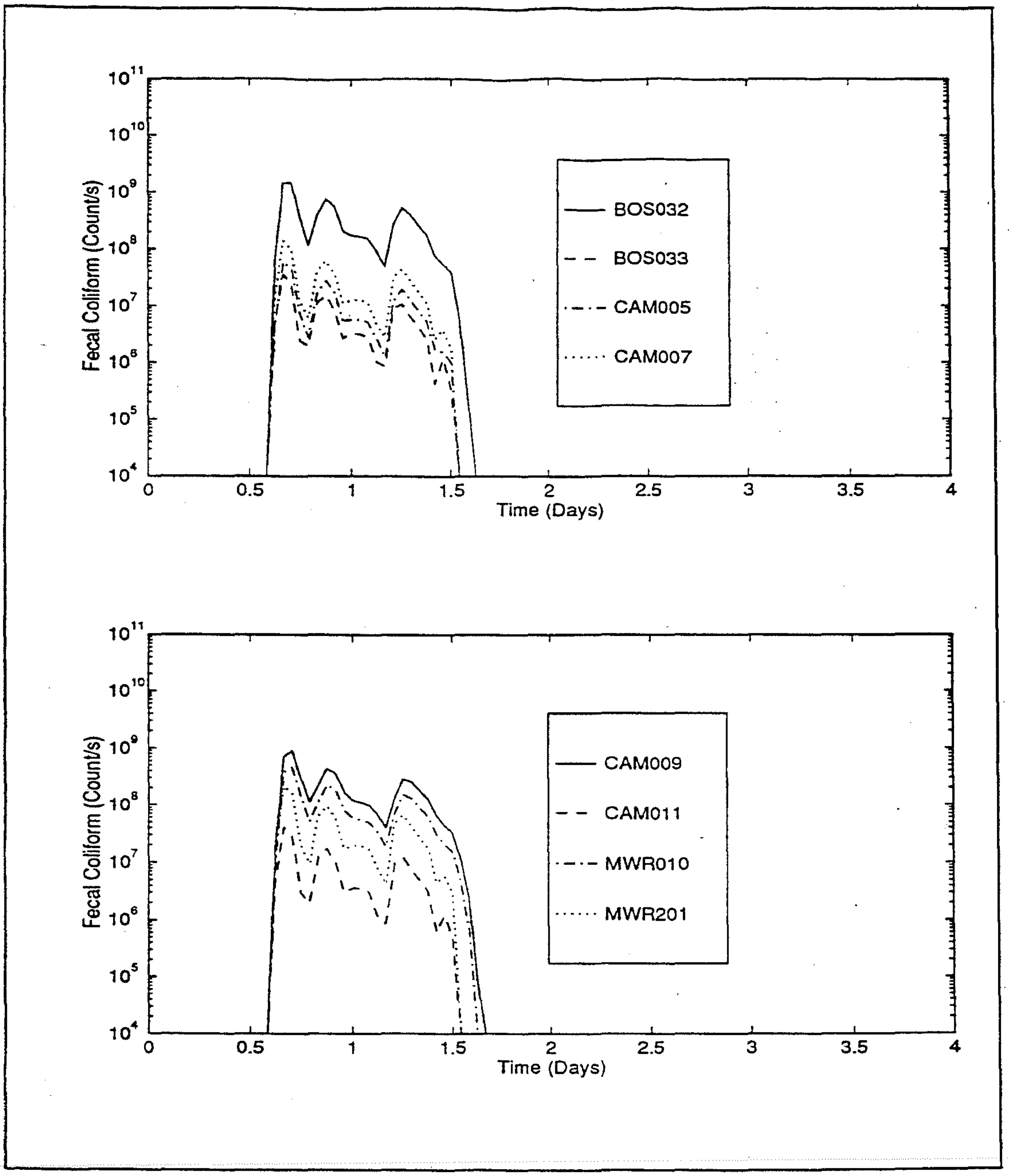


Fig. D.6c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

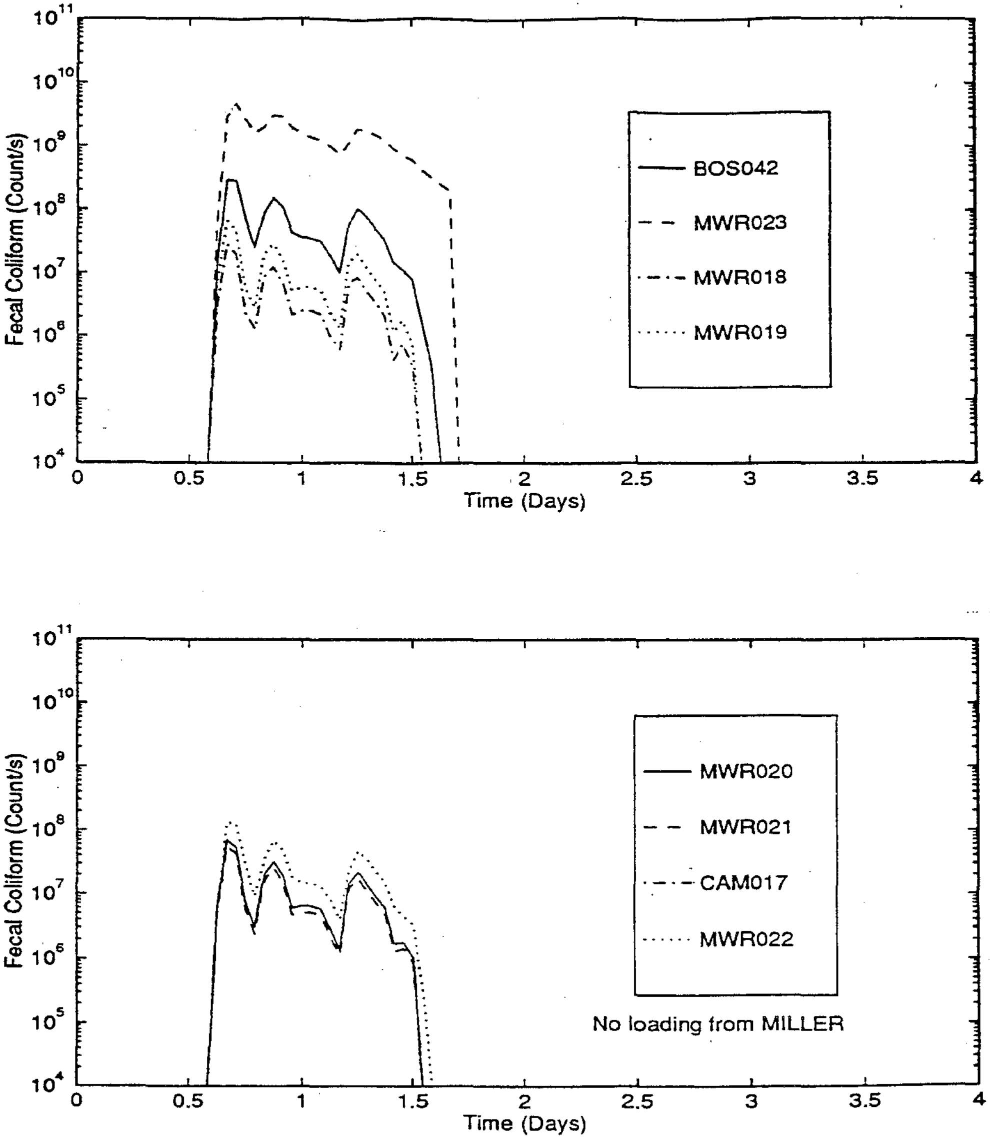


Fig. D.6c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

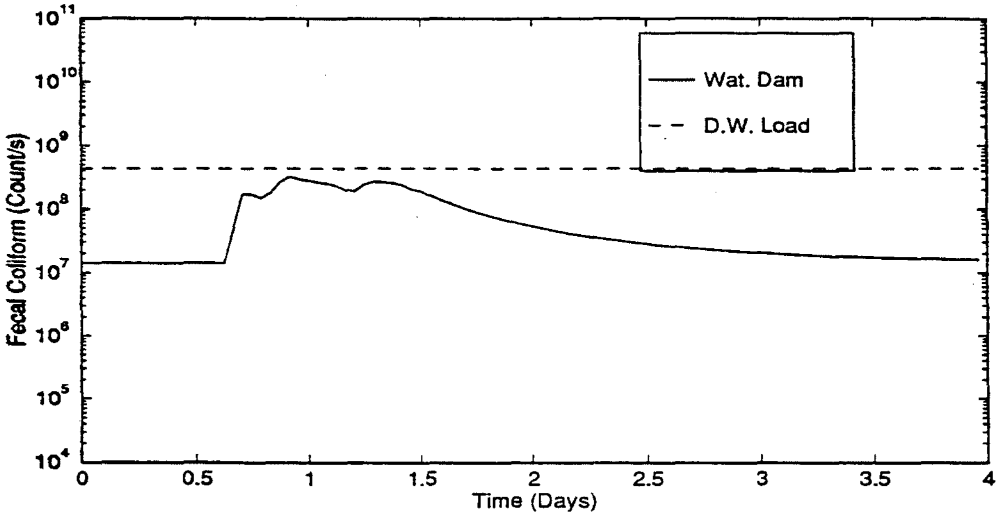


Fig. D.6c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

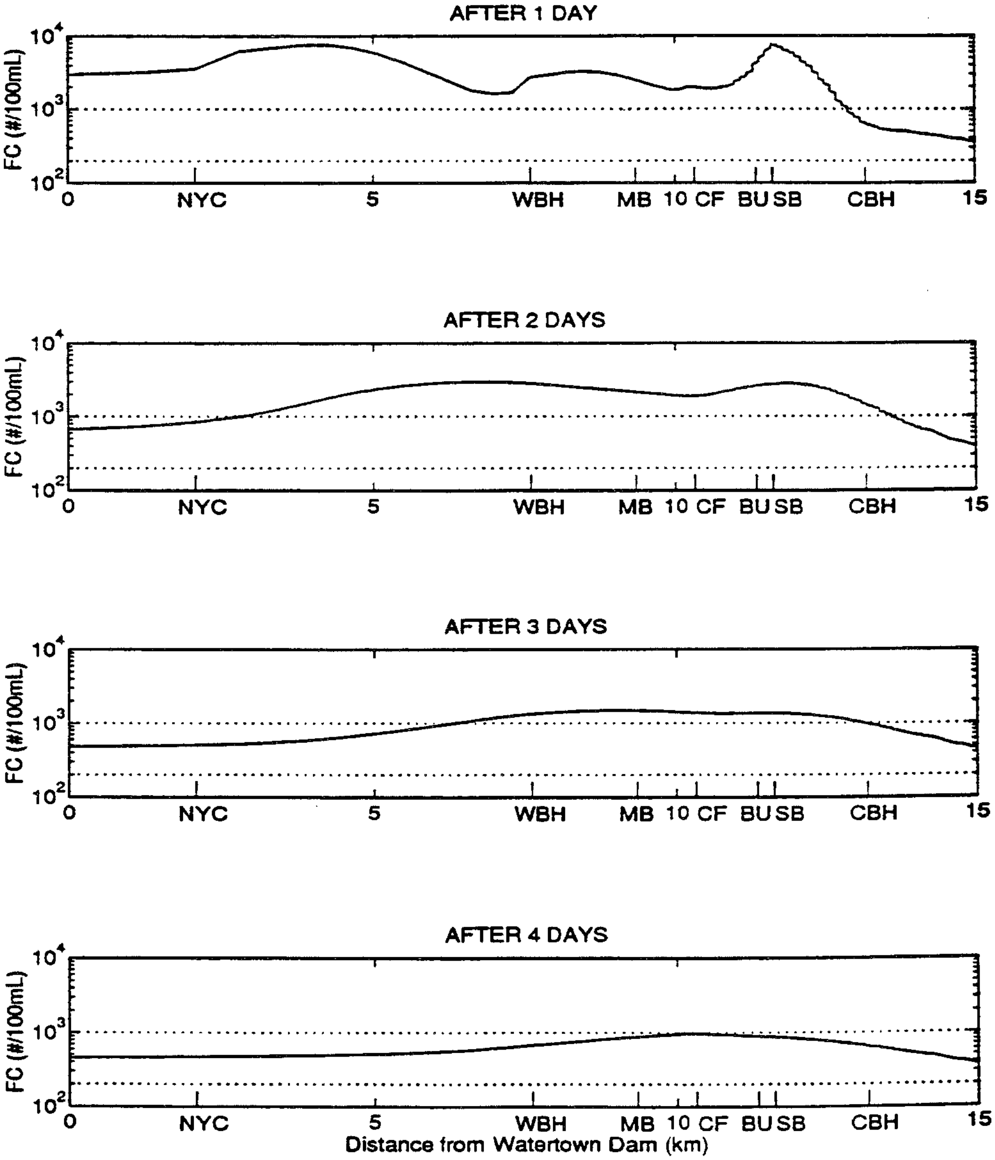


Fig. D.7a Simulated Charles River Fecal Coliform Counts versus Distance for Four Days–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

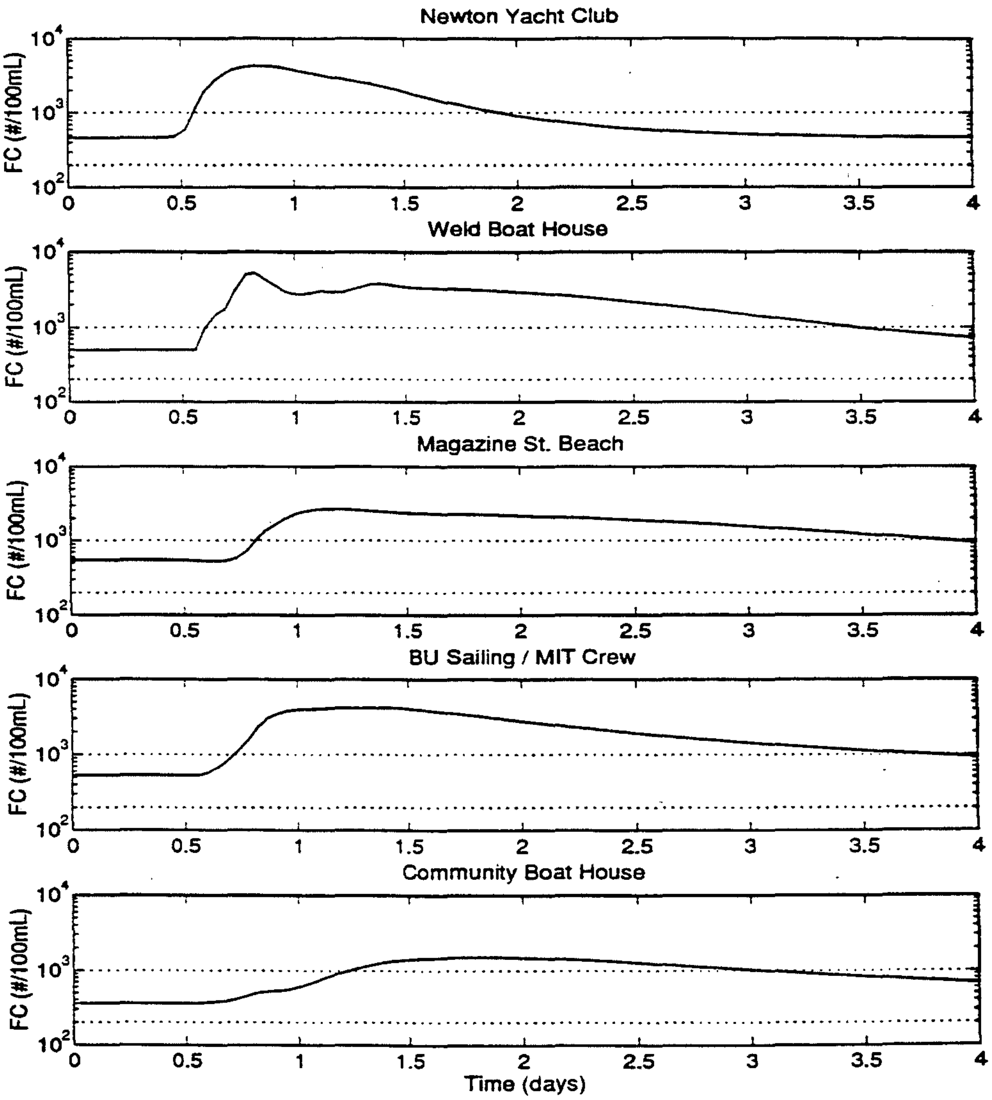


Fig. D.7b Simulated Charles River Fecal Coliform Counts versus Time at Five Locations–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

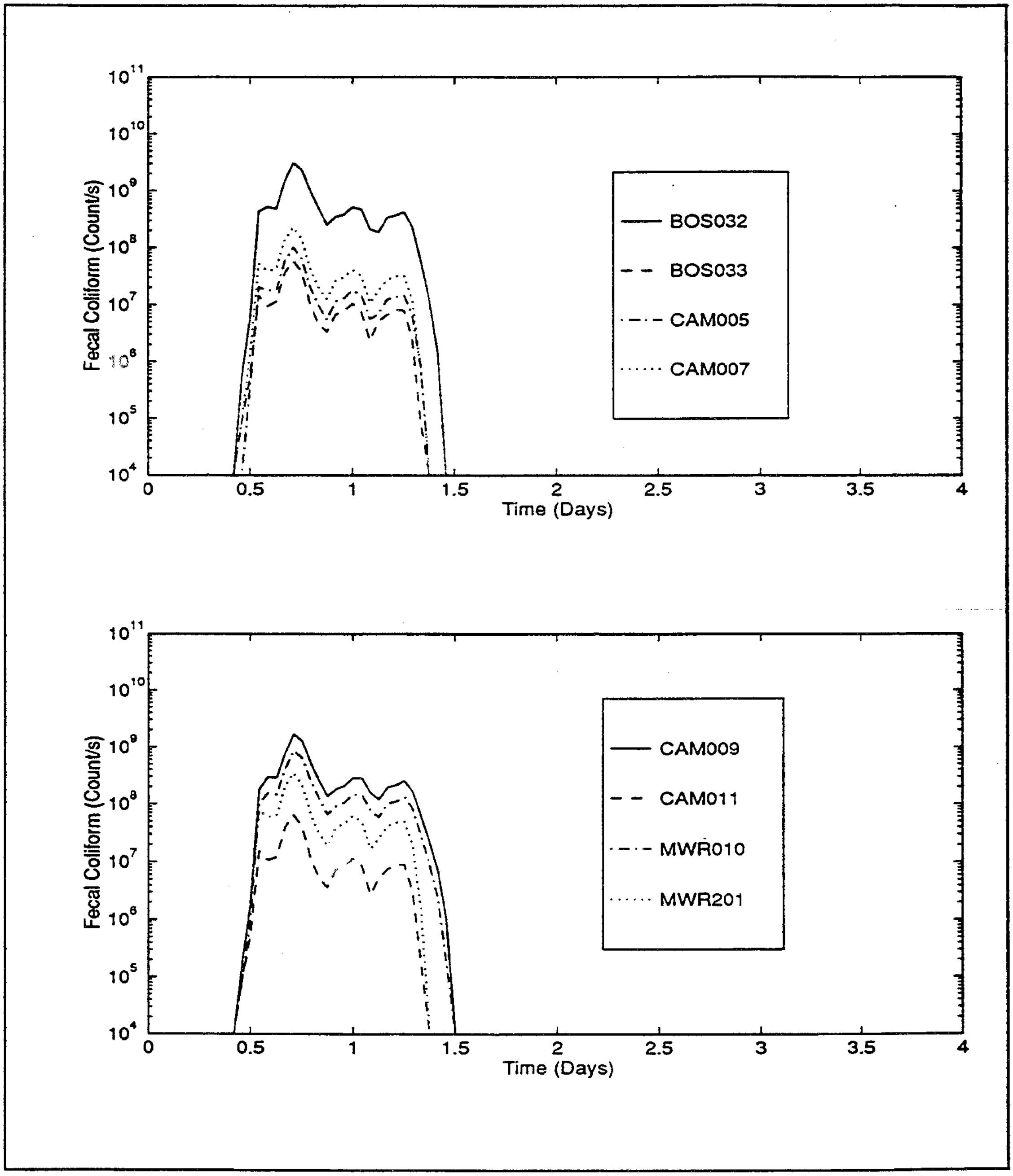


Fig. D.7c1 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

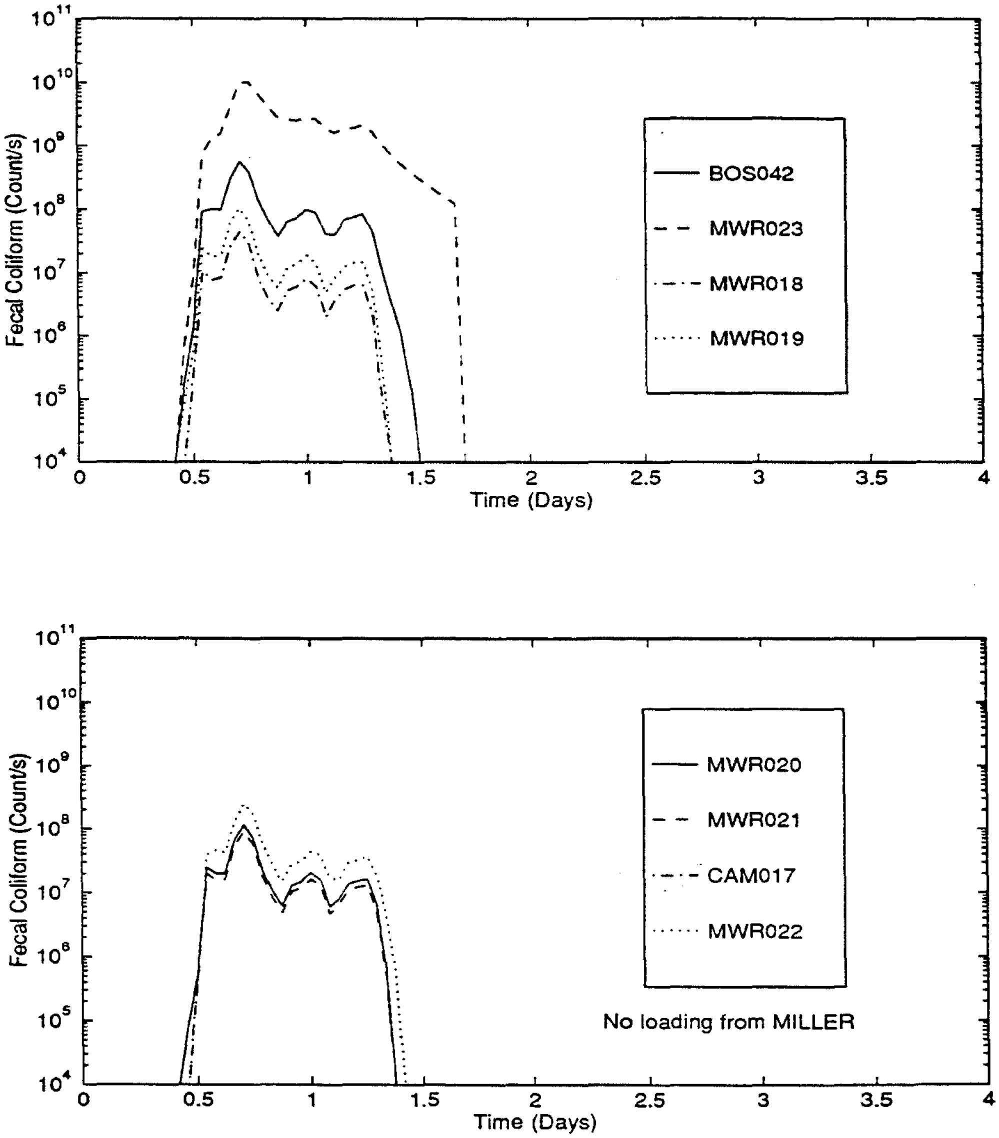


Fig. D.7c2 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

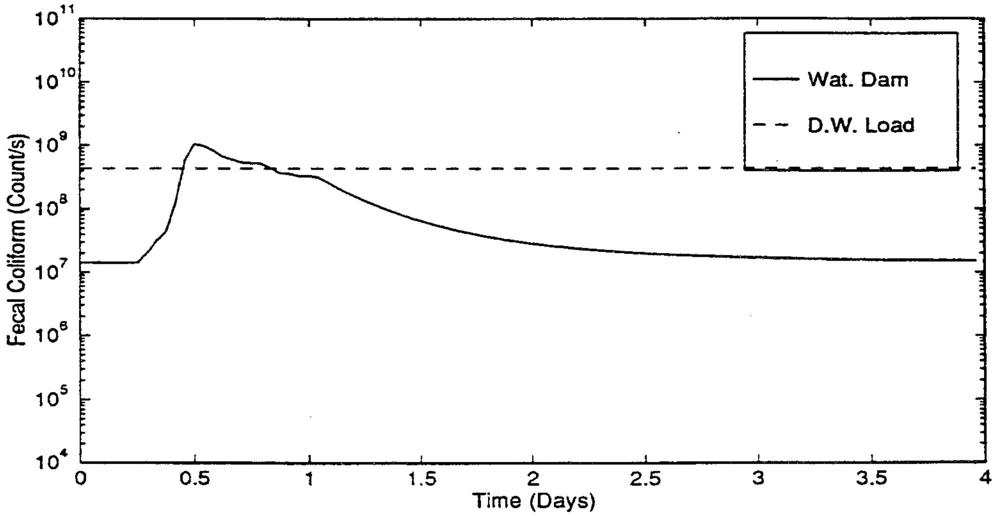


Fig. D.7c3 Simulated Charles River Fecal Coliform Loading versus Time for Each Source–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

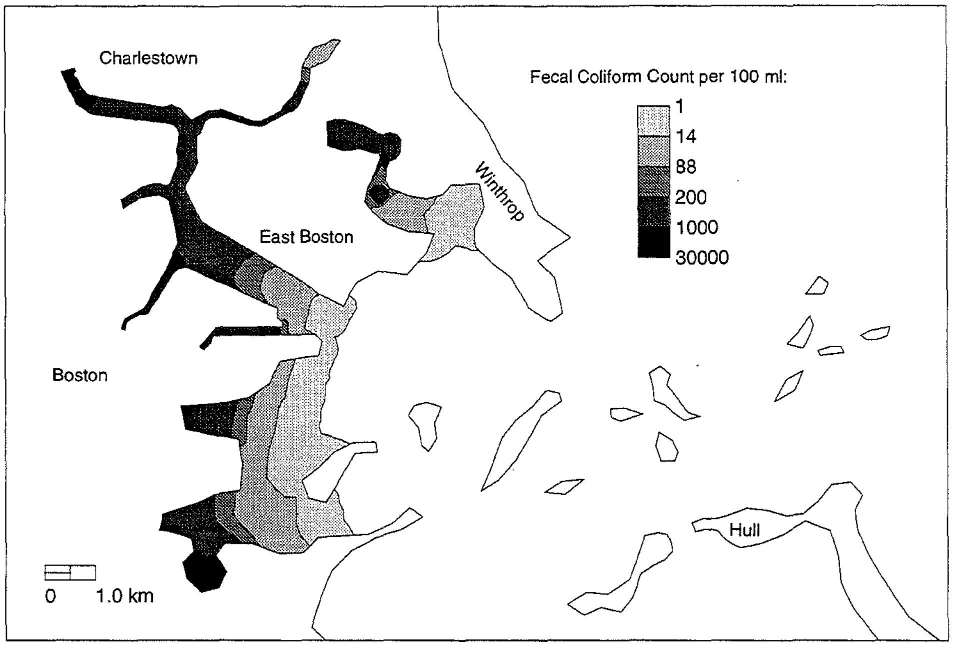


Fig. E.1a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 1: Existing conditions, 3-month design storm, all sources.

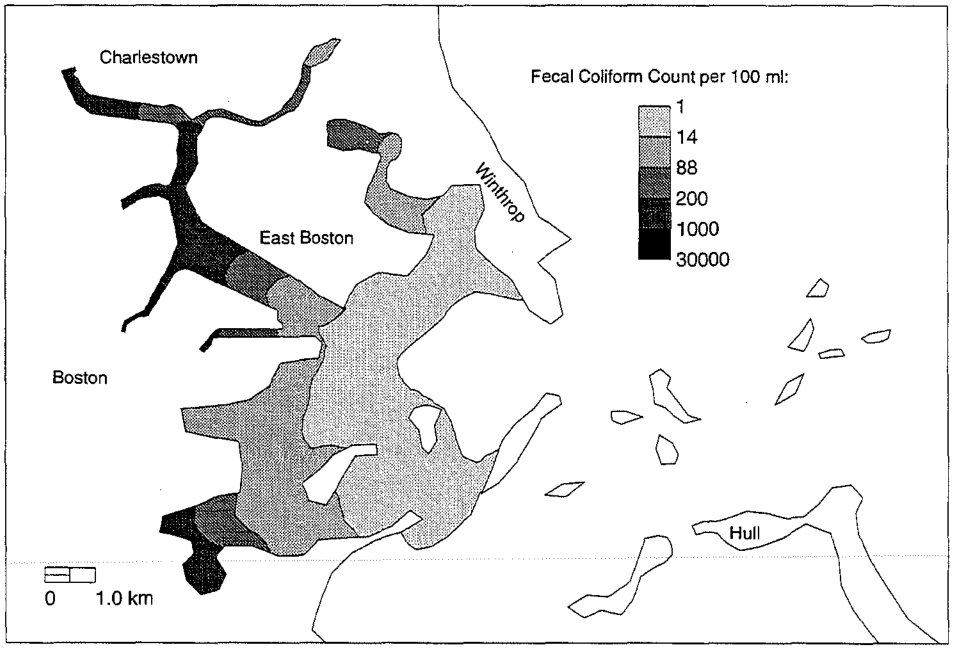


Fig. E.1a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 1: Existing conditions, 3-month design storm, all sources.

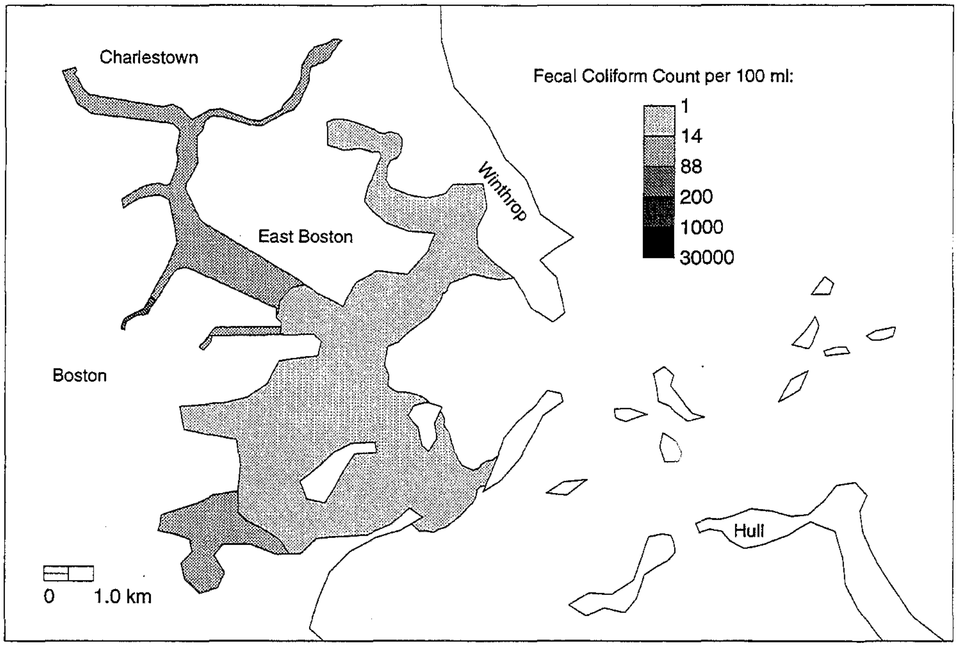


Fig. E.1a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 1: Existing conditions, 3-month design storm, all sources.

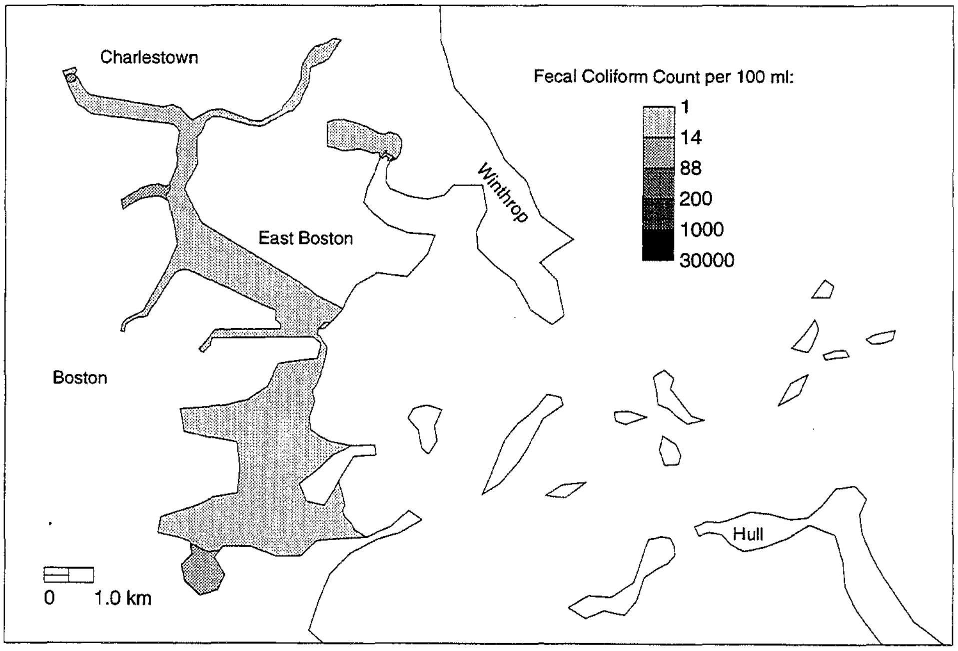


Fig. E.1a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 1: Existing conditions, 3-month design storm, all sources.

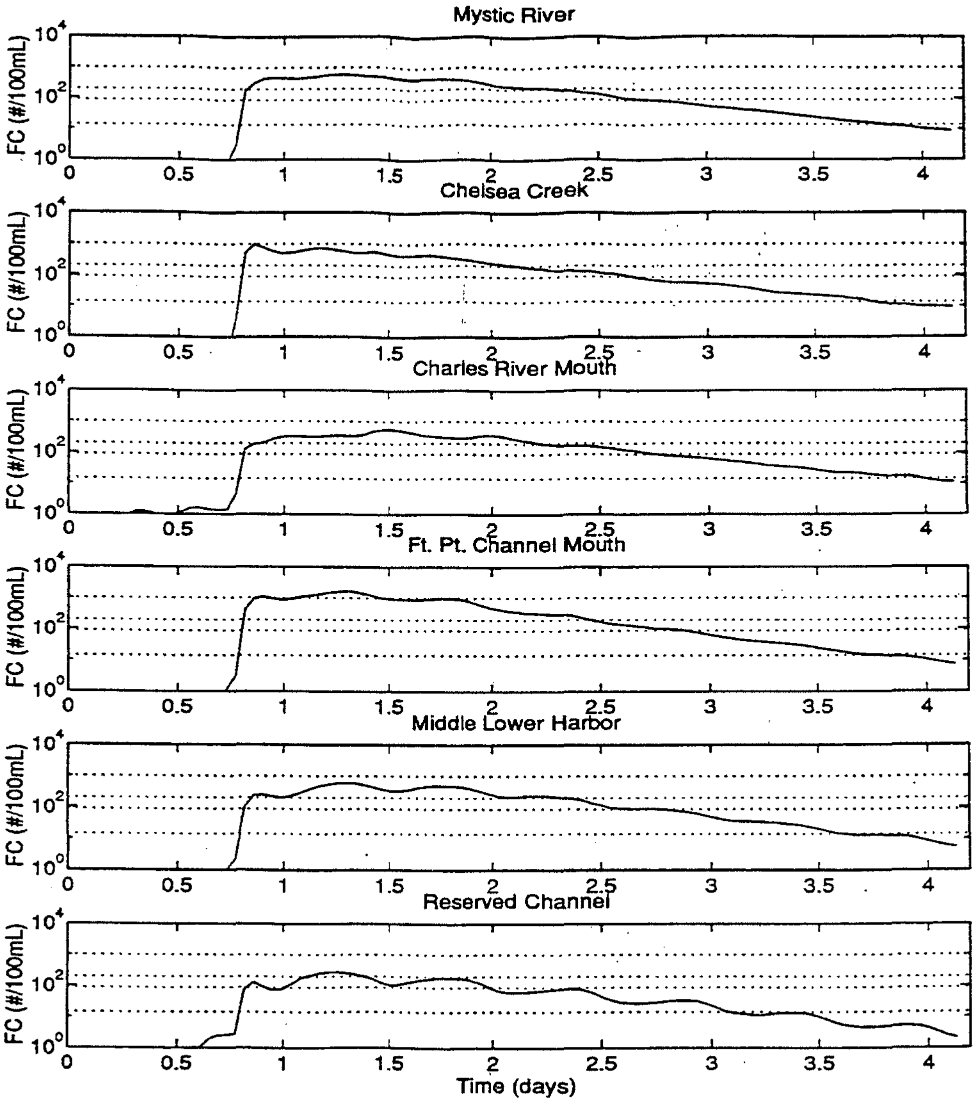
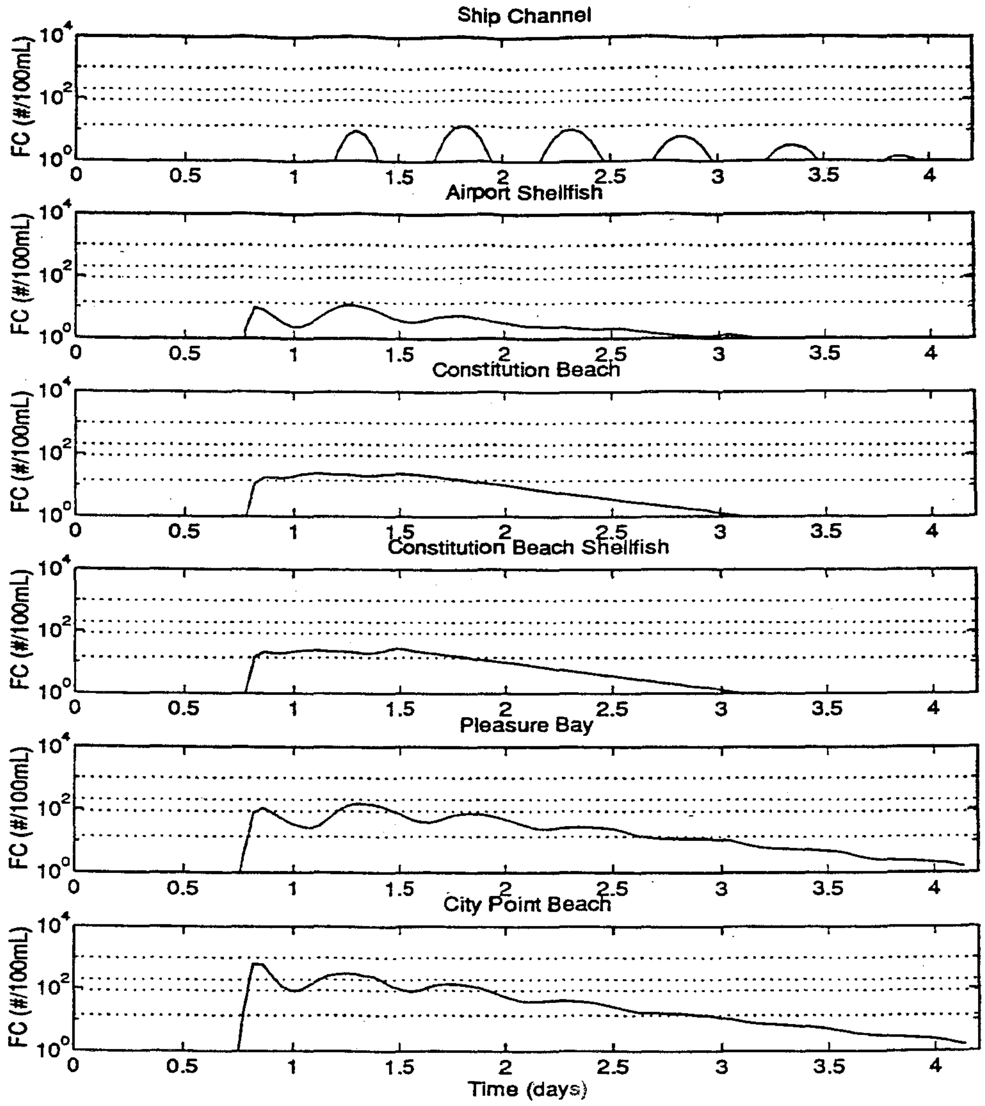


Fig. E.1b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 1: Existing conditions, 3-month design storm, all sources.


Ship Channel

Airport Shellfish

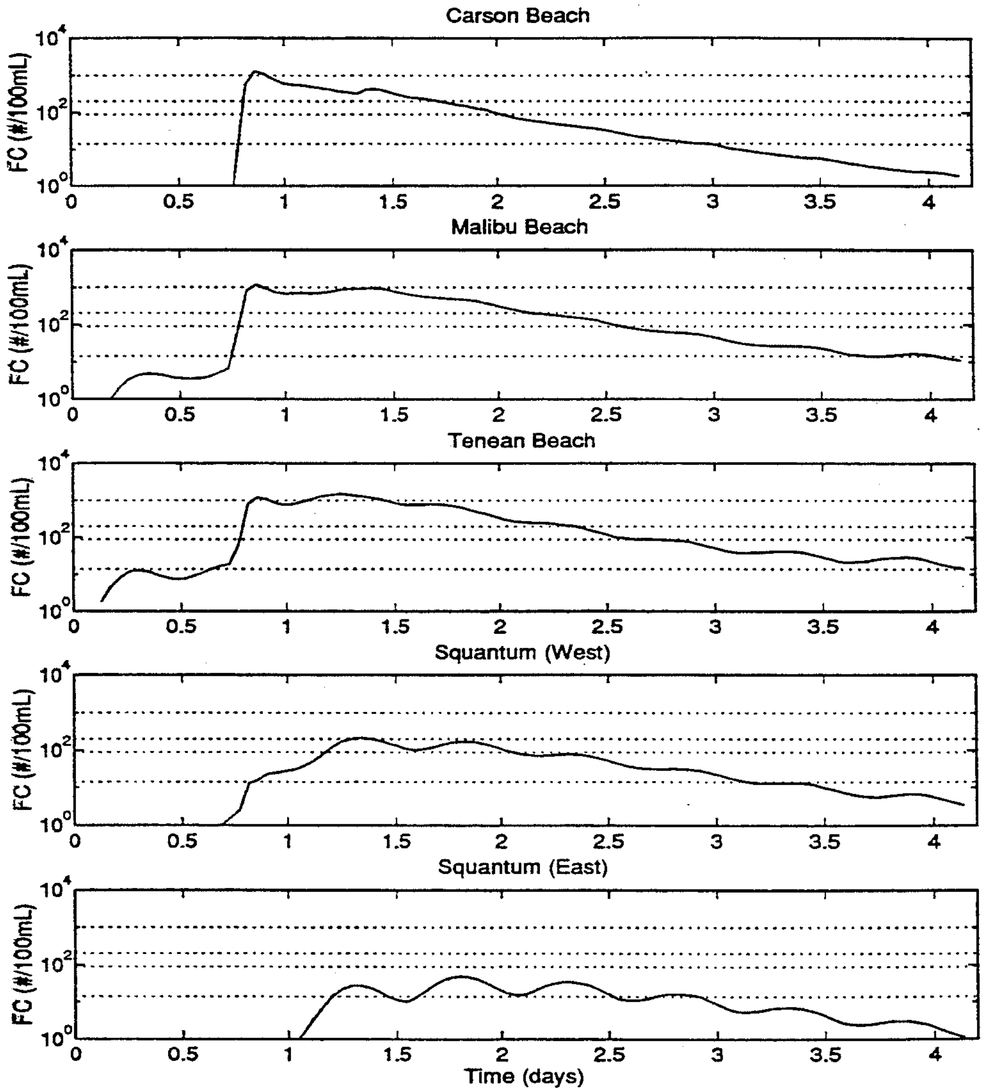
Constitution Beach

Constitution Beach Shellfish

Pleasure Bay

City Point Beach

Fig. E.1b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 1: Existing conditions, 3-month design storm, all sources.


Carson Beach

Malibu Beach

Tenean Beach

Squantum (West)

Squantum (East)

Fig. E.1b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 1: Existing conditions, 3-month design storm, all sources.

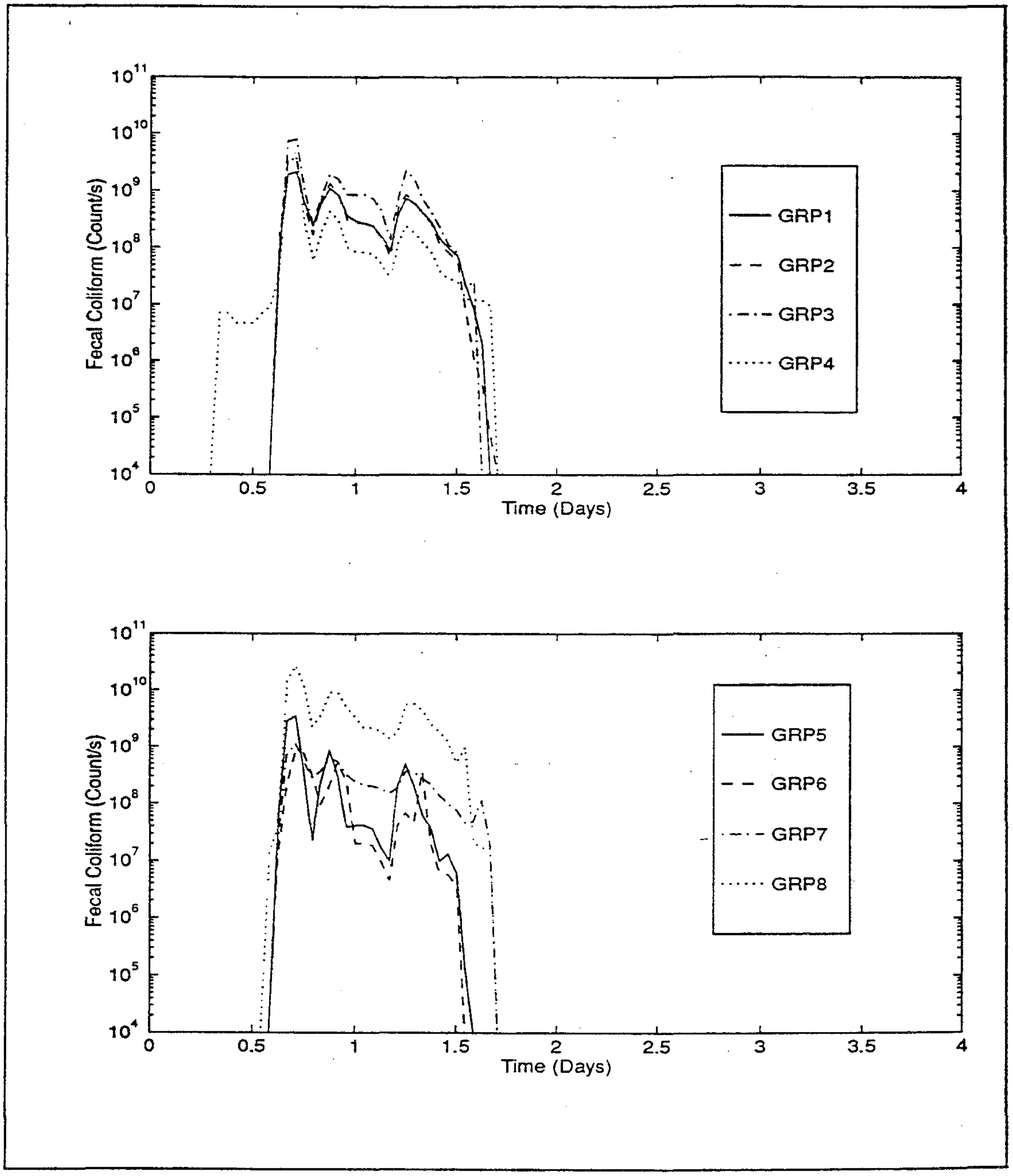


Fig. E.1c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 1: Existing conditions, 3-month design storm, all sources.

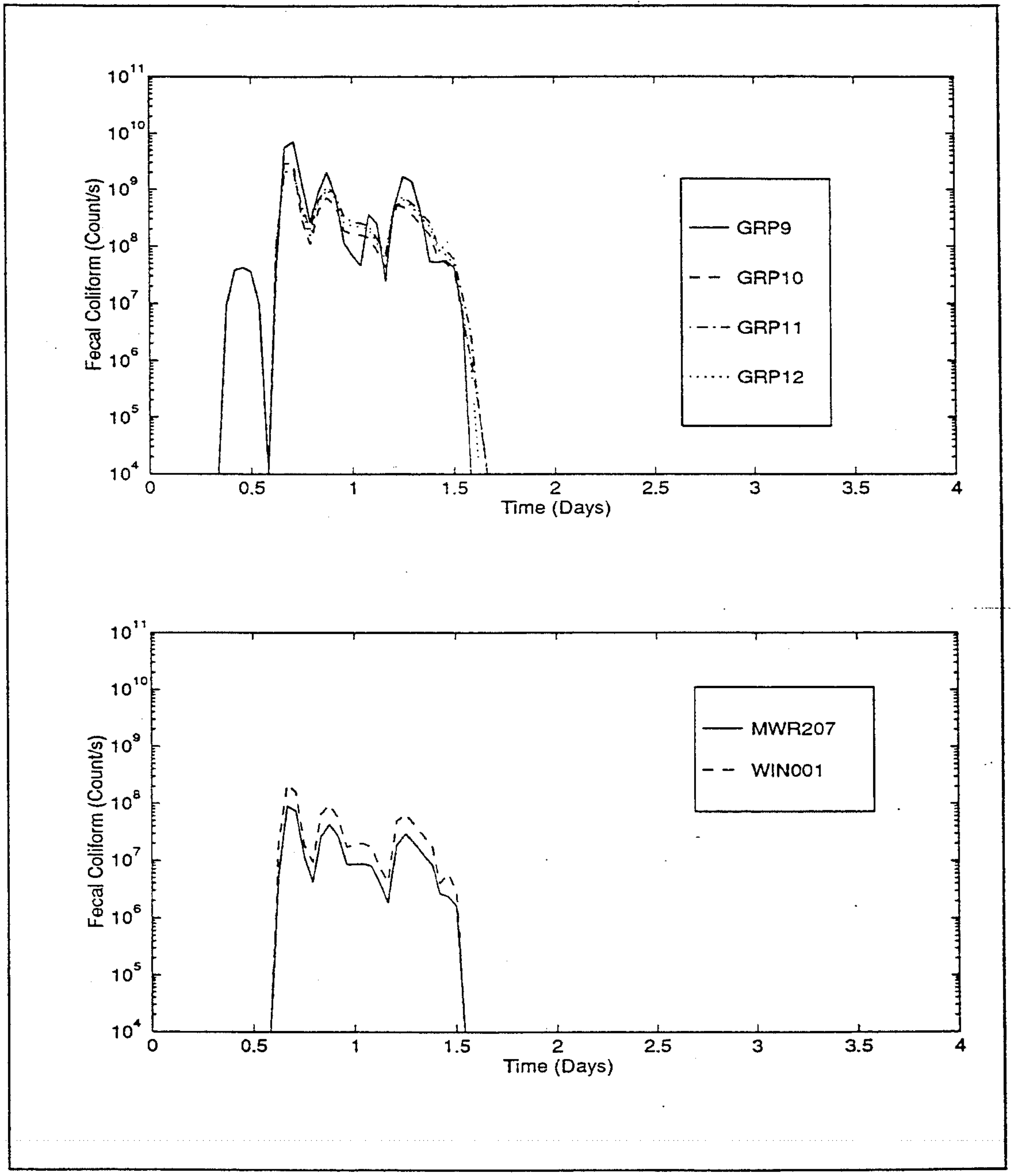


Fig. E.1c2 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 1: Existing conditions, 3-month design storm, all sources.

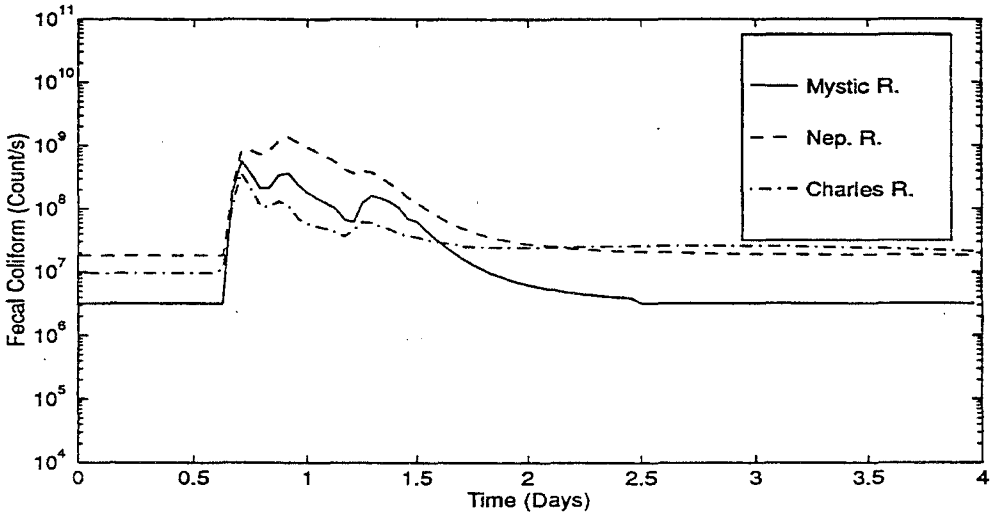


Fig. E.1c3 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 1: Existing conditions, 3-month design storm, all sources.

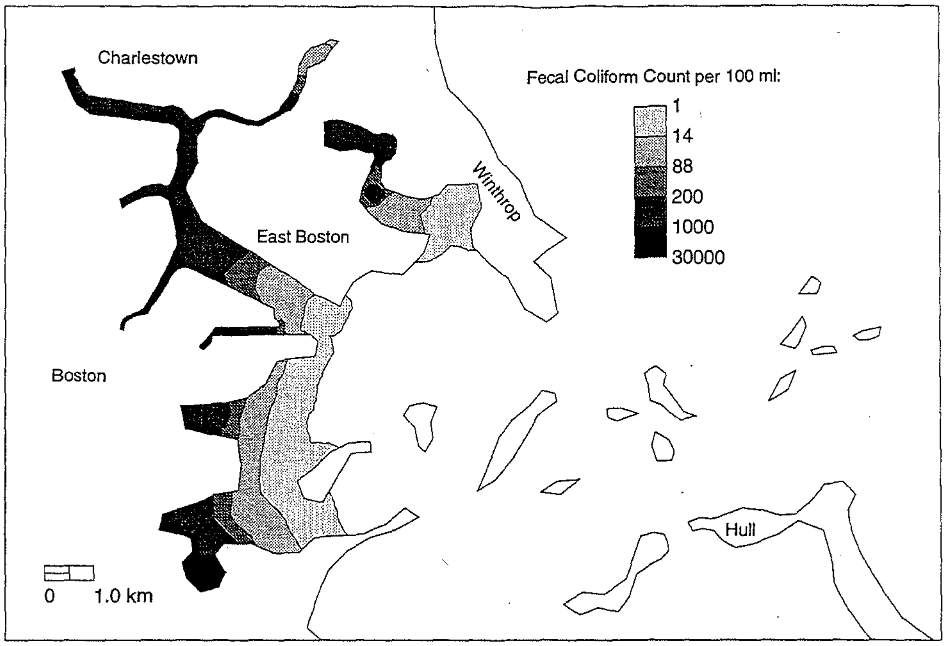


Fig. E.2a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 2: Future planned conditions, 3-month design storm, all sources.

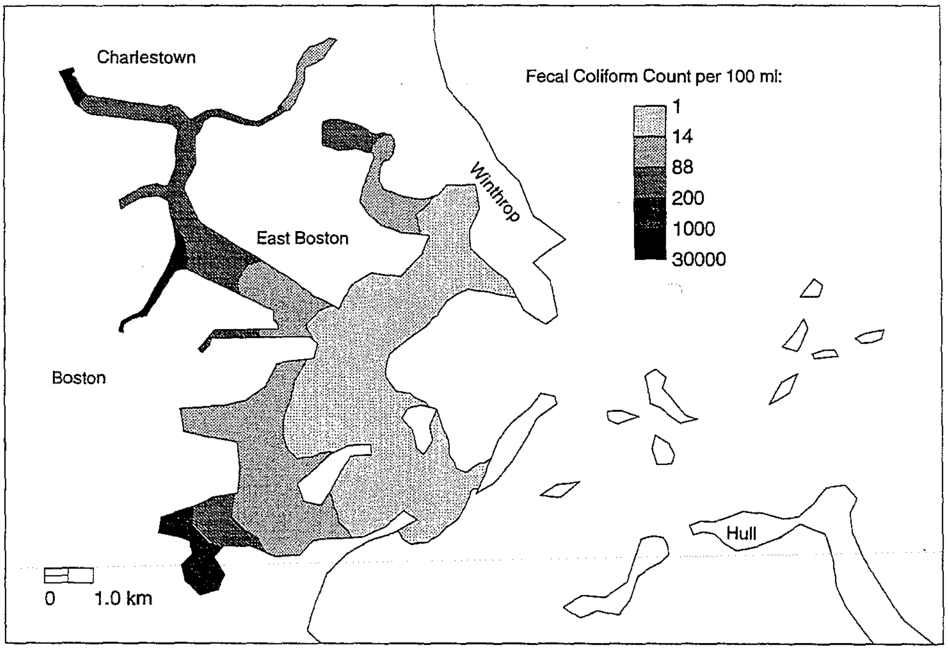


Fig. E.2a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 2: Future planned conditions, 3-month design storm, all sources.

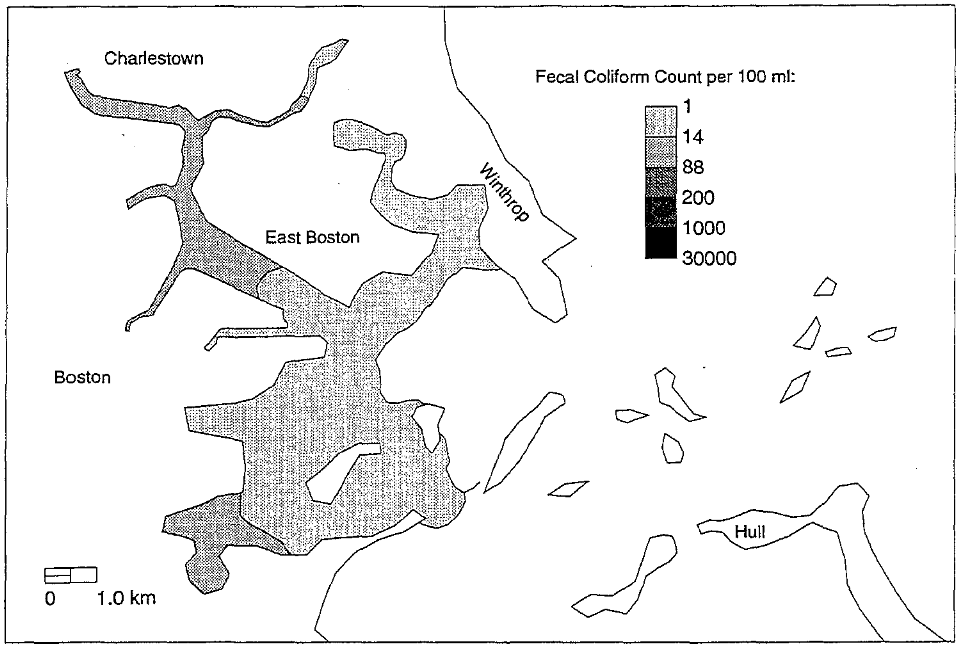


Fig. E.2a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 2: Future planned conditions, 3-month design storm, all sources.

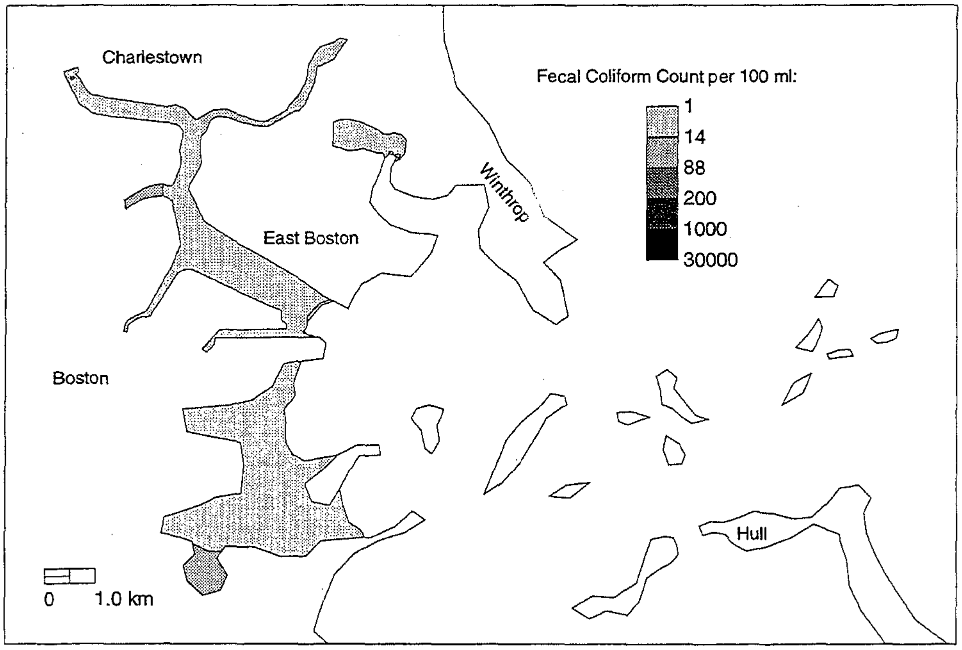


Fig. E.2a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 2: Future planned conditions, 3-month design storm, all sources.

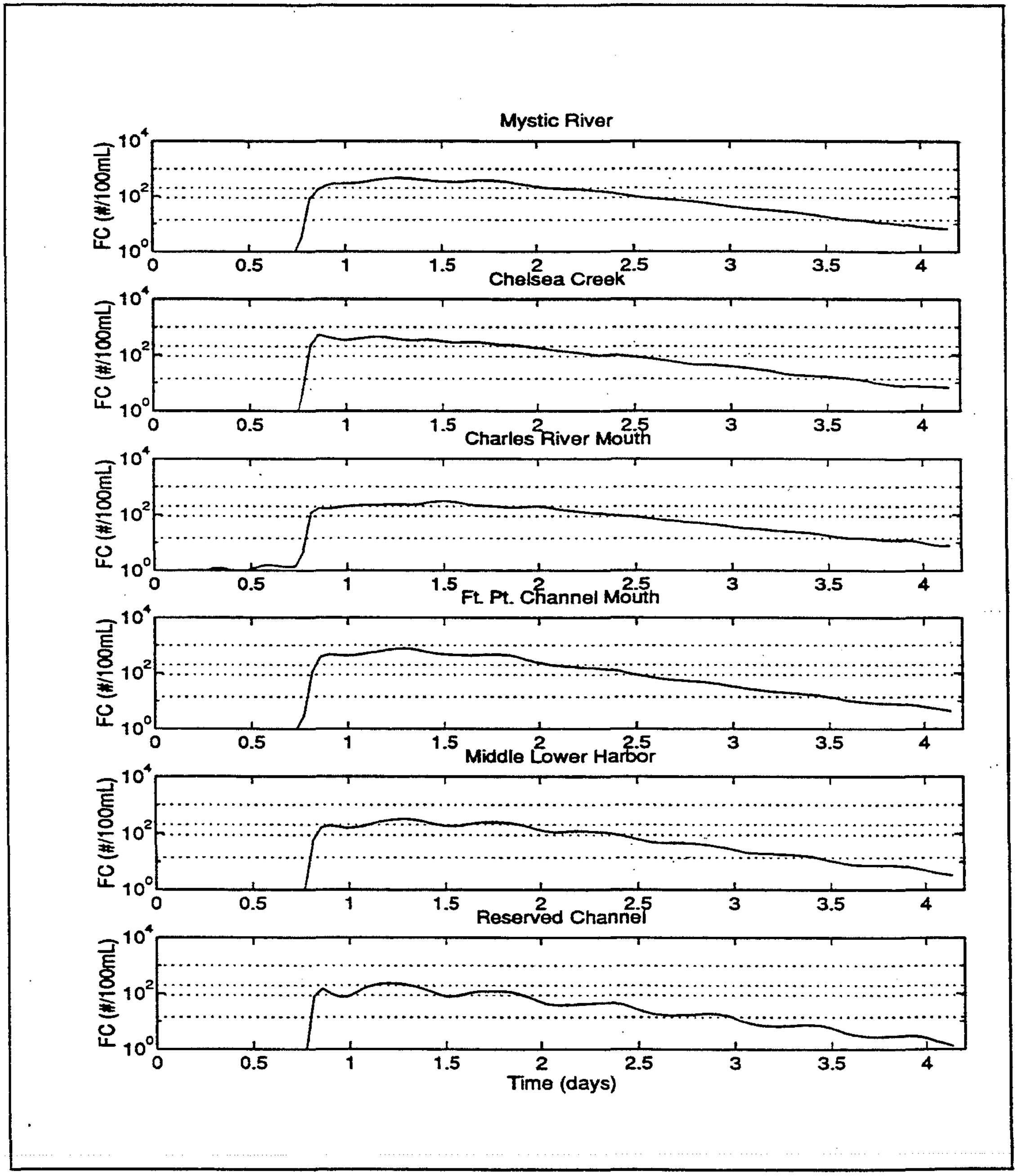


Fig. E.2b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 2: Future planned conditions, 3-month design storm, all sources.

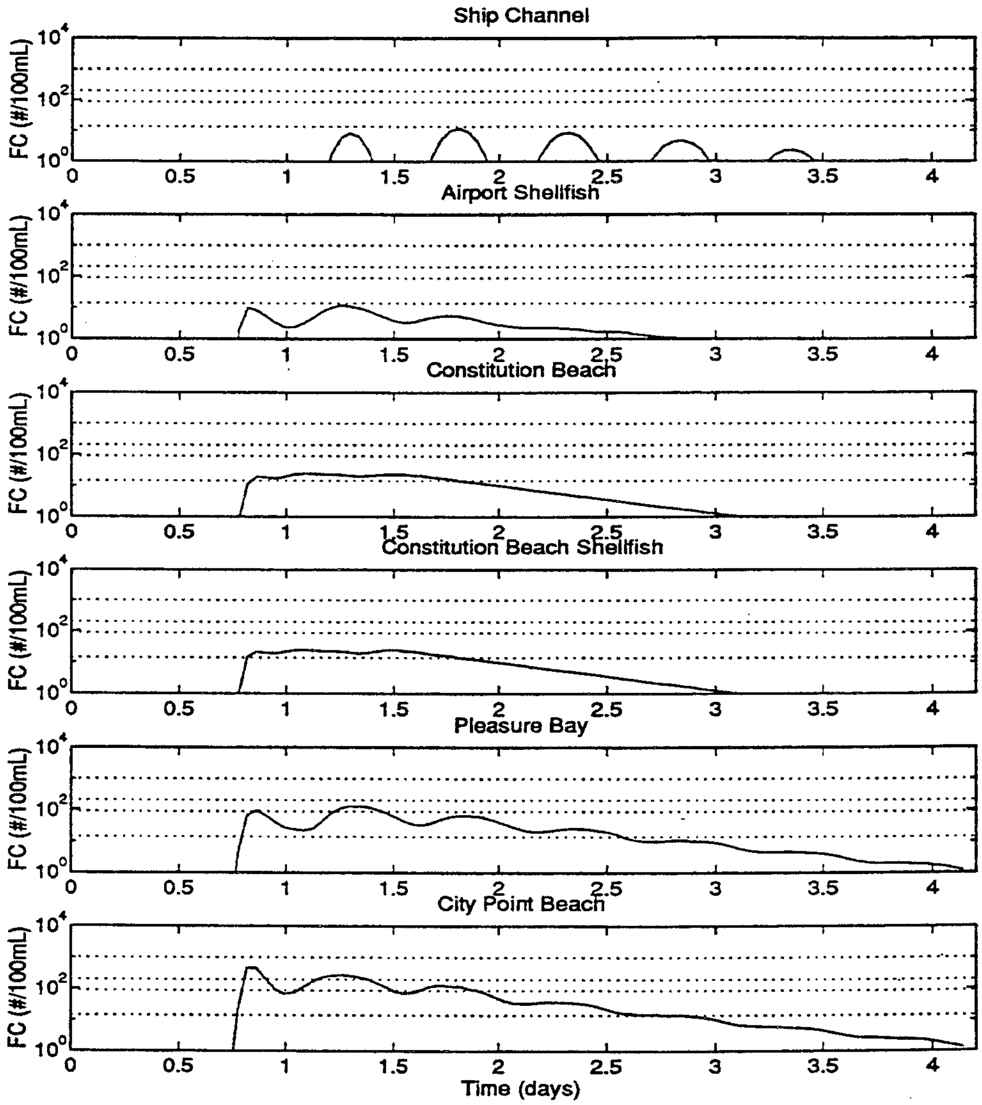


Fig. E.2b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 2: Future planned conditions, 3-month design storm, all sources.

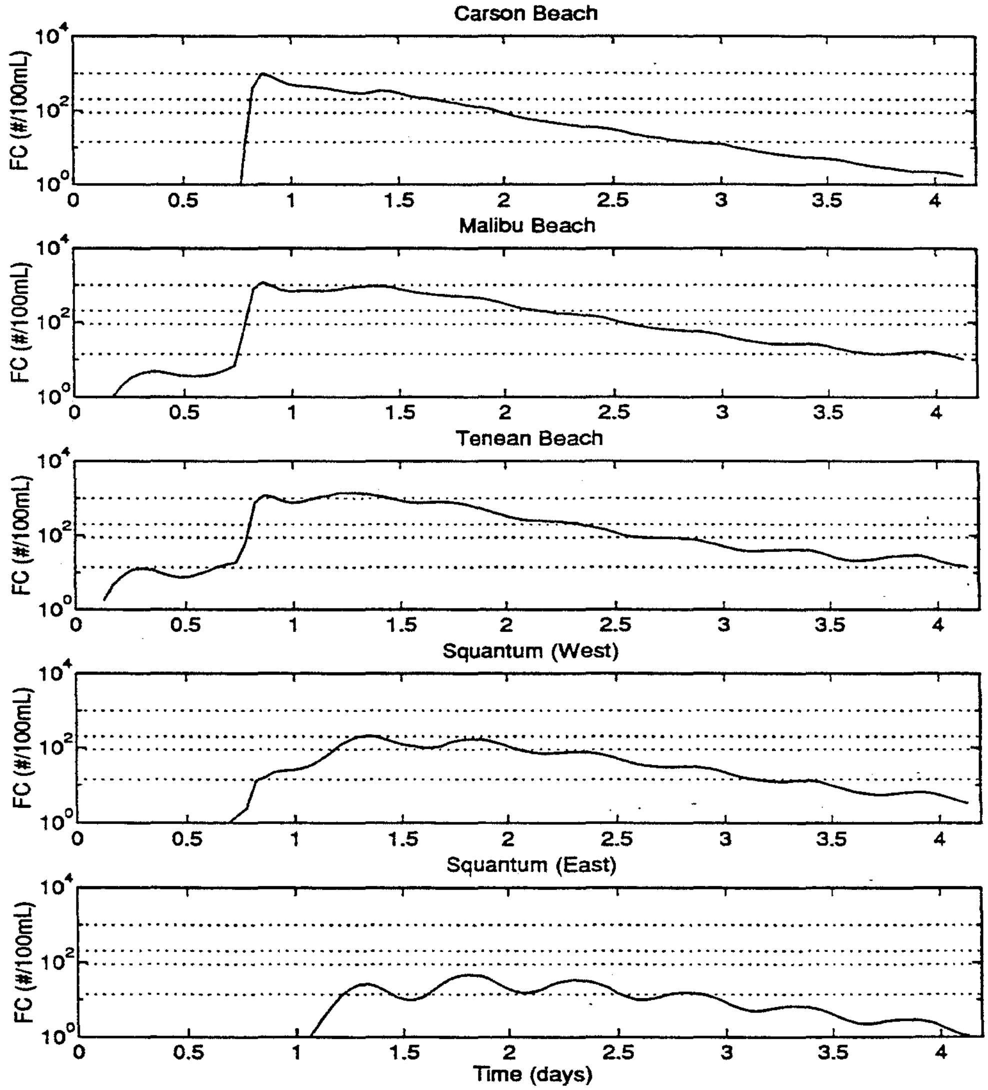


Fig. E.2b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 2: Future planned conditions, 3-month design storm, all sources.

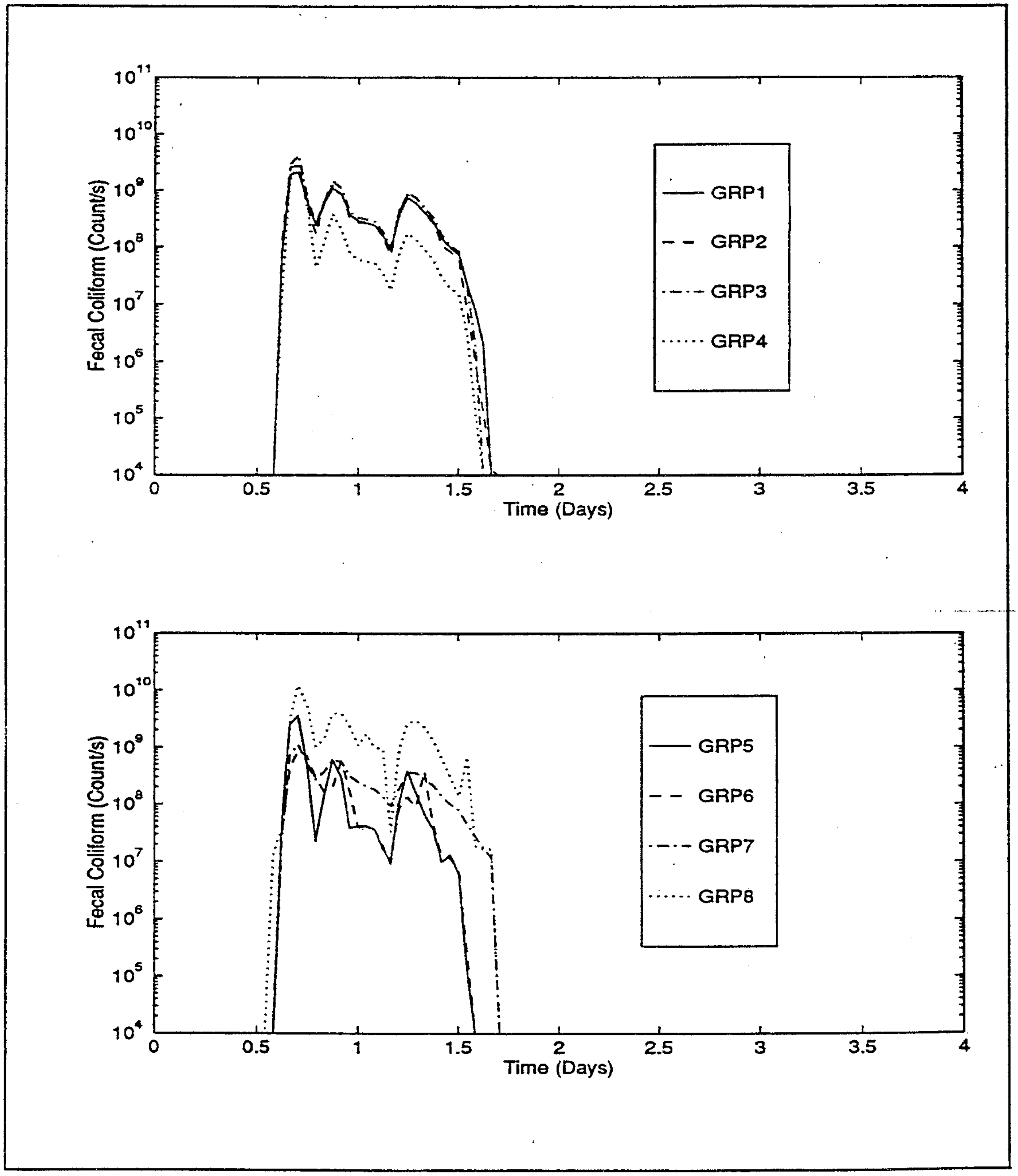


Fig. E.2c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 2: Future planned conditions, 3-month design storm, all sources.

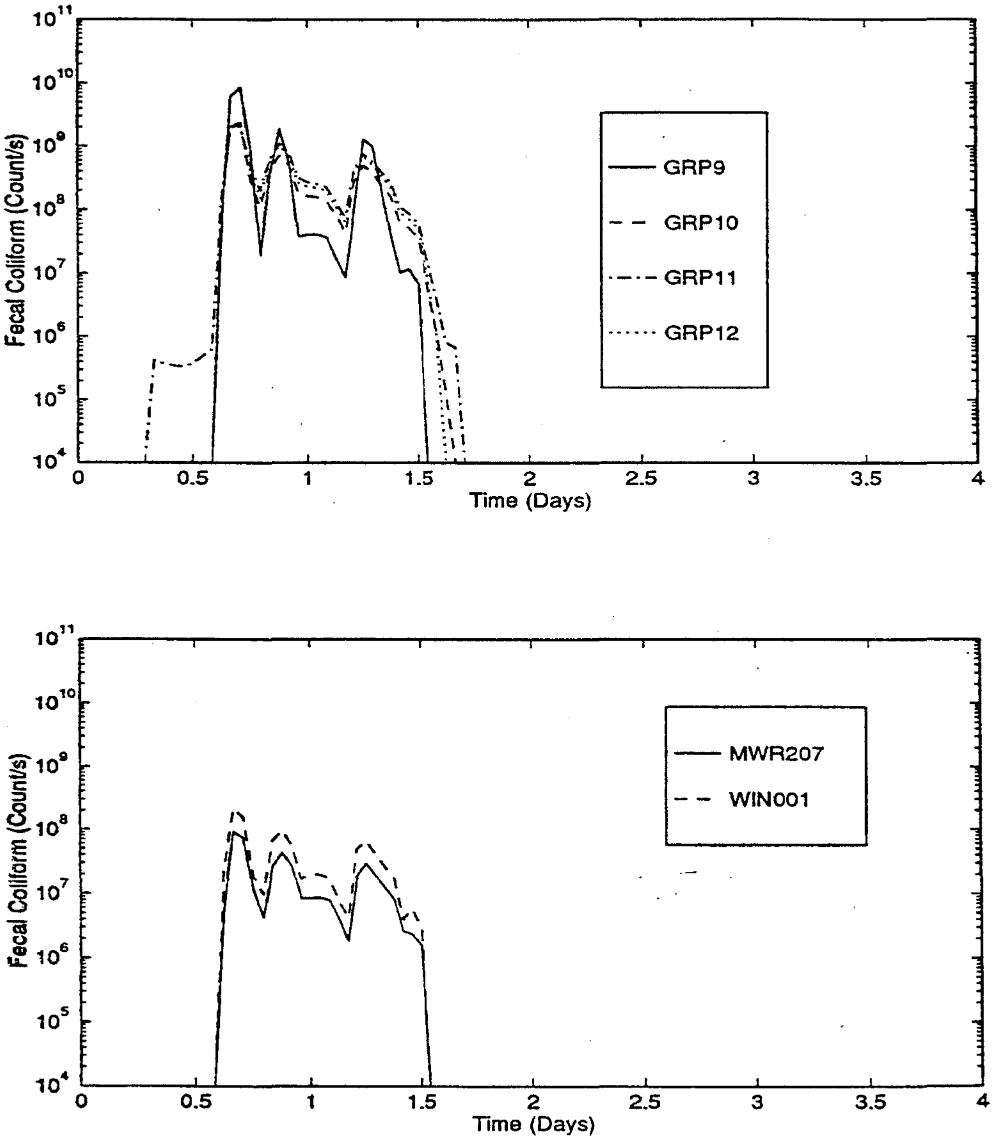


Fig. E.2c2 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 2: Future planned conditions, 3-month design storm, all sources.

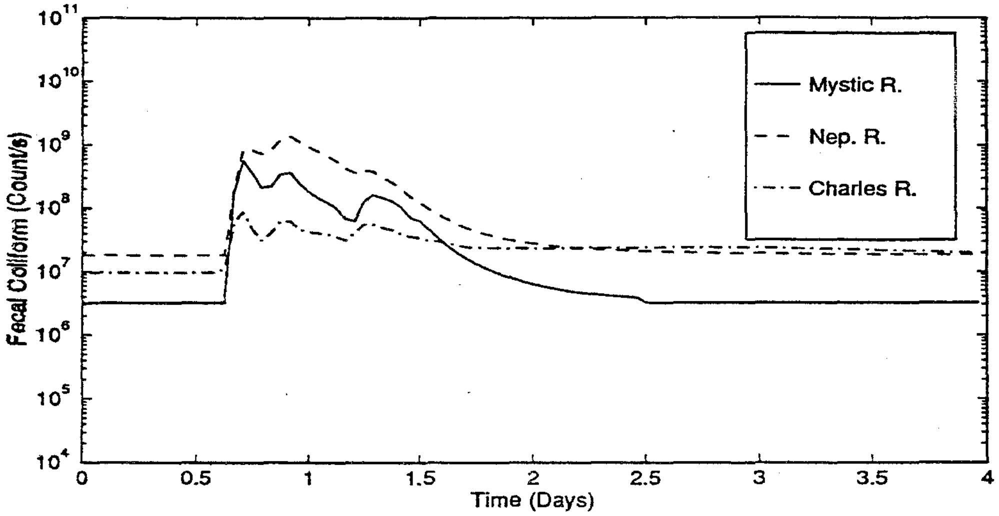


Fig. E.2c3 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 2: Future planned conditions, 3-month design storm, all sources.

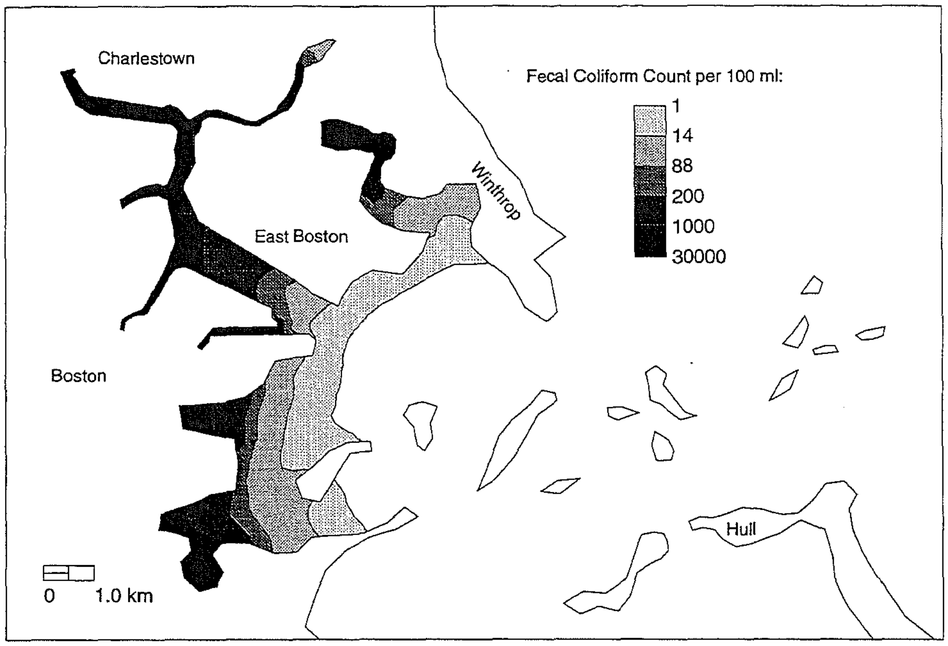


Fig. E.3a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 3: Future planned conditions, 1-year design storm, all sources.

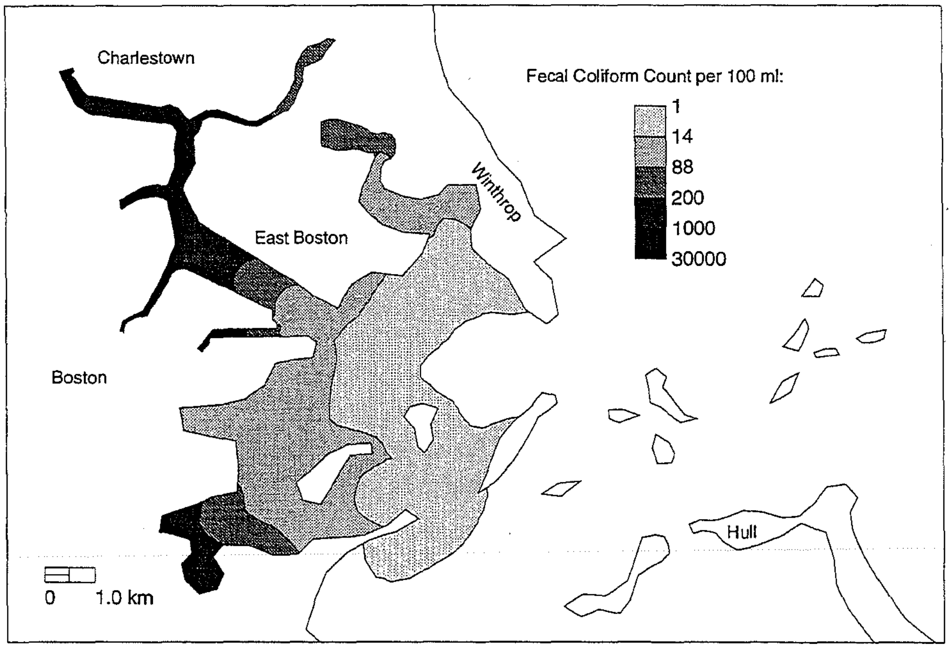


Fig. E.3a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 3: Future planned conditions, 1-year design storm, all sources.

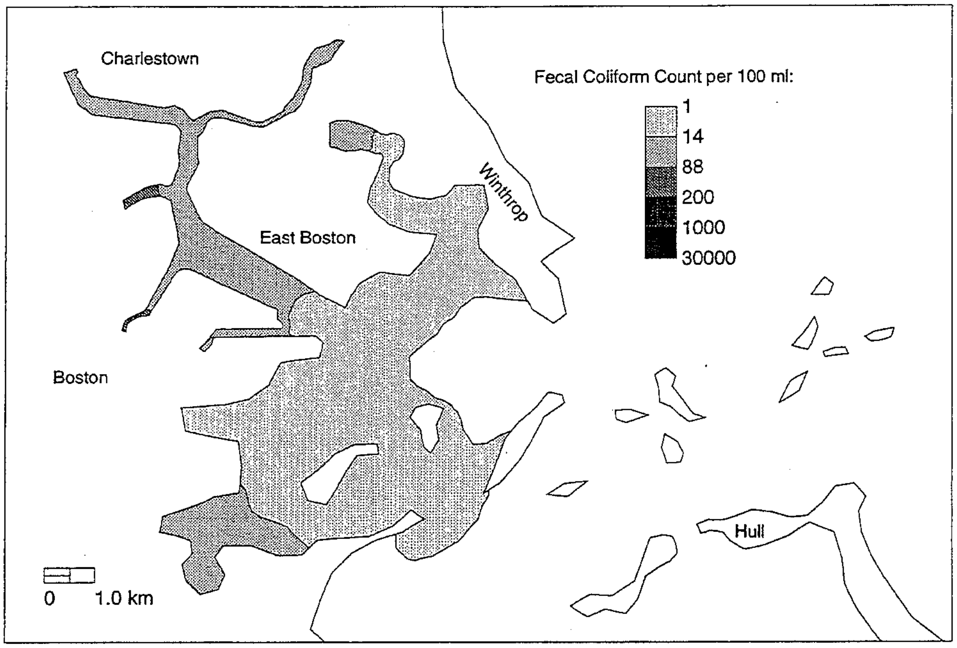


Fig. E.3a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 3: Future planned conditions, 1-year design storm, all sources.

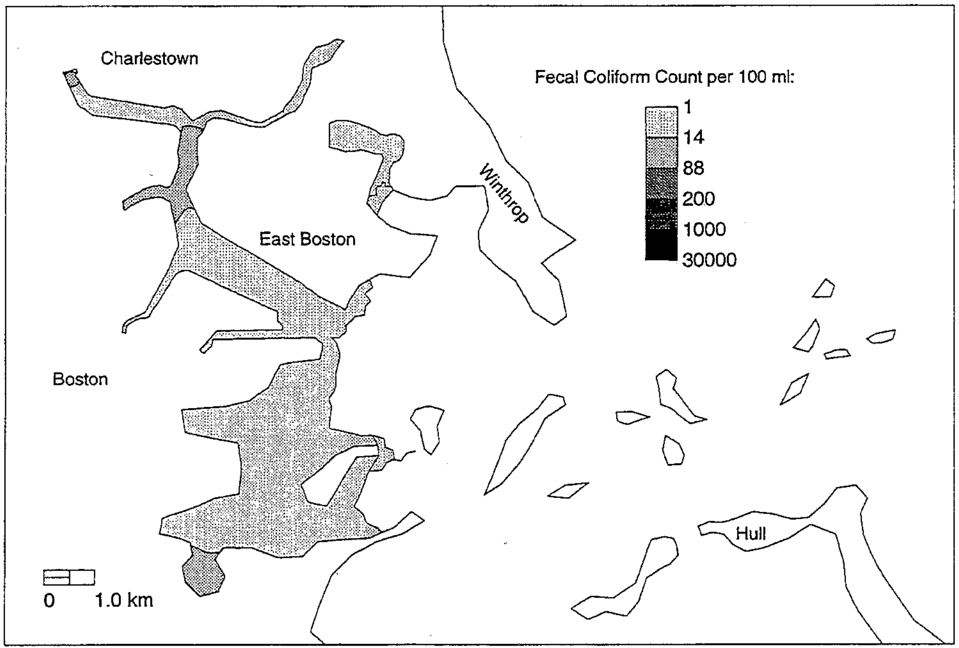


Fig. E.3a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 3: Future planned conditions, 1-year design storm, all sources.

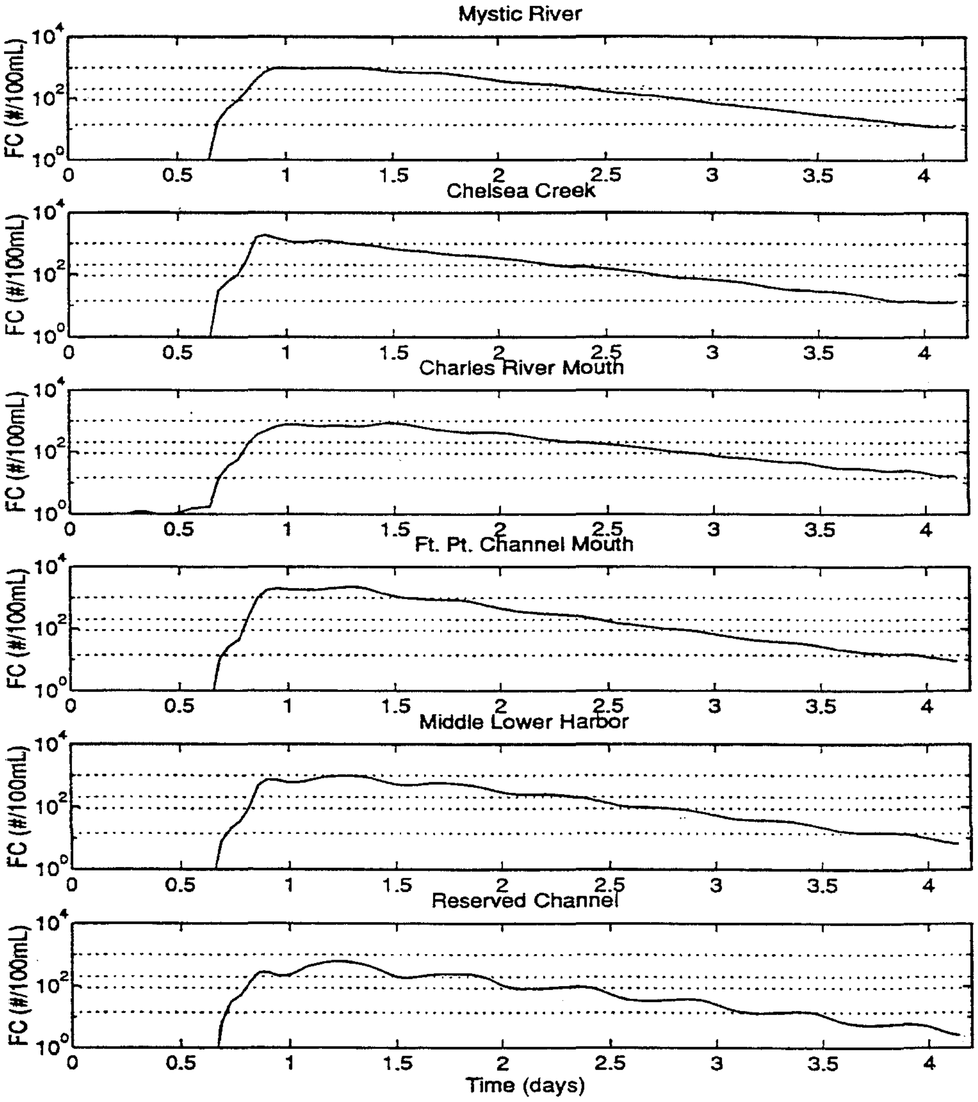


Fig. E.3b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 3: Future planned conditions, 1-year design storm, all sources.

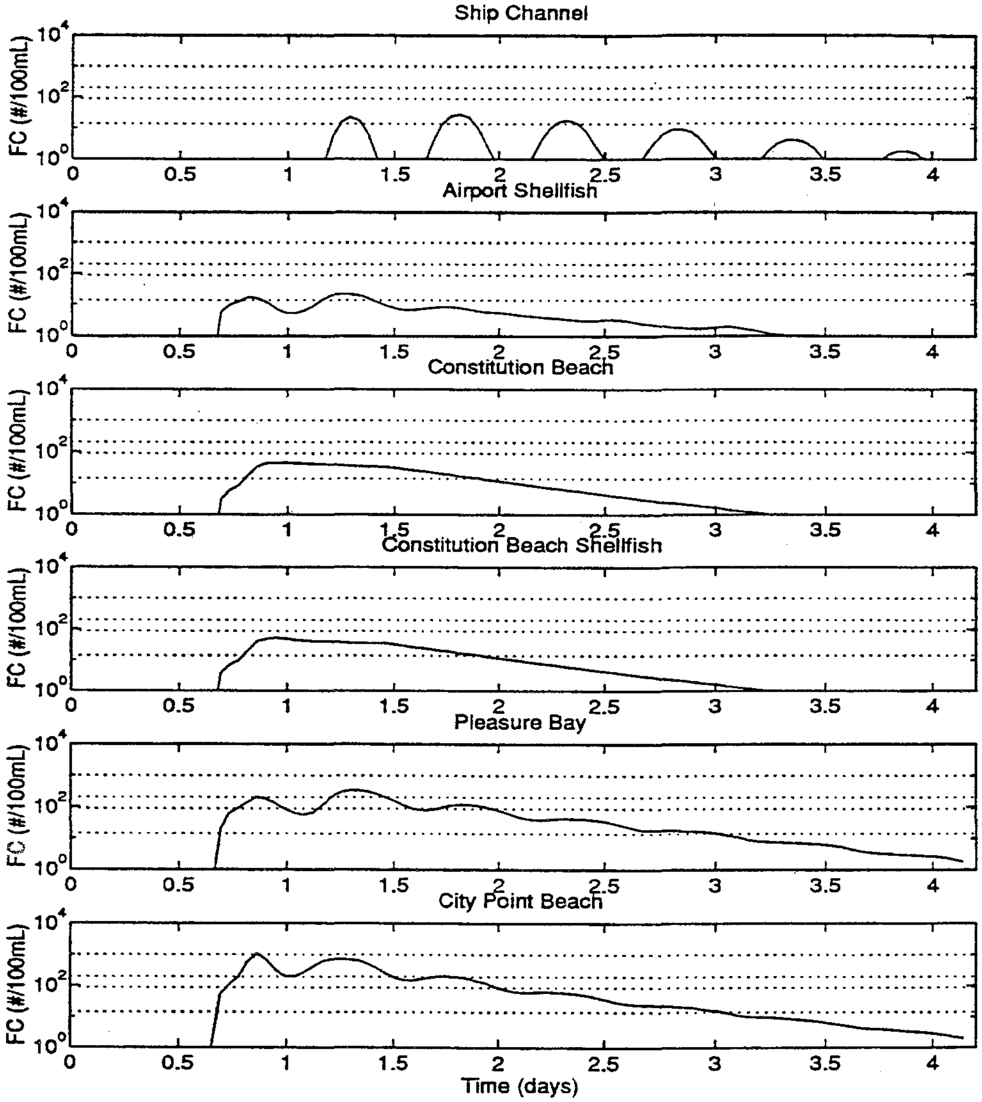


Fig. E.3b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 3: Future planned conditions, 1-year design storm, all sources.

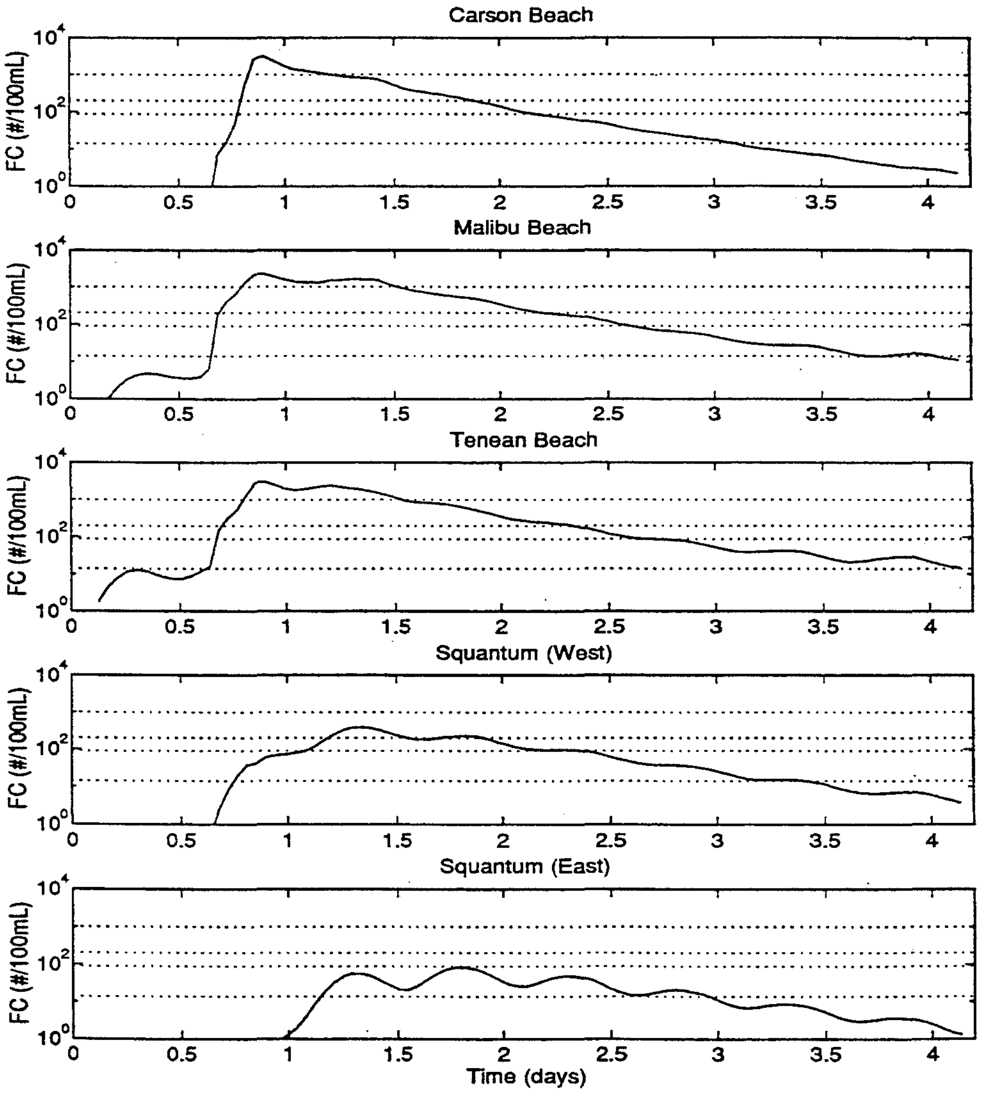


Fig. E.3b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 3: Future planned conditions, 1-year design storm, all sources.

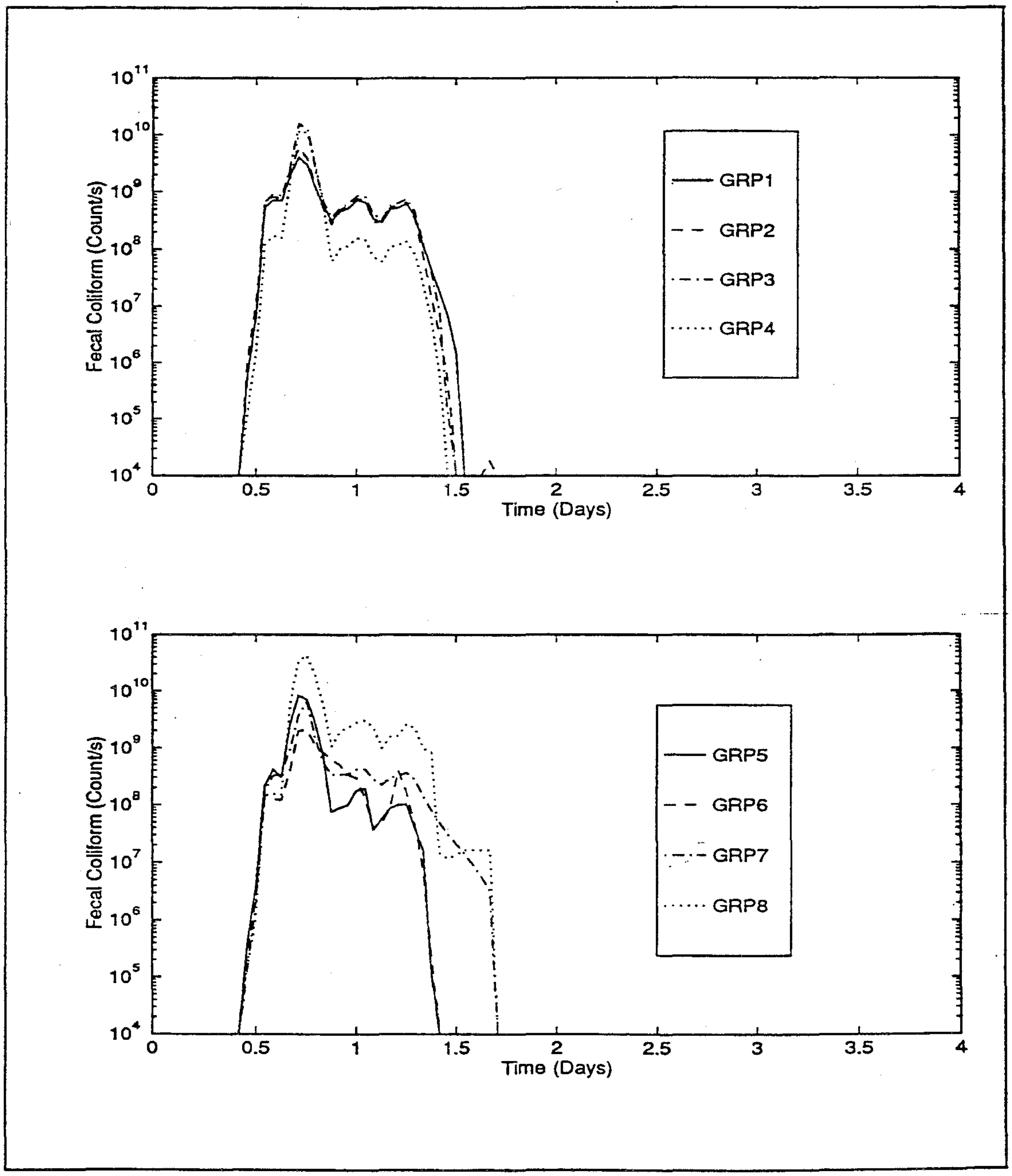


Fig. E.3c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 3: Future planned conditions, 1-year design storm, all sources.

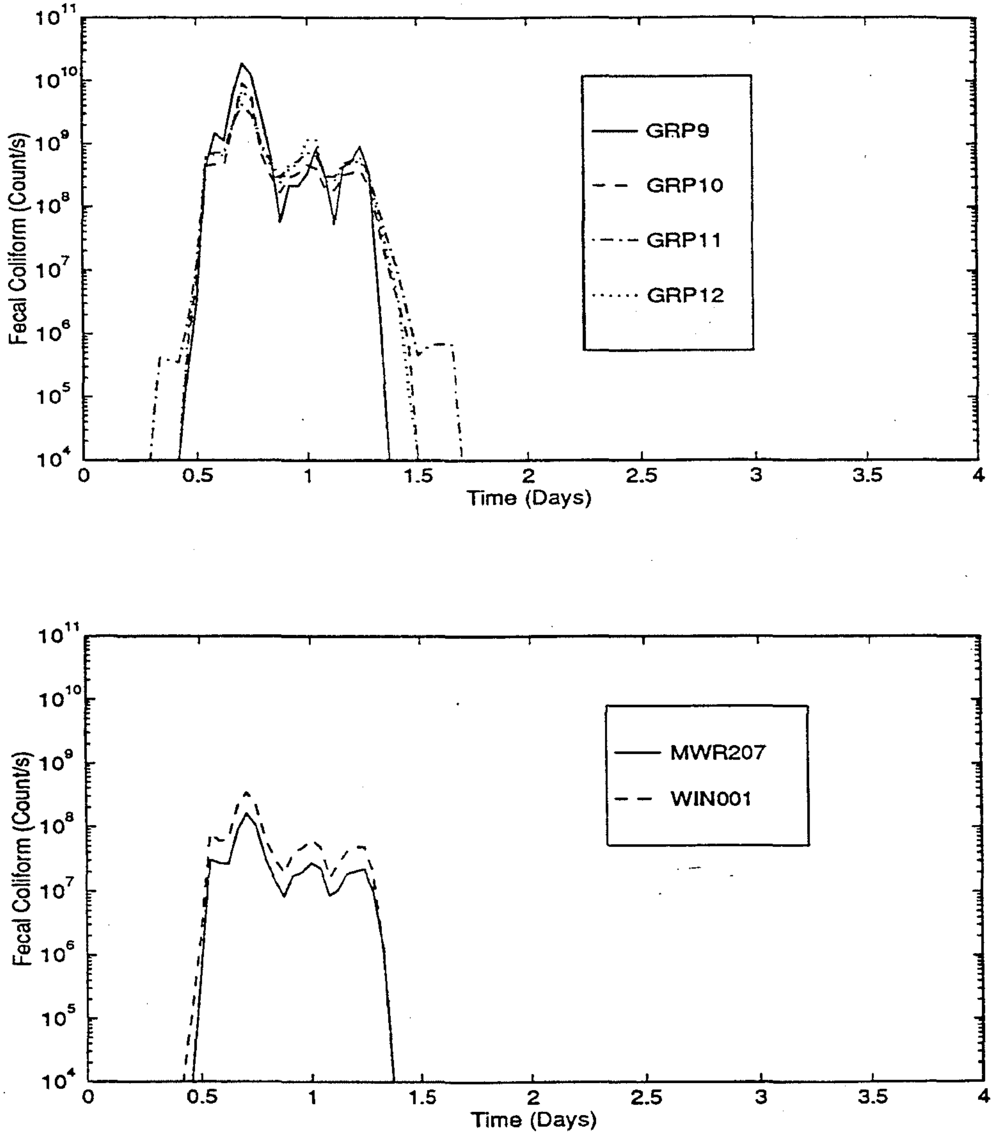


Fig. E.3c2 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 3: Future planned conditions, 1-year design storm, all sources.

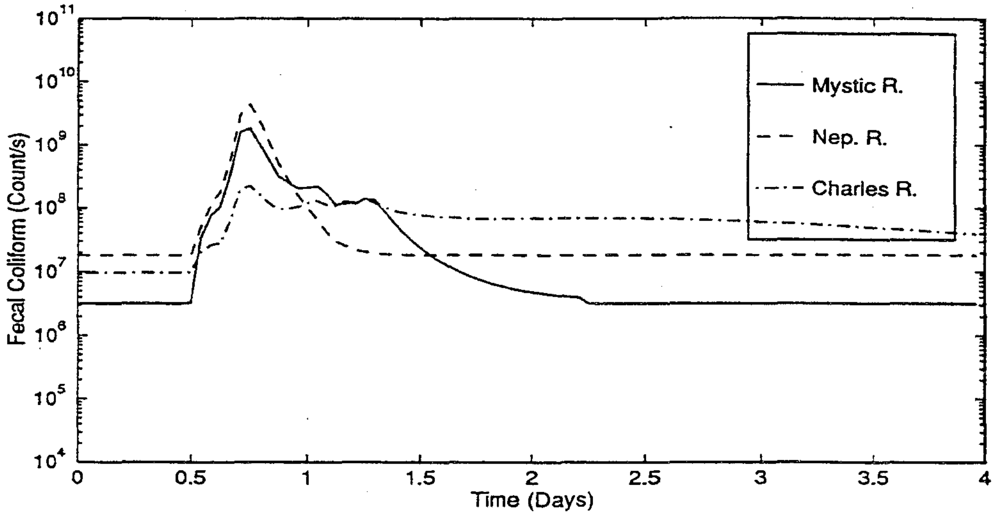


Fig. E.3c3 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 3: Future planned conditions, 1-year design storm, all sources.

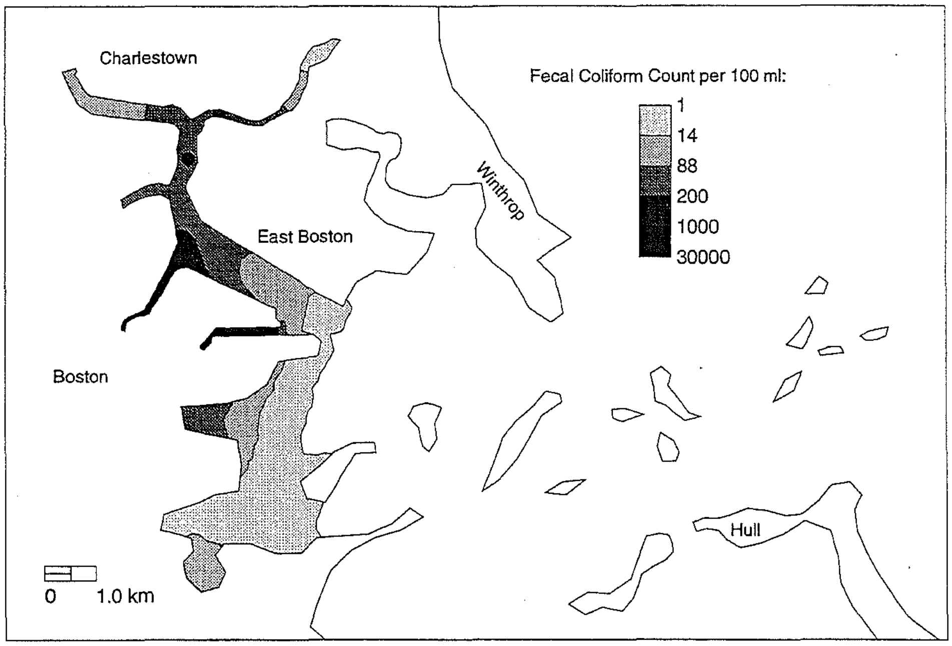


Fig. E.4a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

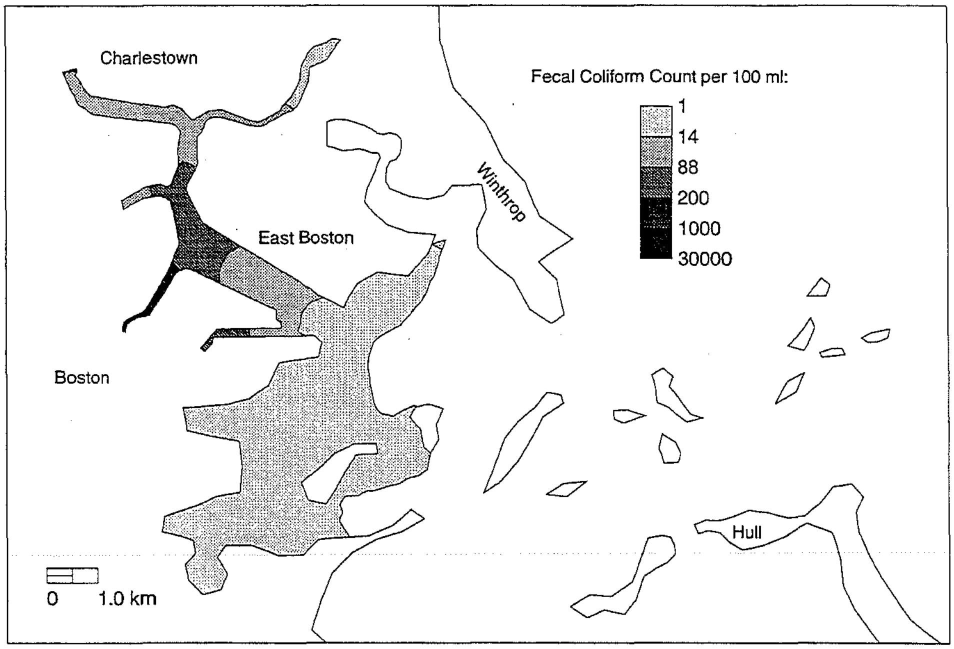


Fig. E.4a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

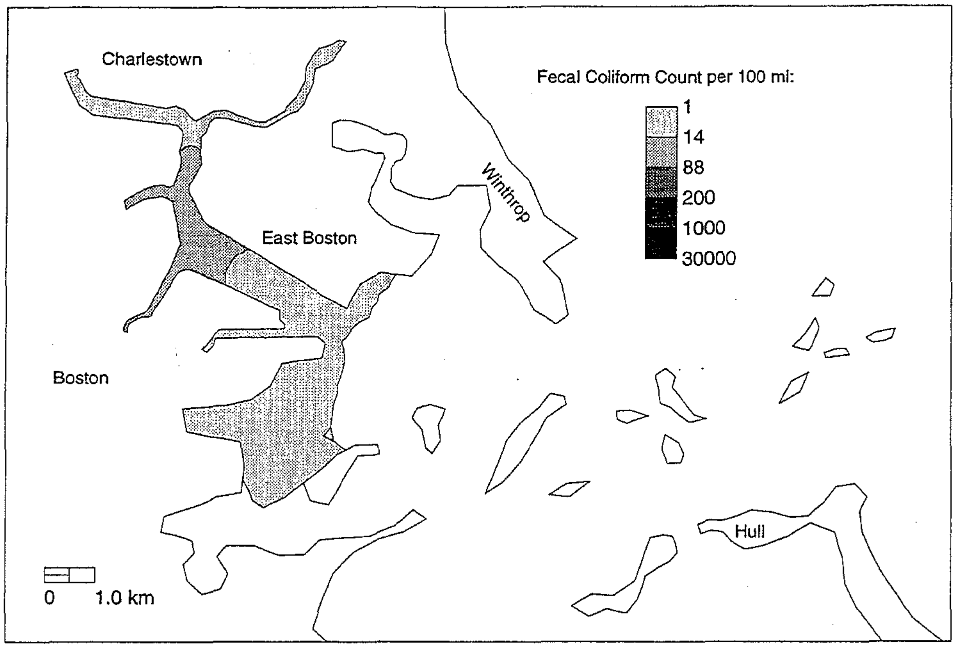


Fig. E.4a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

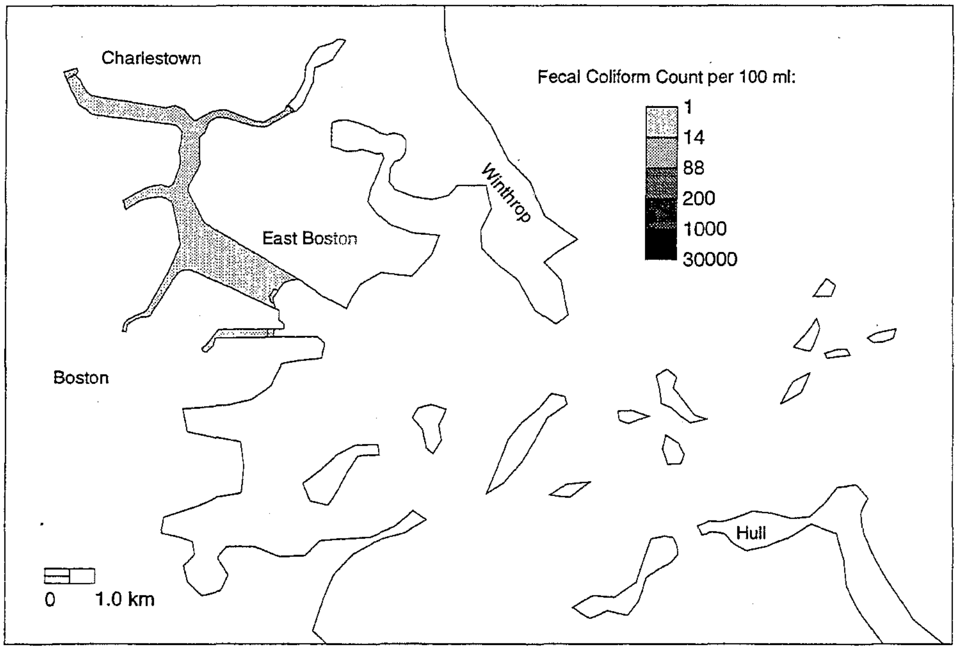


Fig. E.4a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

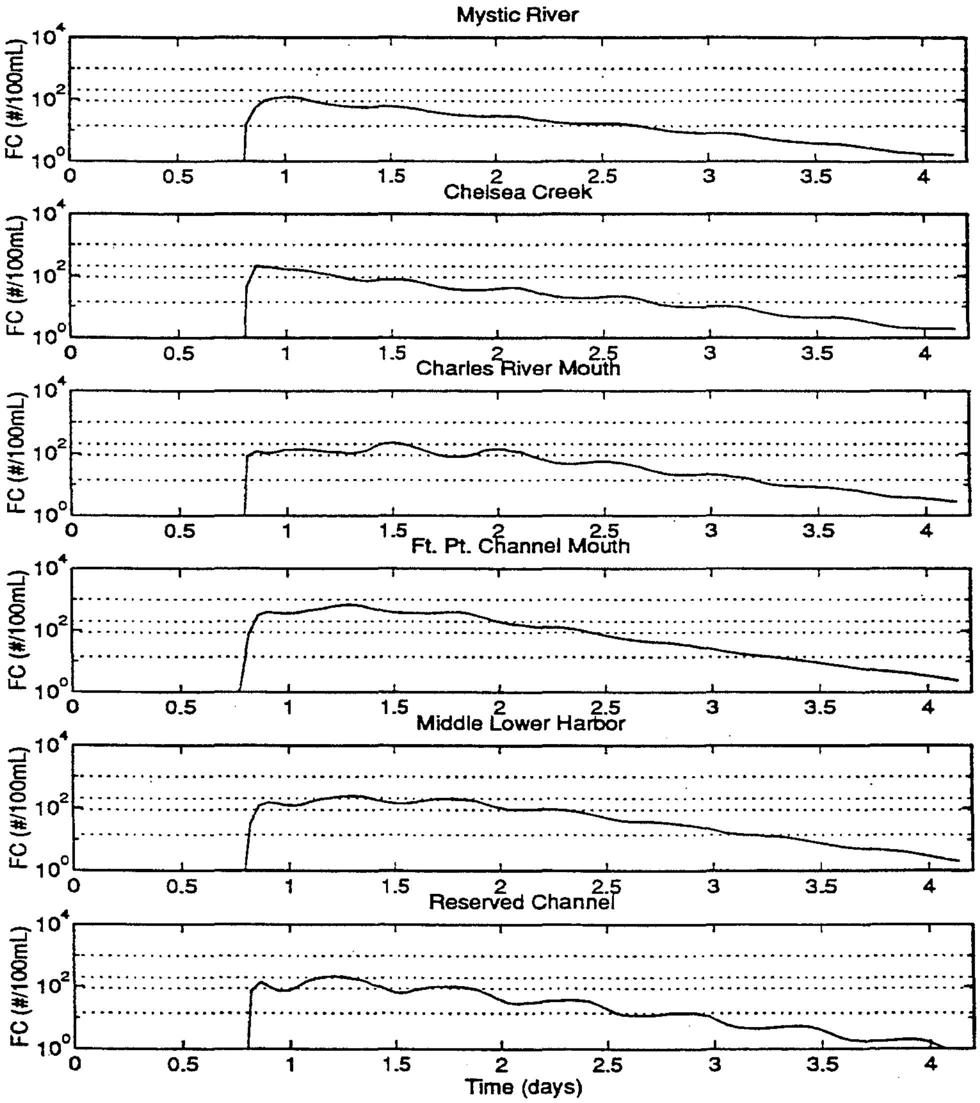


Fig. E.4b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

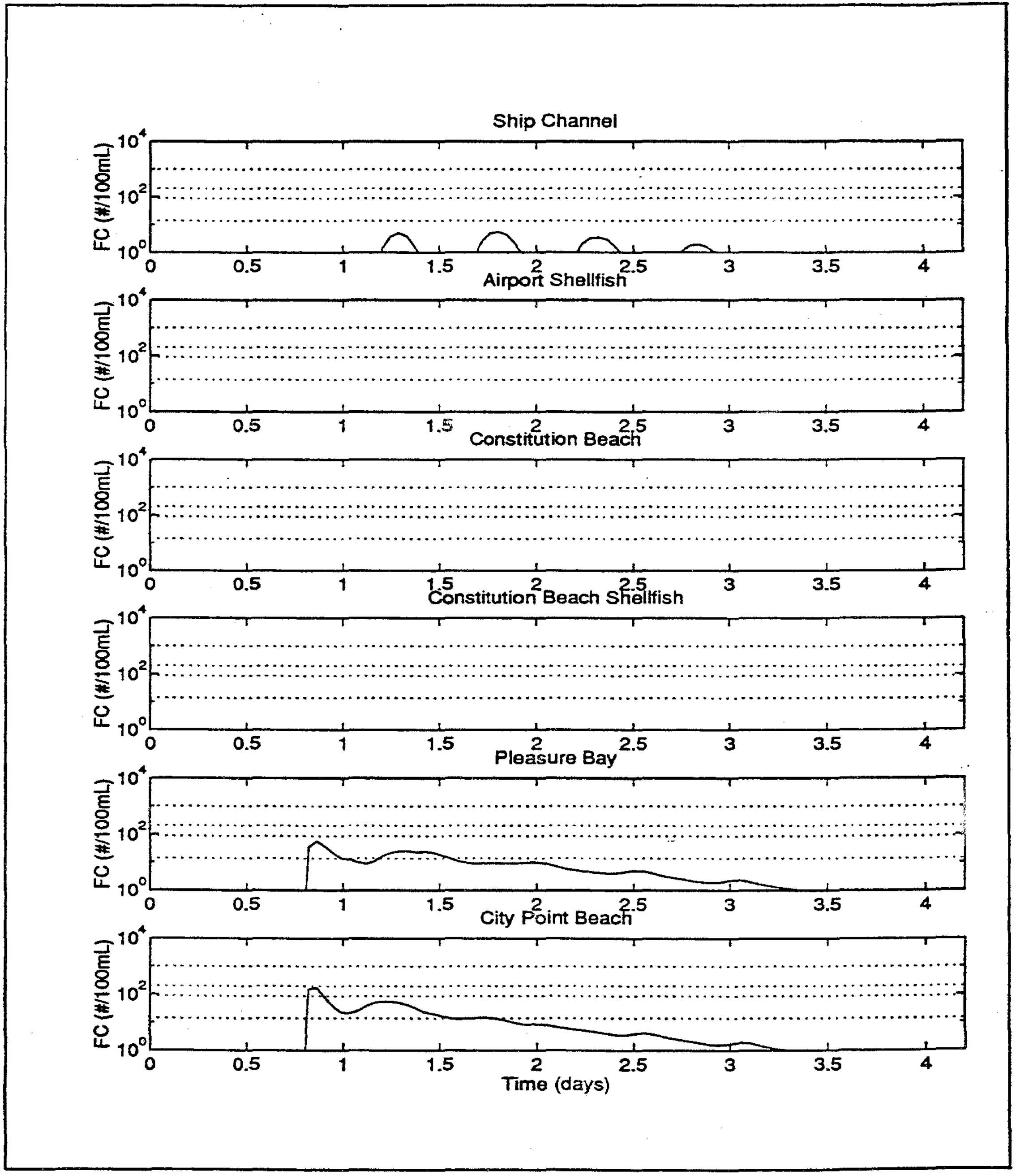


Fig. E.4b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

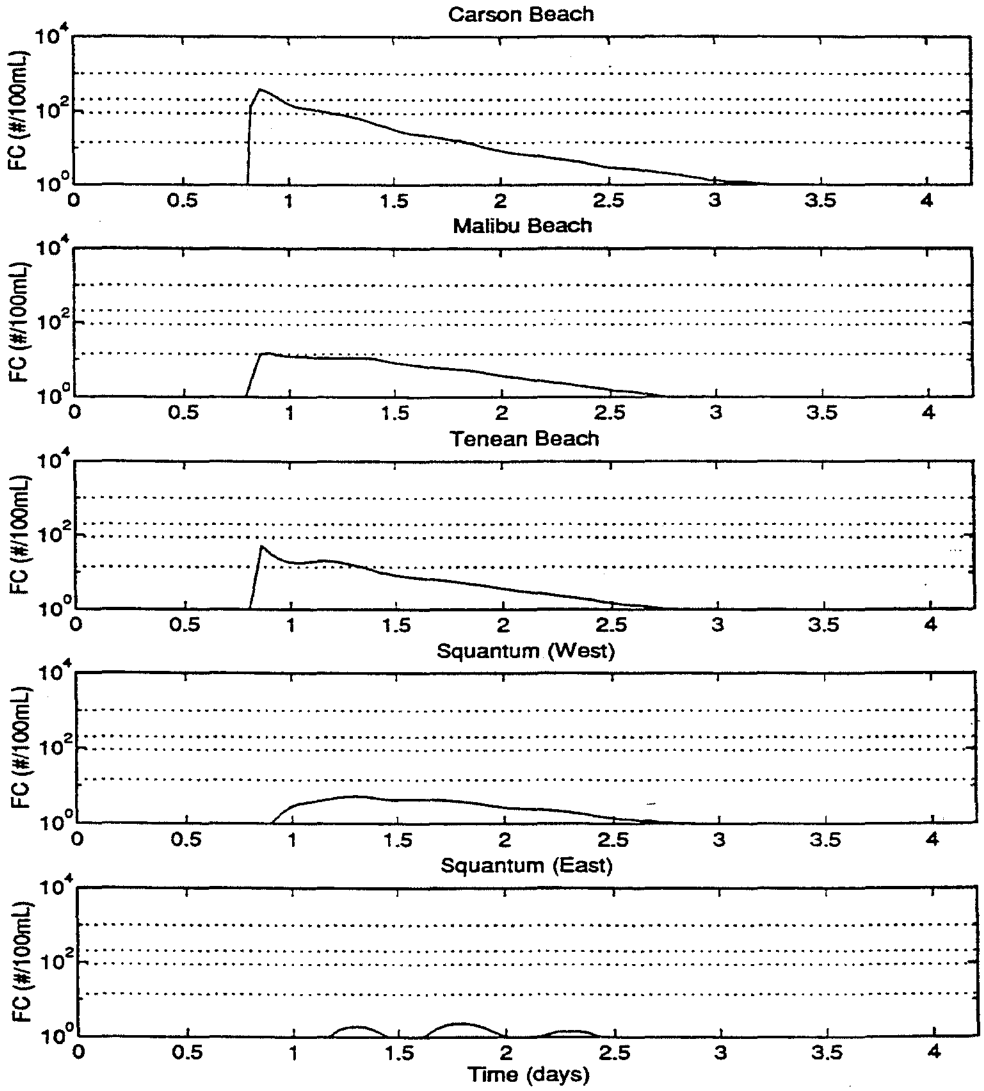


Fig. E.4b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

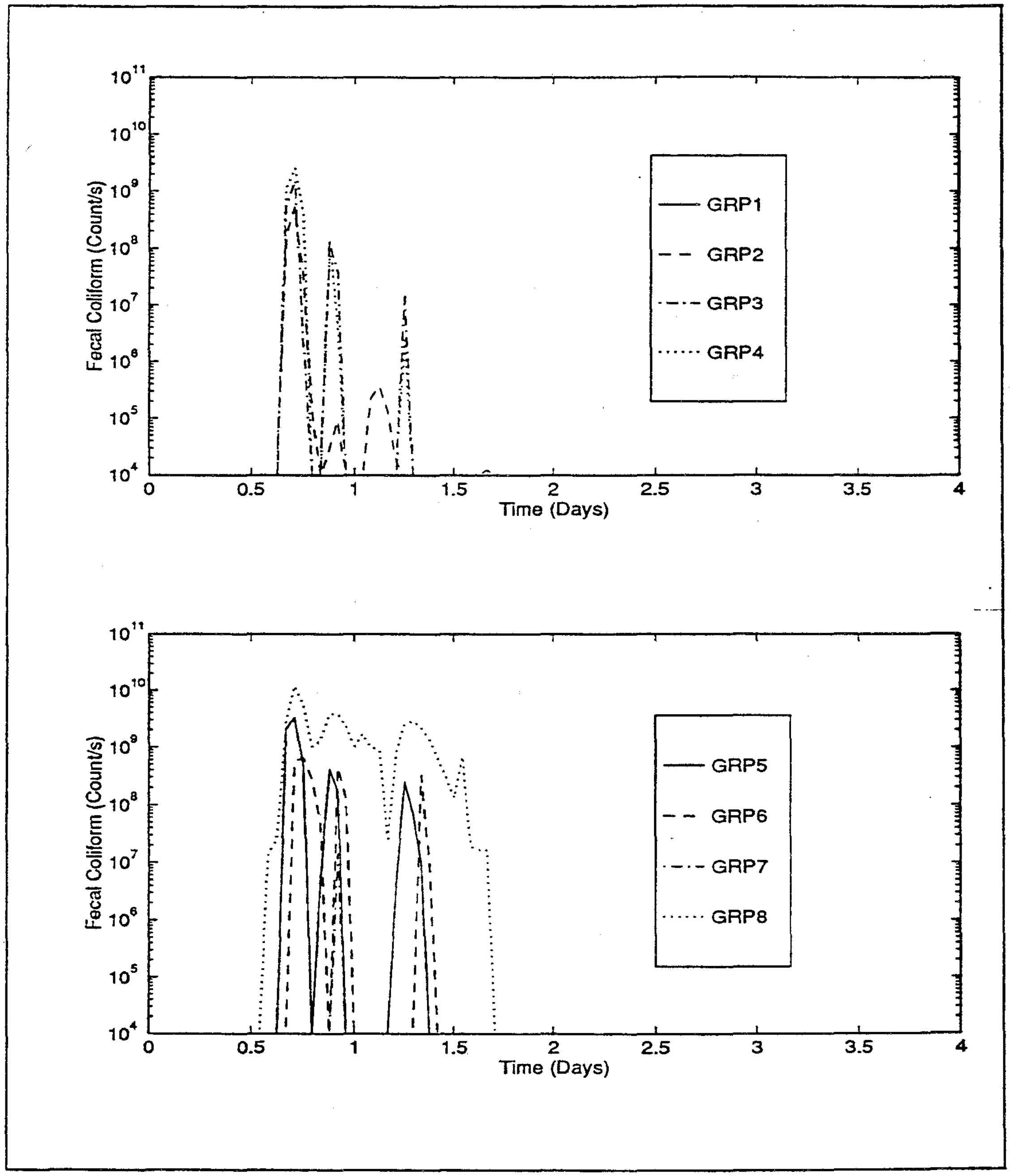


Fig. E.4c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

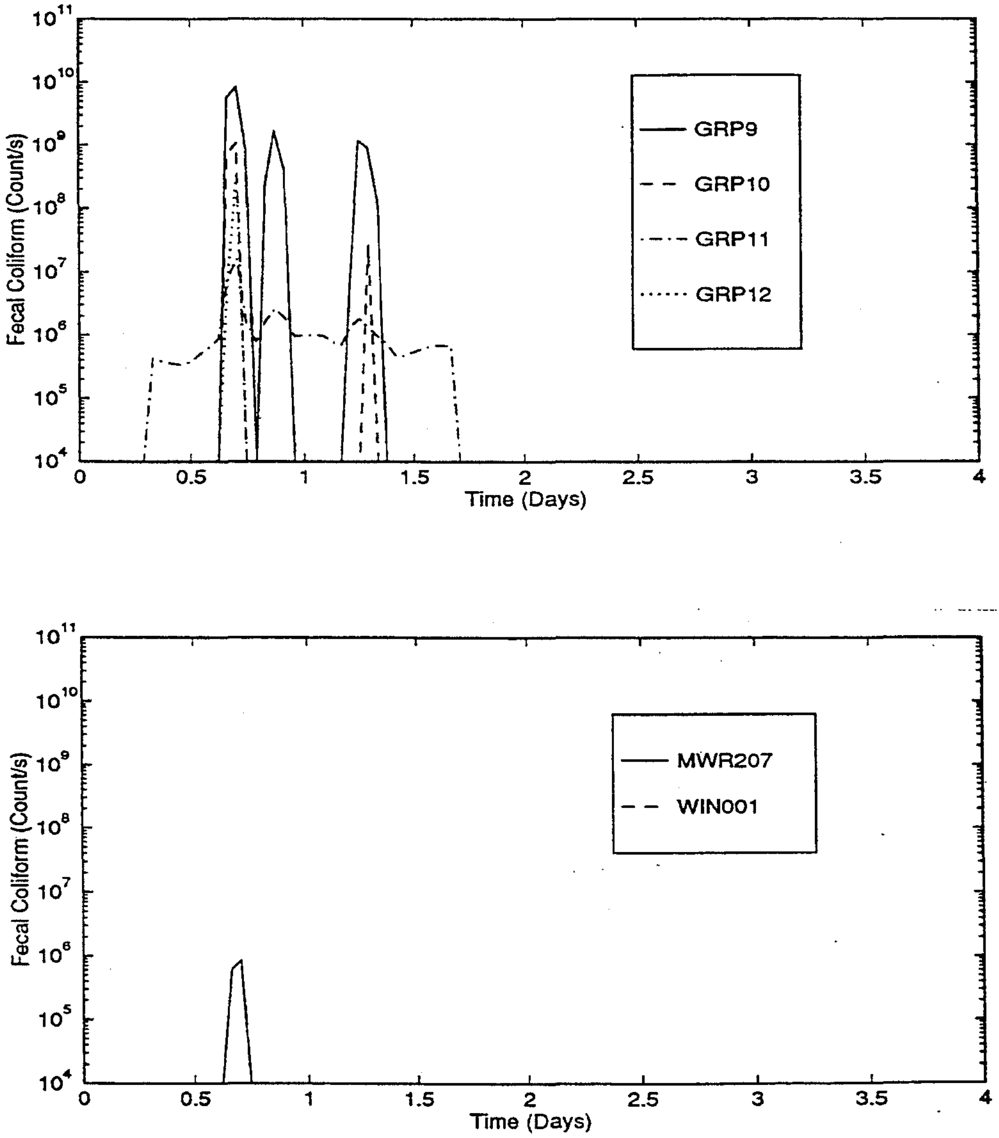


Fig. E.4c2 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

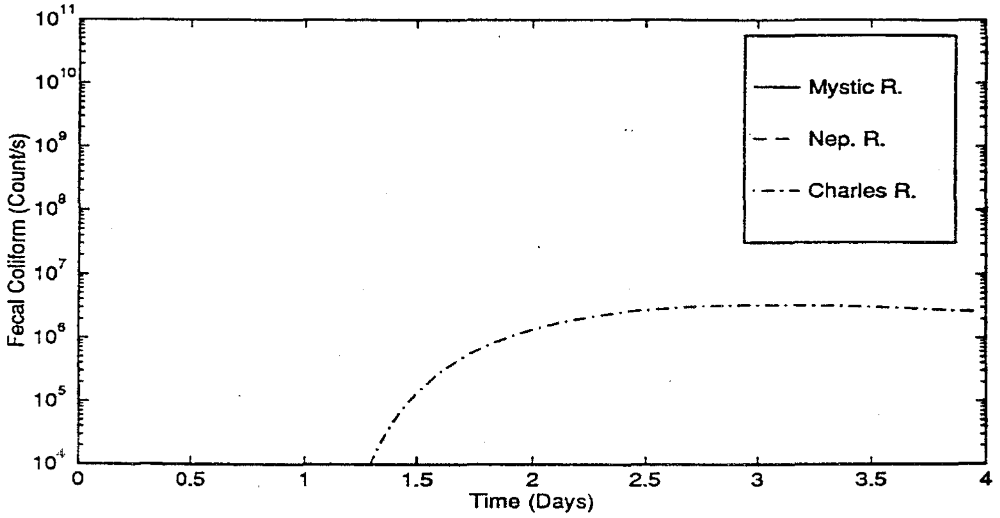


Fig. E.4c3 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 4: Future planned conditions, 3-month design storm, CSO sources only.

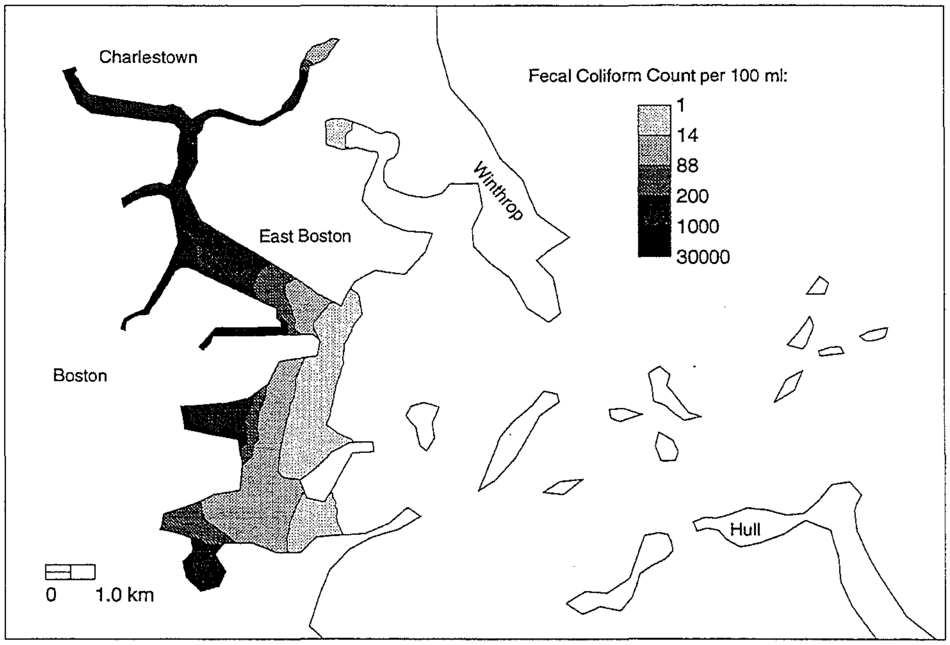


Fig. E.5a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

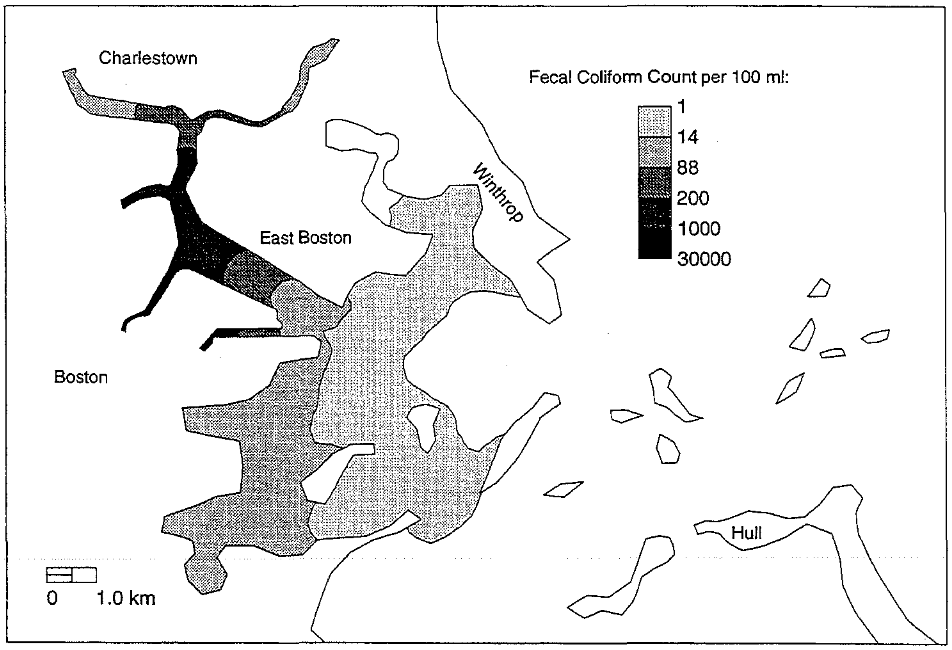


Fig. E.5a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

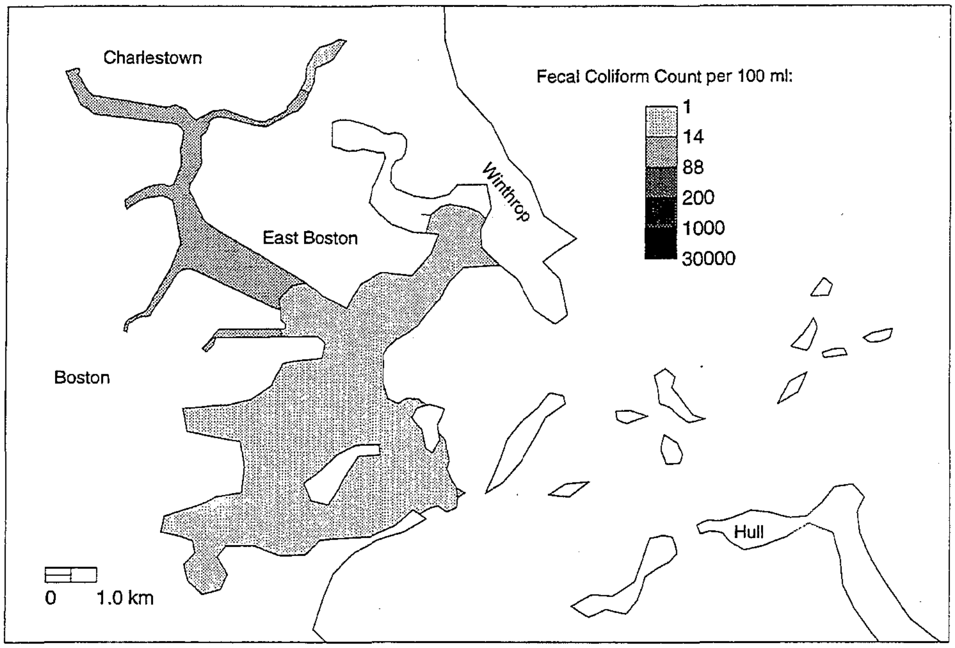


Fig. E.5a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

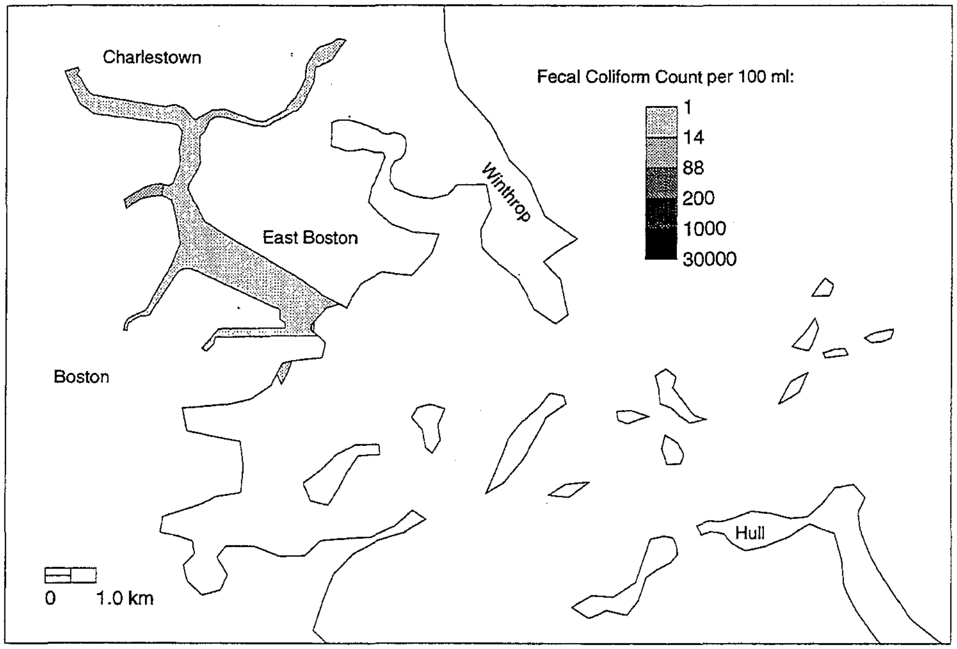


Fig. E.5a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

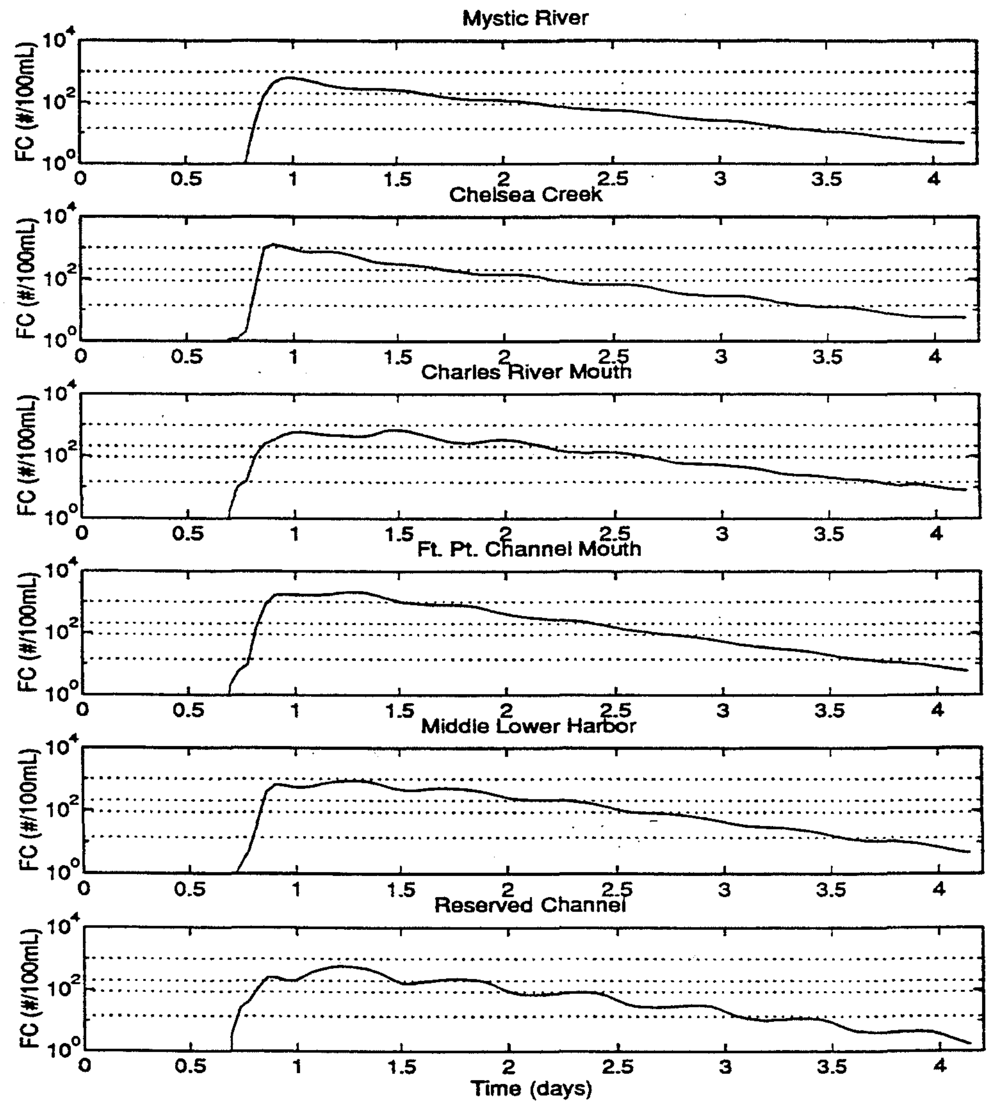


Fig. E.5b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

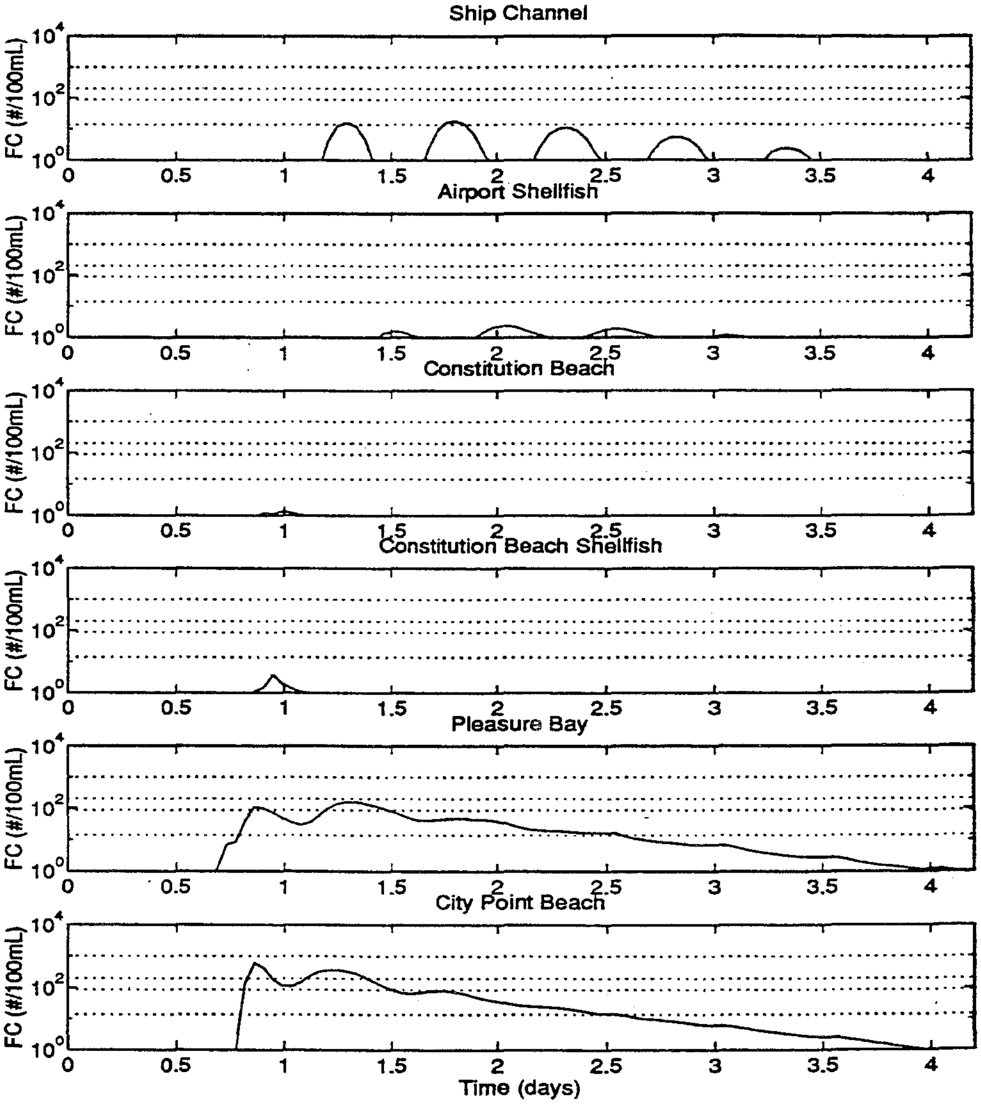


Fig. E.5b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

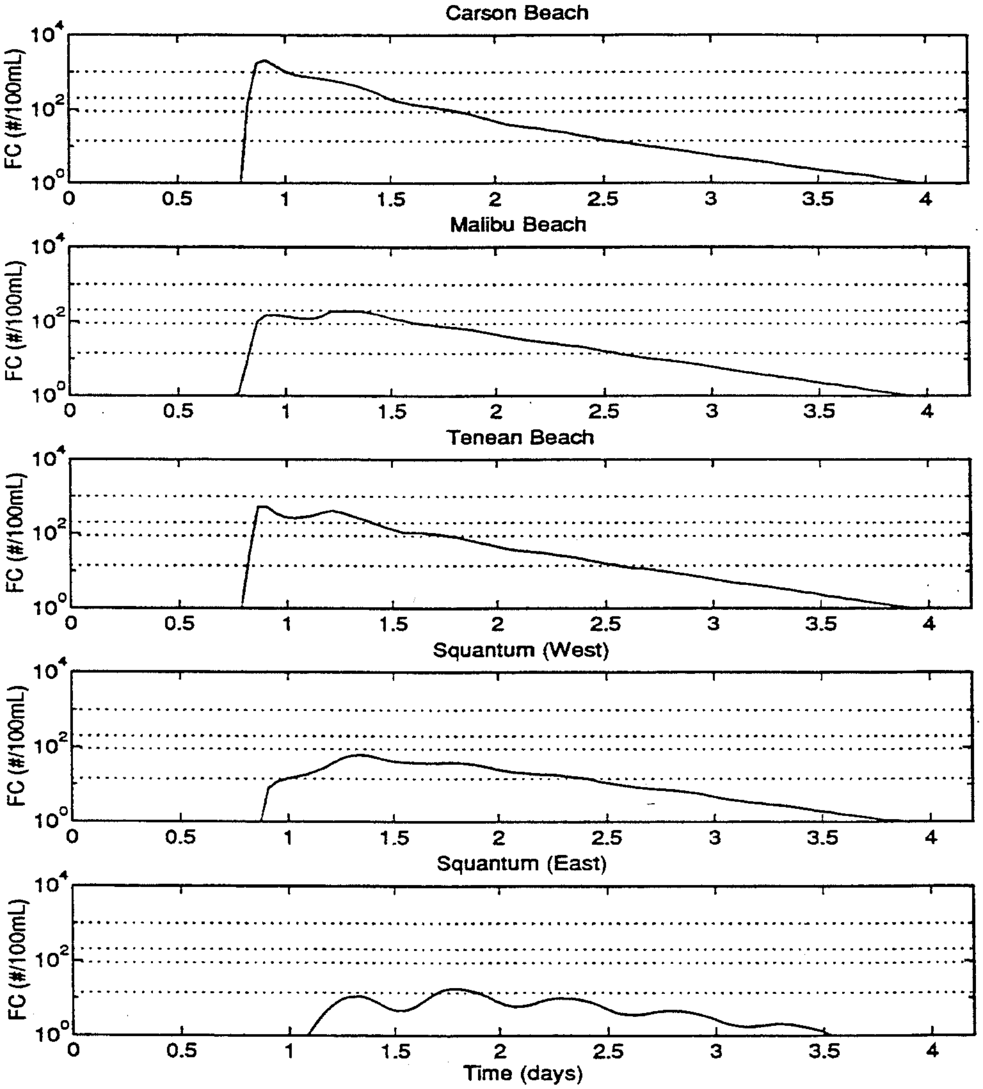


Fig. E.5b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

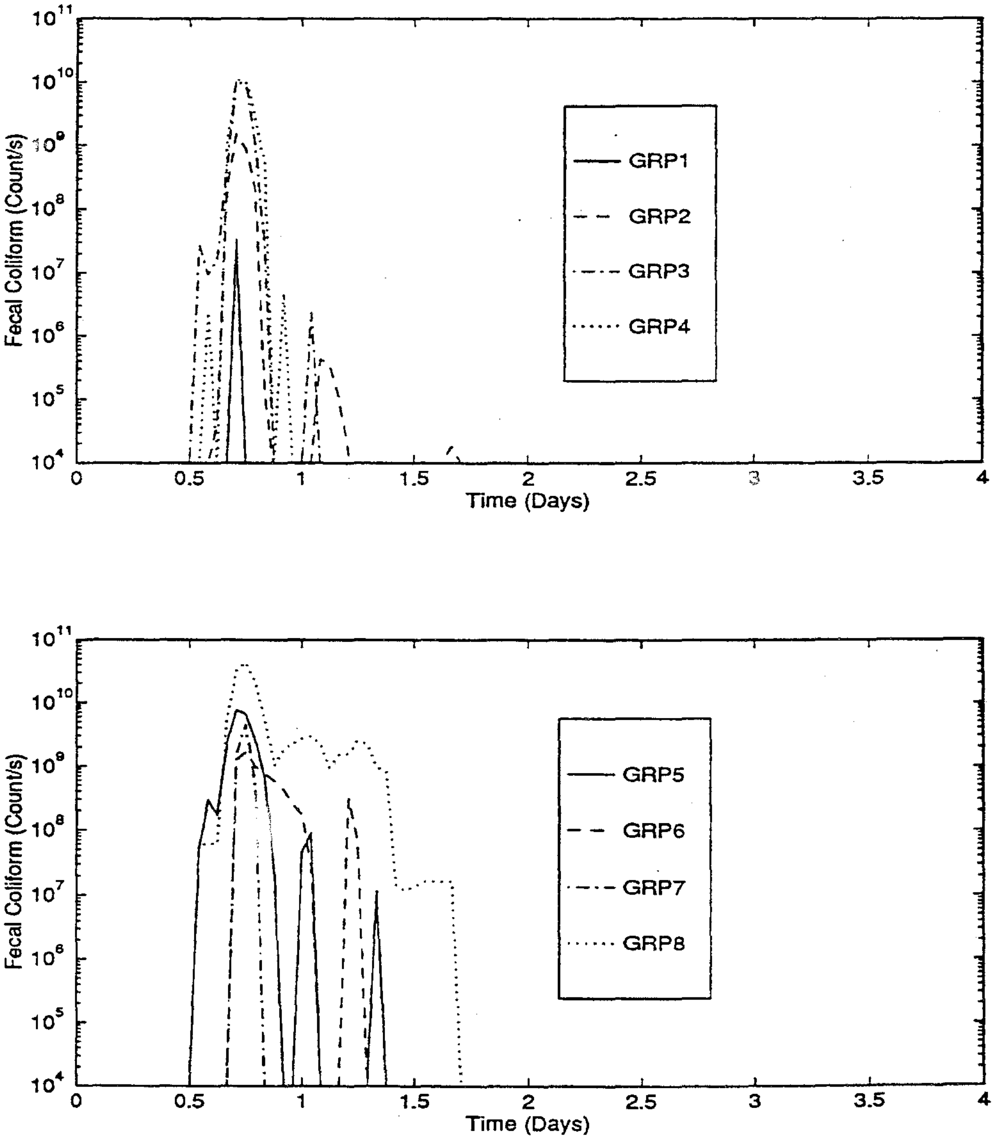


Fig. E.5c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

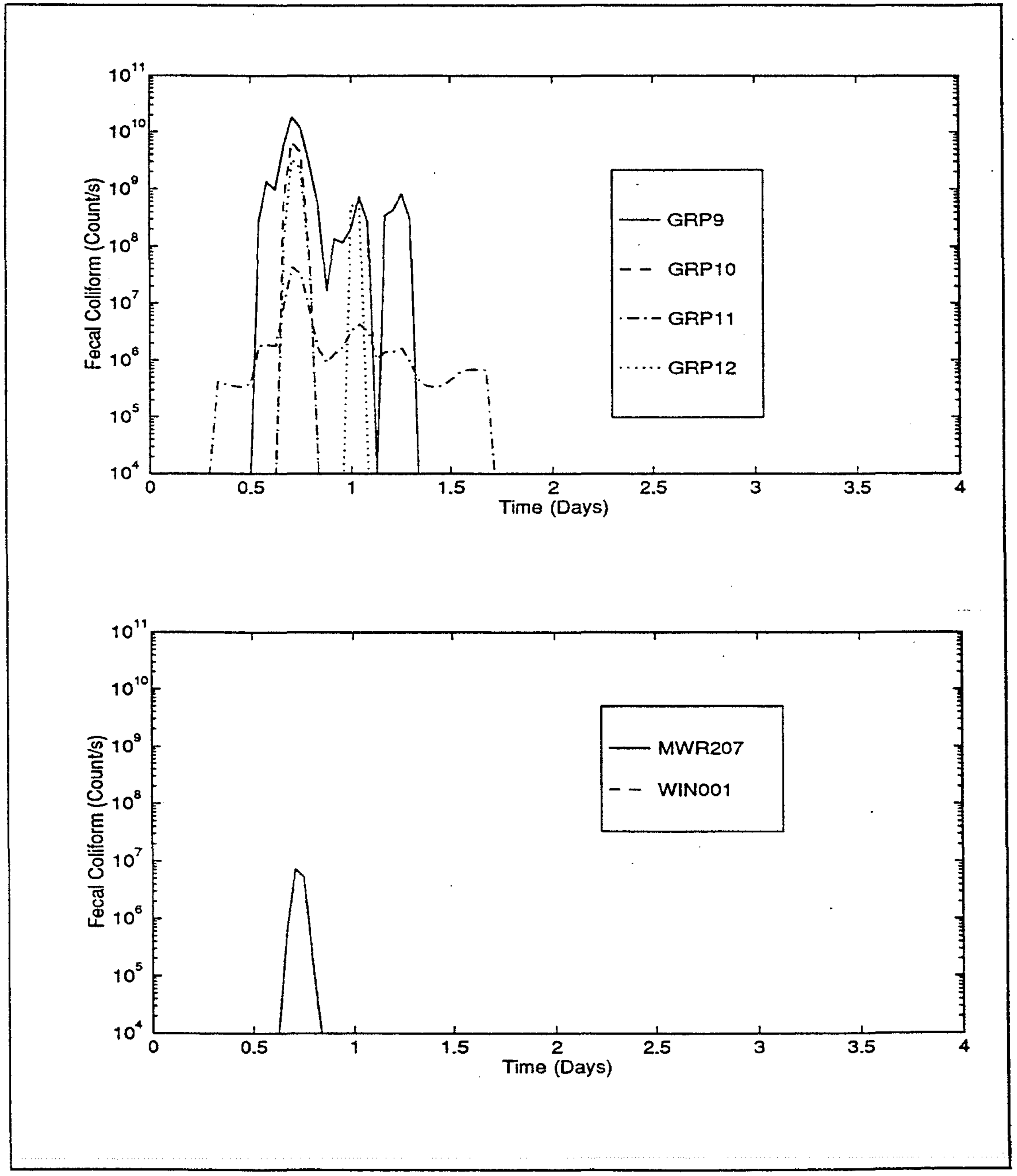


Fig. E.5c2 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

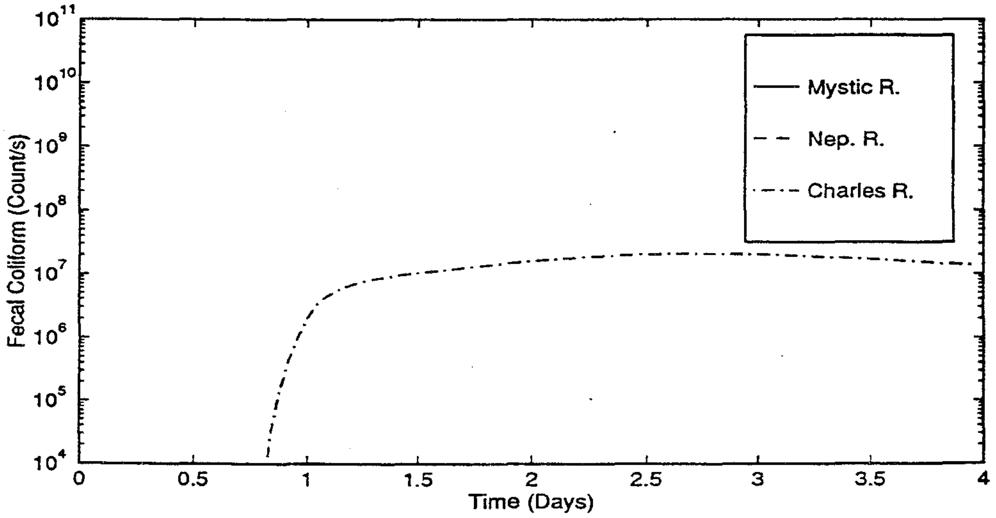


Fig. E.5c3 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 5: Future planned conditions, 1-year design storm, CSO sources only.

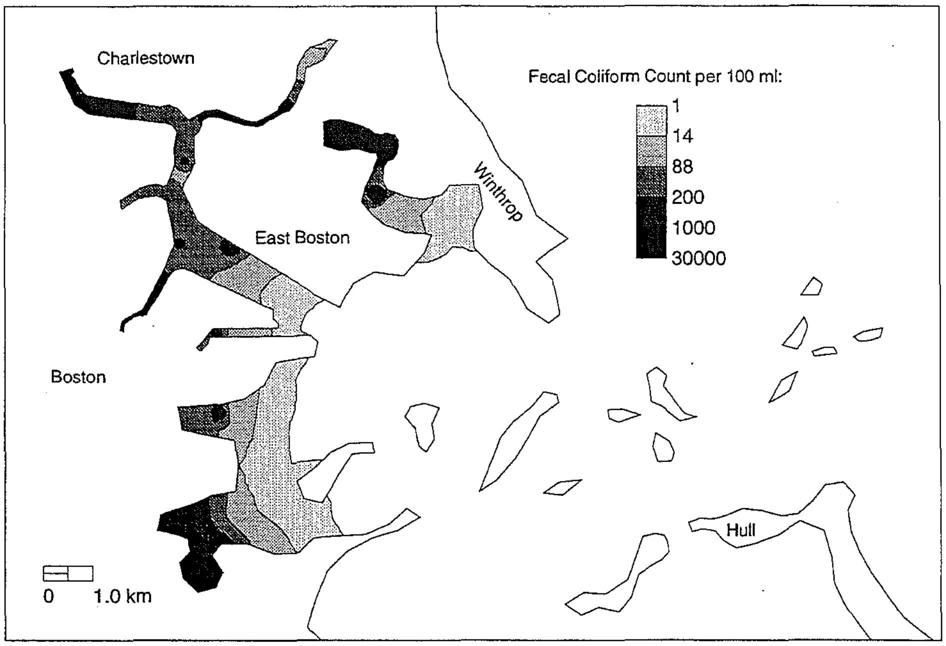


Fig. E.6a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 6: Future planned conditions, 3-month design storm, non-CSO sources.

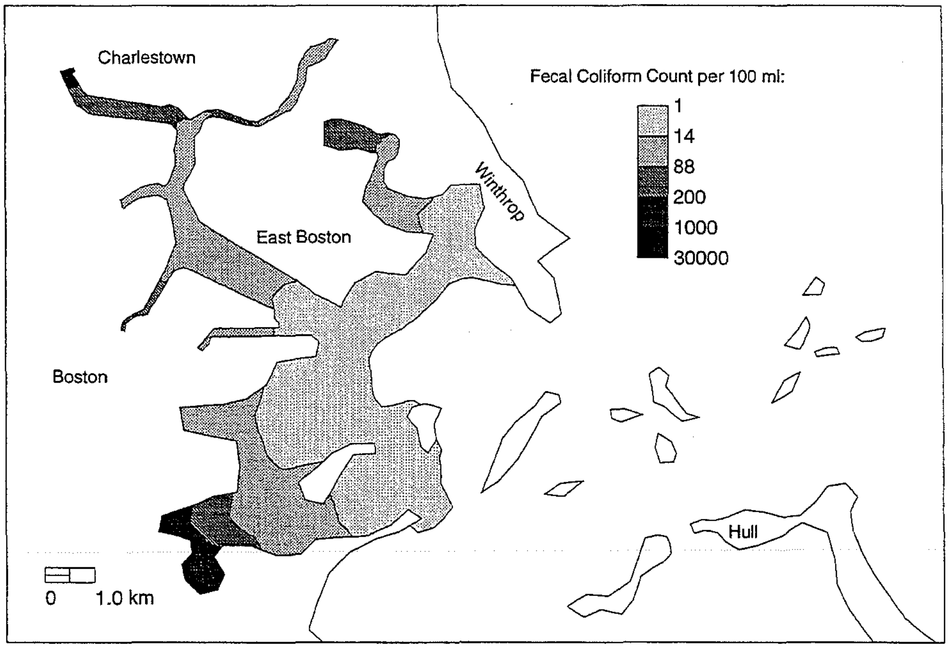


Fig. E.6a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 6: Future planned conditions, 3-month design storm, non-CSO sources.

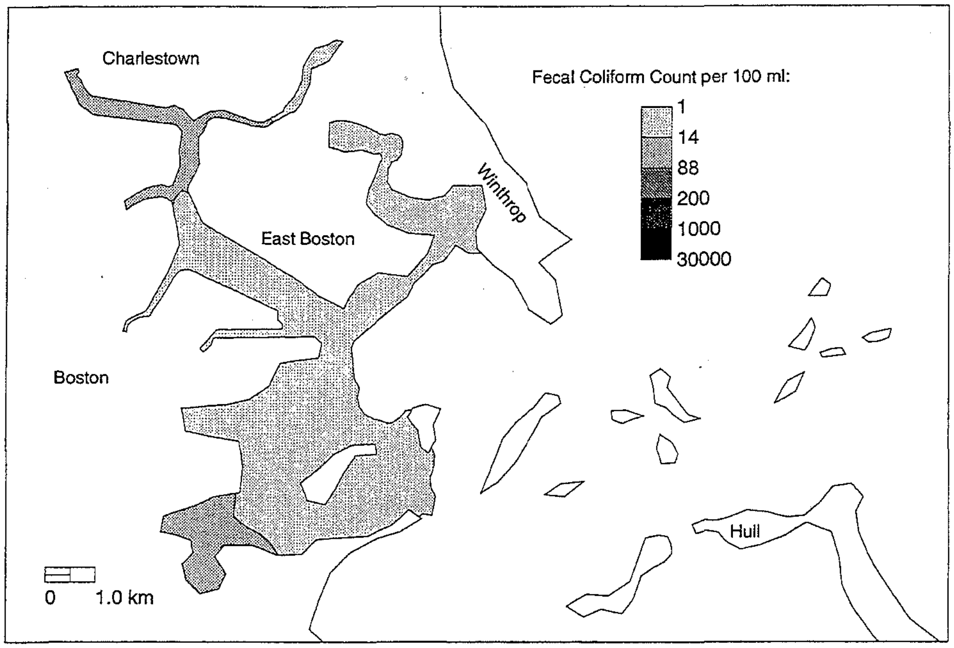


Fig. E.6a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 6: Future planned conditions, 3-month design storm, non-CSO sources.

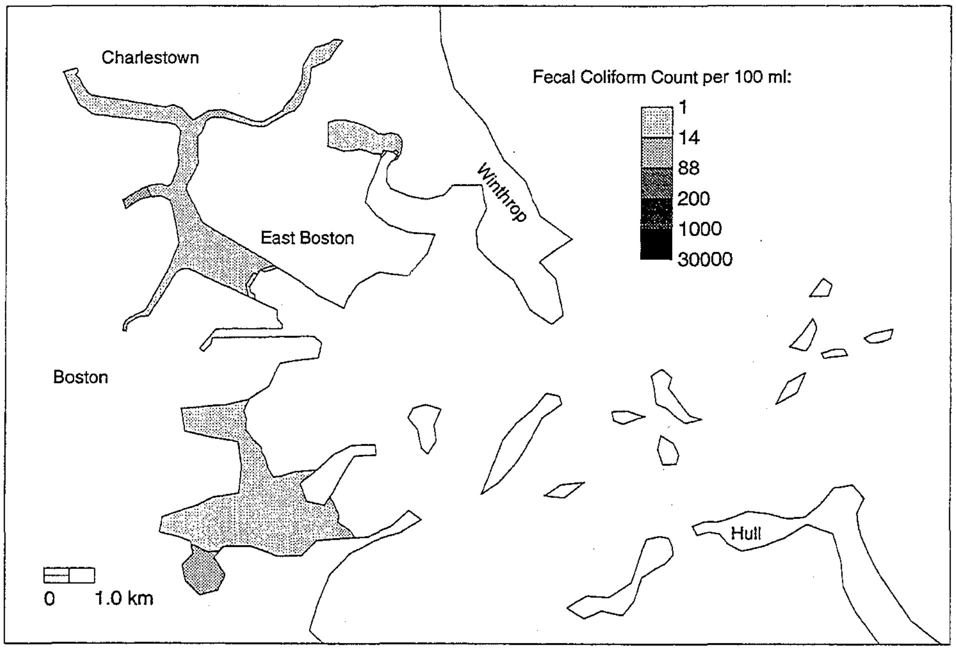


Fig. E.6a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 6: Future planned conditions, 3-month design storm, non-CSO sources.

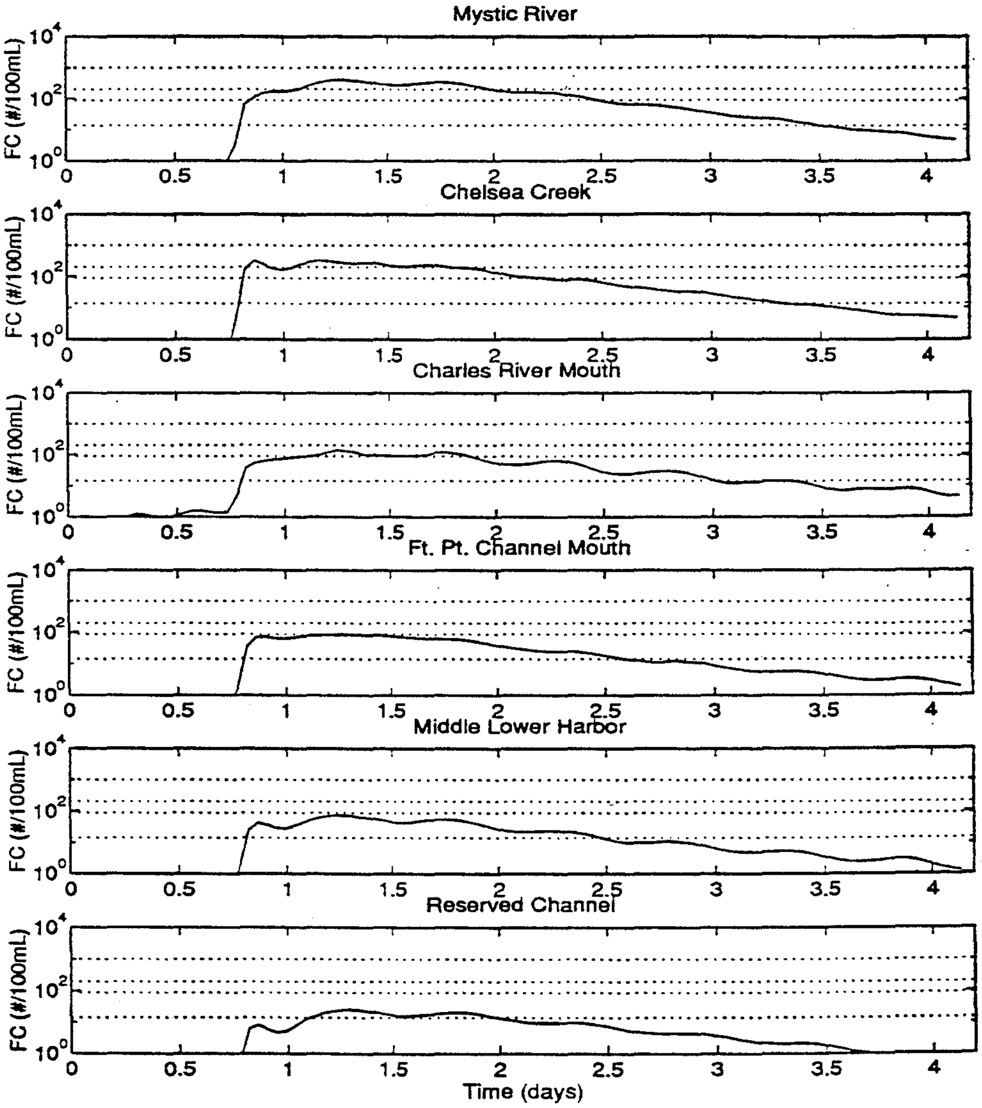


Fig. E.6b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

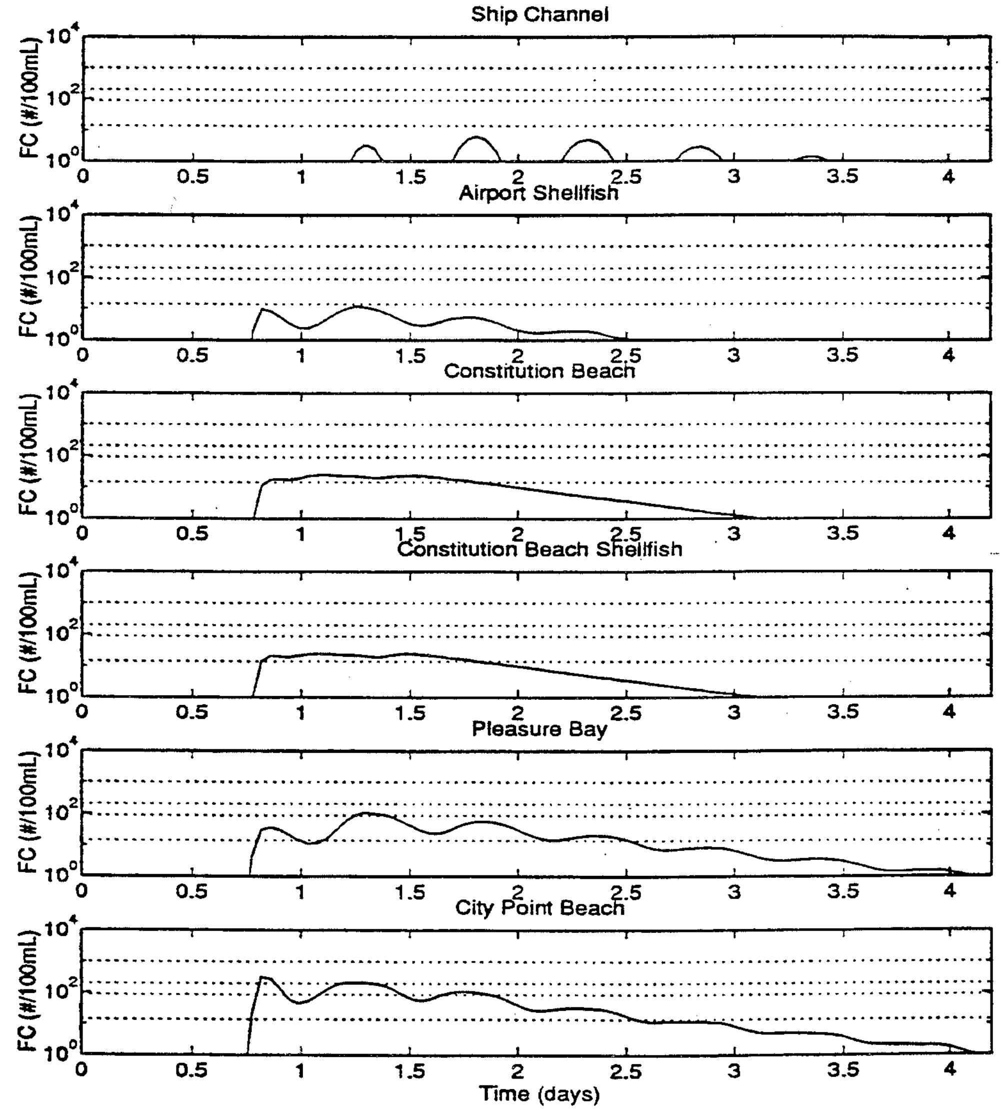


Fig. E.6b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

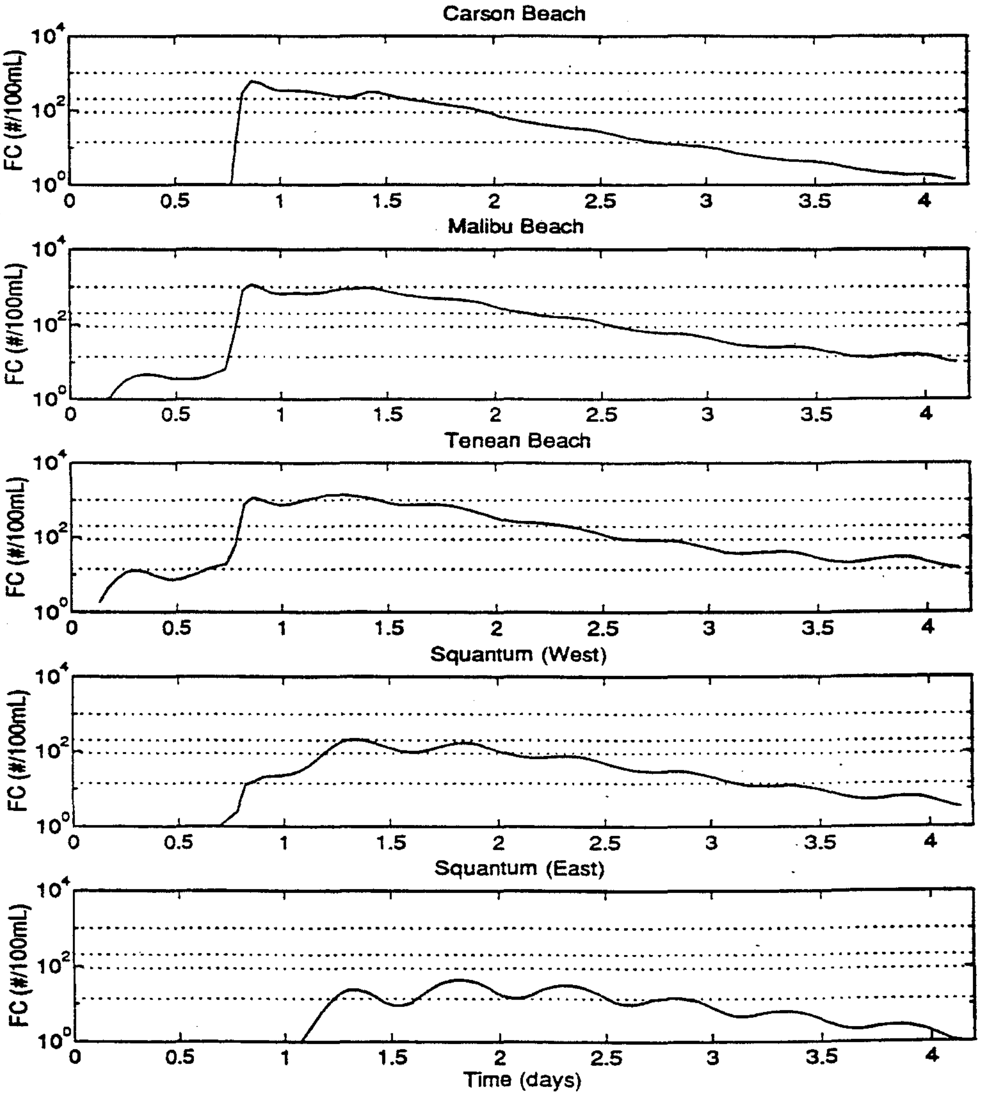


Fig. E.6b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

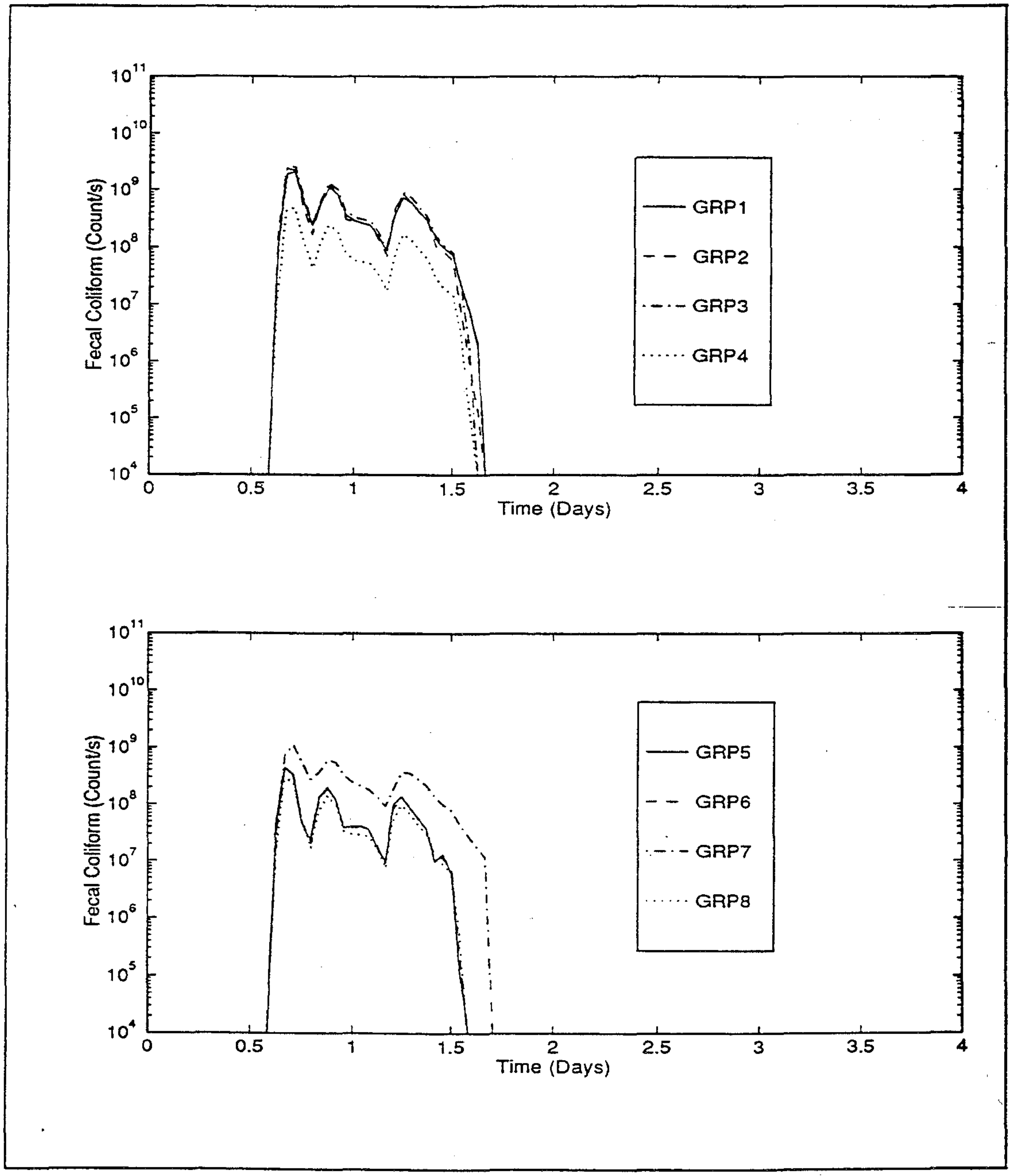


Fig. E.6c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

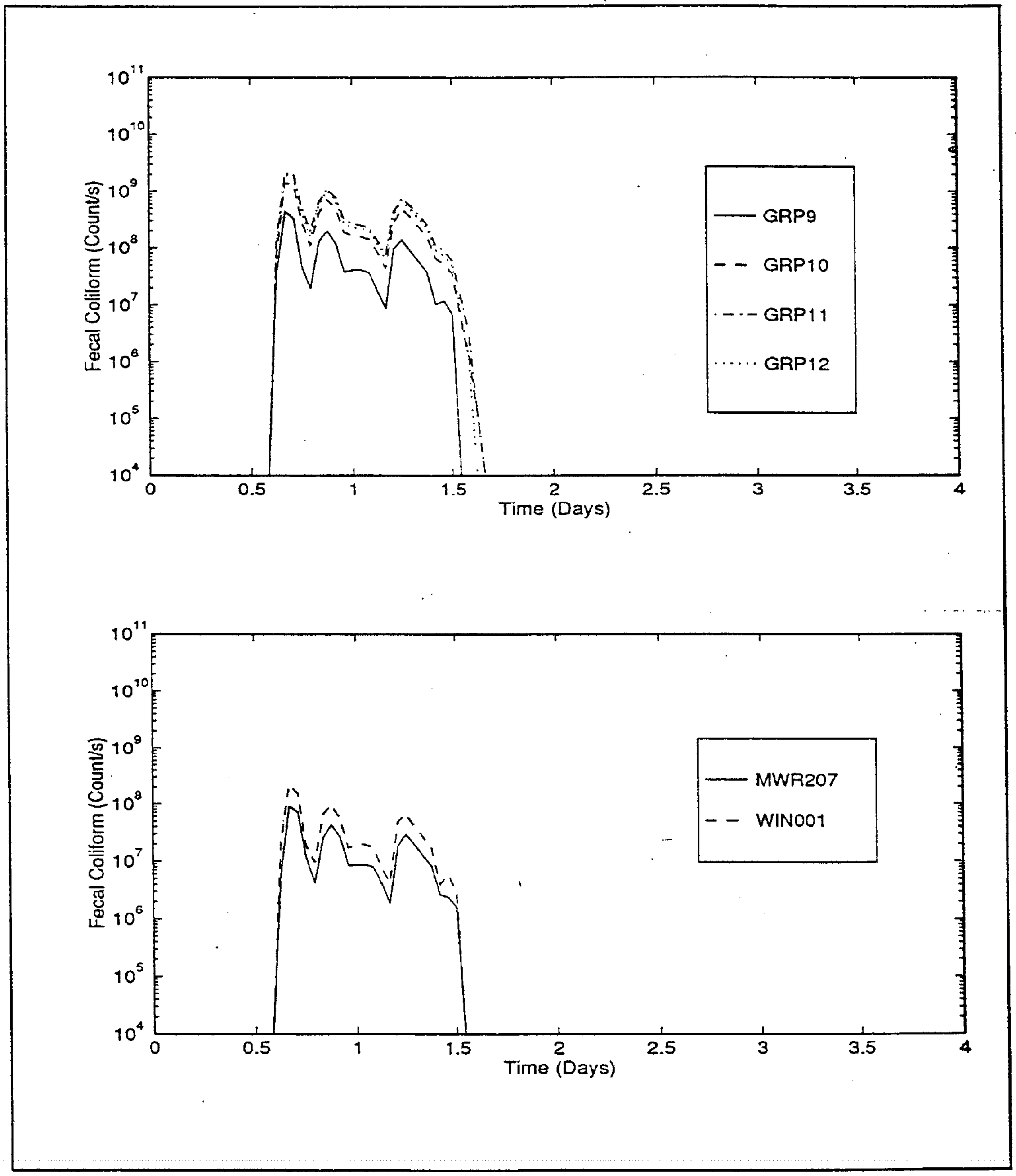


Fig. E.6c2 Harbor Fecal Coliform Loadings versus Time for Each Source–**Run 6:** Future planned conditions, 3-month design storm, non-CSO sources only.

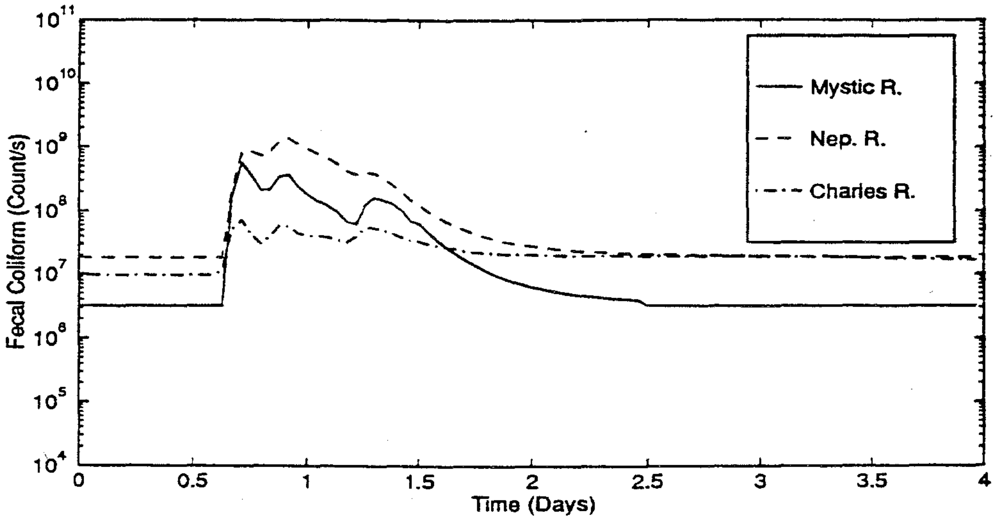


Fig. E.6c3 Harbor Fecal Coliform Psfiles/Loadings versus Time for Each Source–Run 6: Future planned conditions, 3-month design storm, non-CSO sources only.

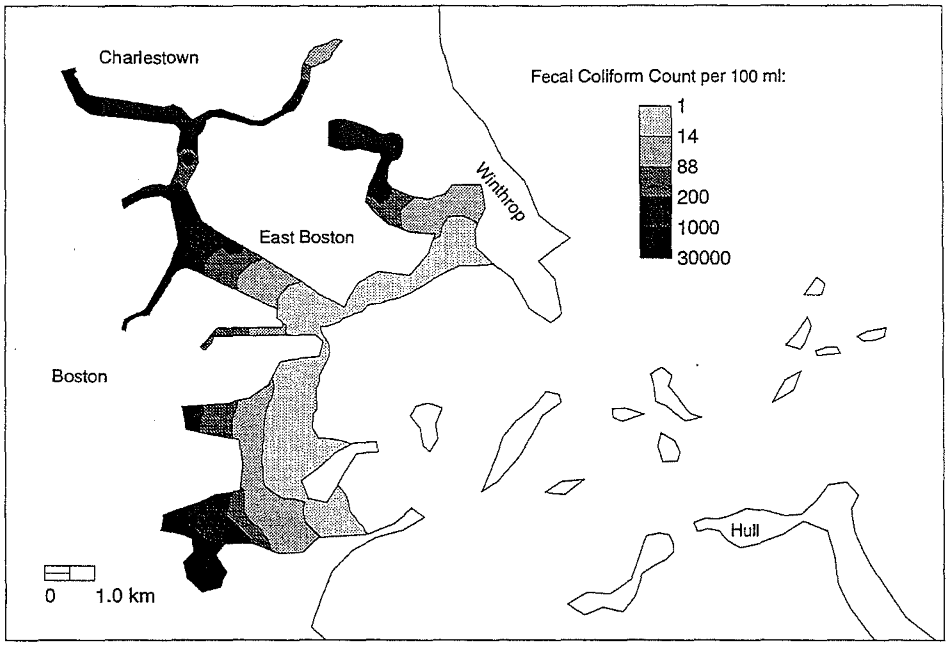


Fig. E.7a1 Simulated Harbor Fecal Coliform Counts after One Day–Run 7: Future planned conditions, 1-year design storm, non-CSO sources.

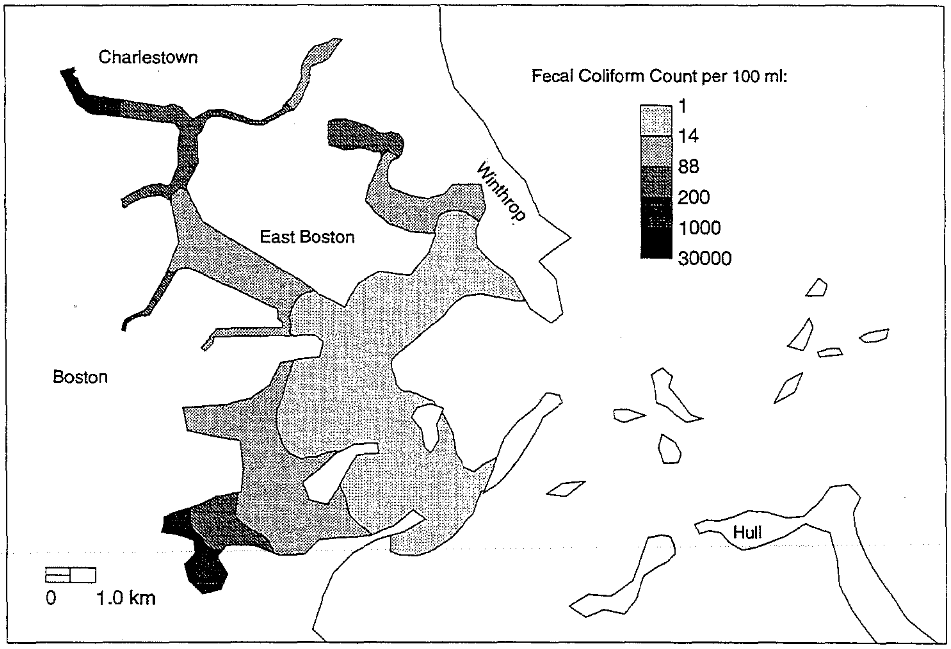


Fig. E.7a2 Simulated Harbor Fecal Coliform Counts after Two Days–Run 7: Future planned conditions, 1-year design storm, non-CSO sources.

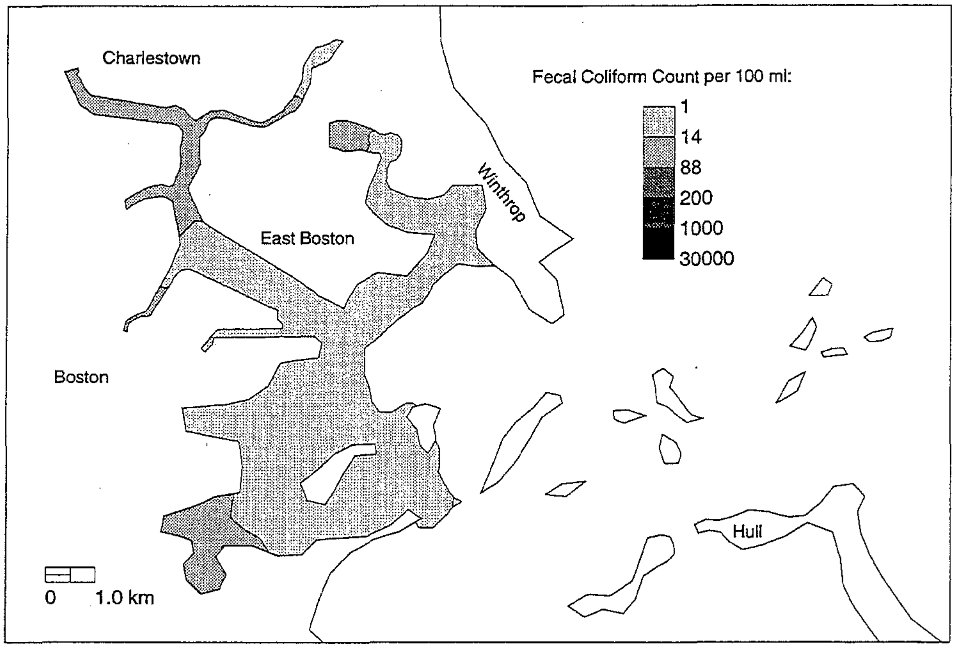


Fig. E.7a3 Simulated Harbor Fecal Coliform Counts after Three Days–Run 7: Future planned conditions, 1-year design storm, non-CSO sources.

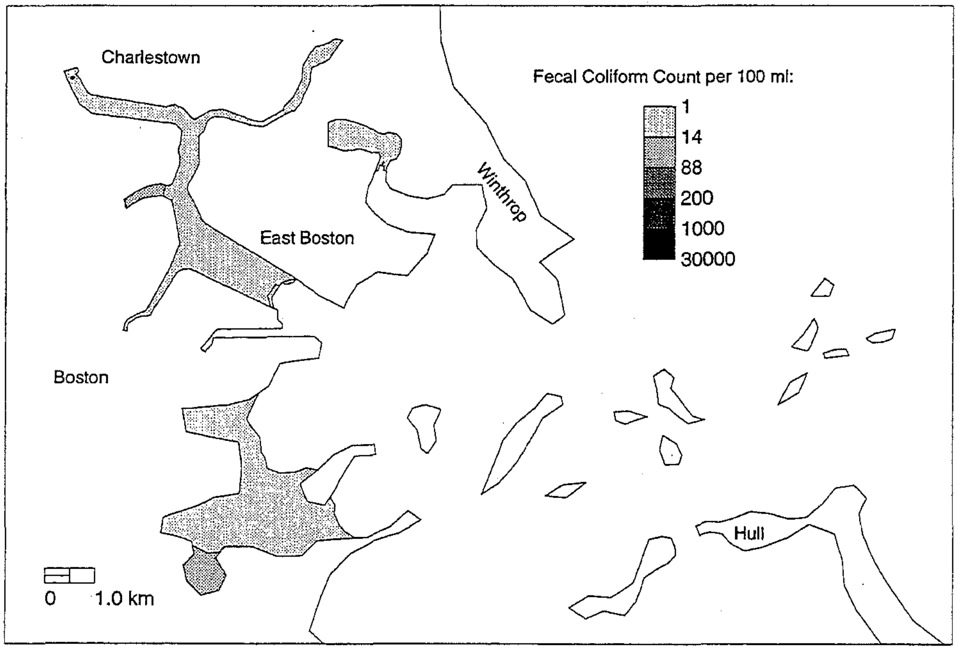


Fig. E.7a4 Simulated Harbor Fecal Coliform Counts after Four Days–Run 7: Future planned conditions, 1-year design storm, non-CSO sources.

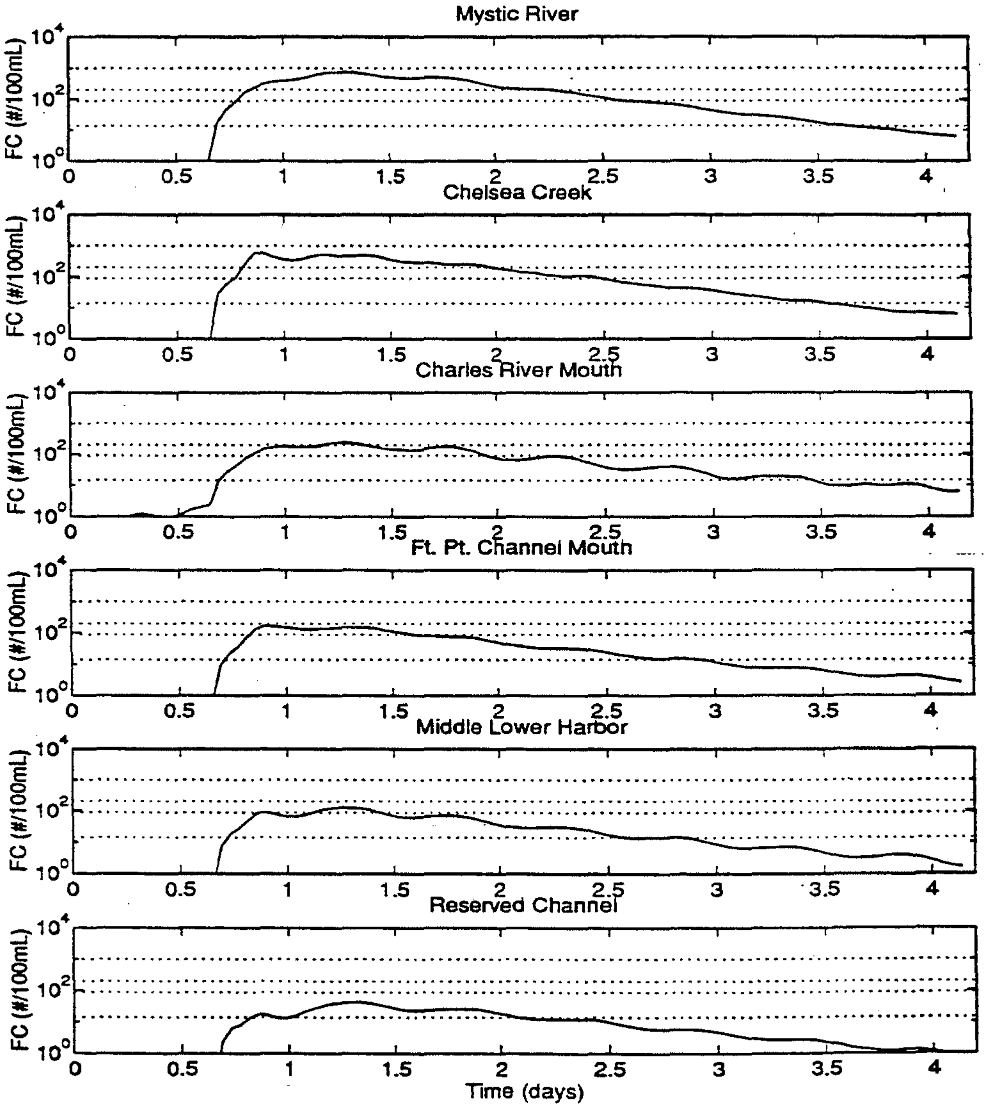


Fig. E.7b1 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

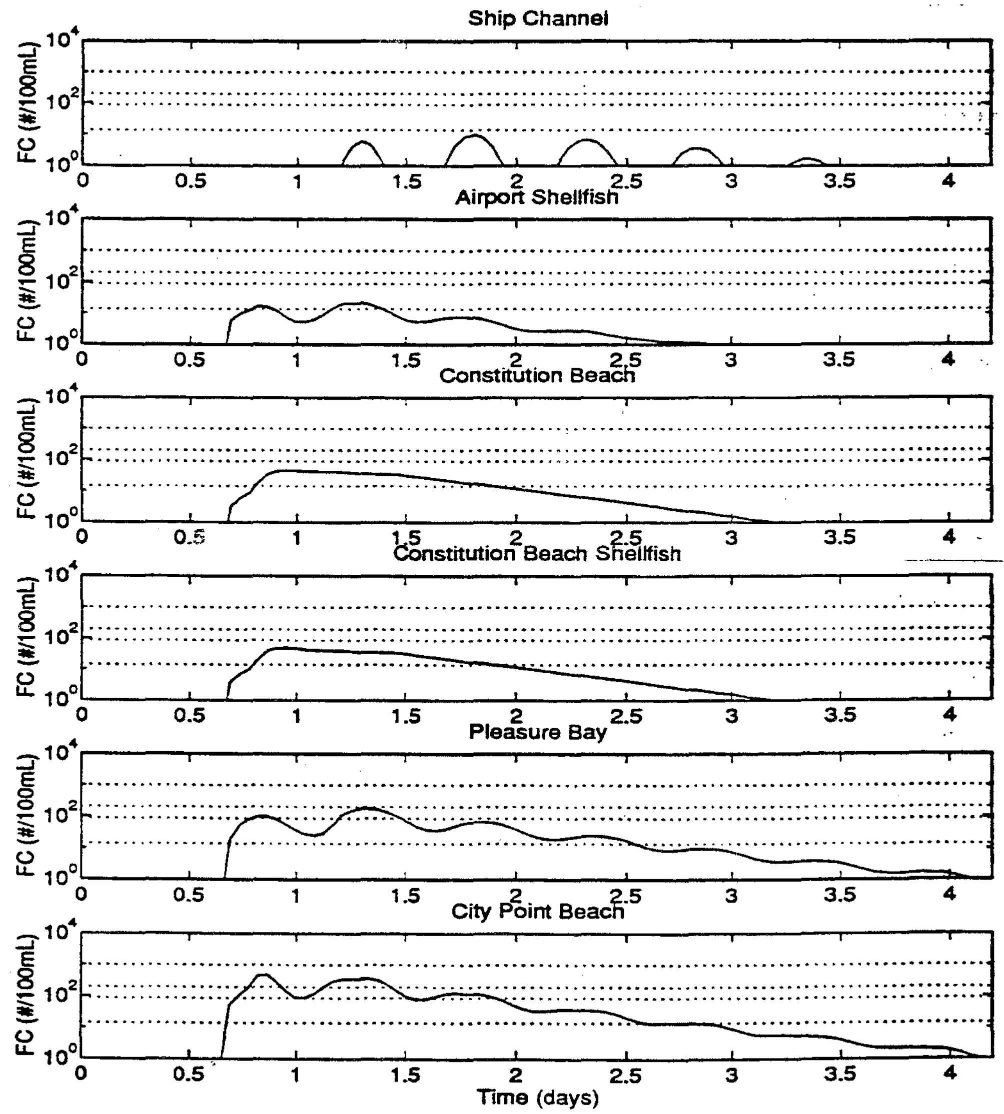


Fig. E.7b2 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

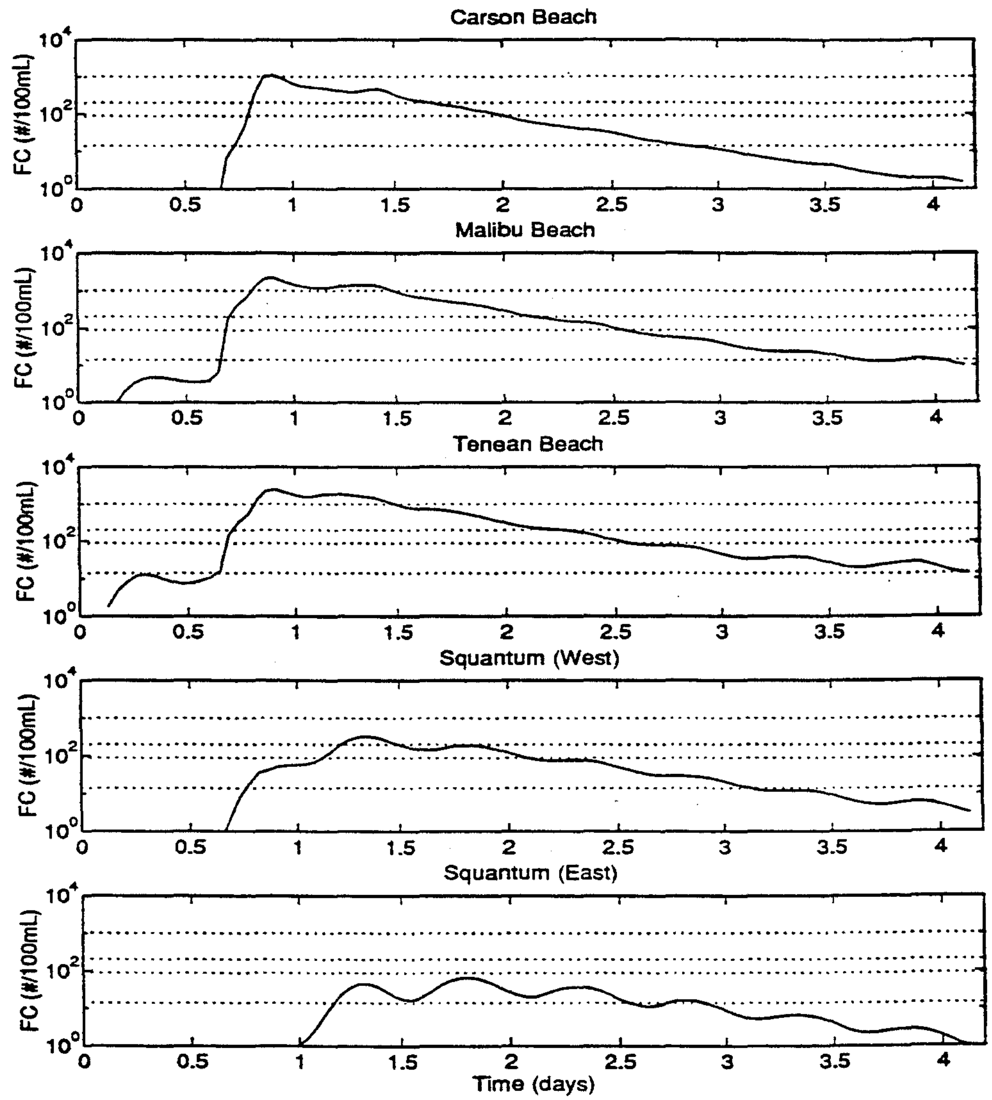


Fig. E.7b3 Simulated Harbor Fecal Coliform Counts versus Time at Seventeen Locations–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

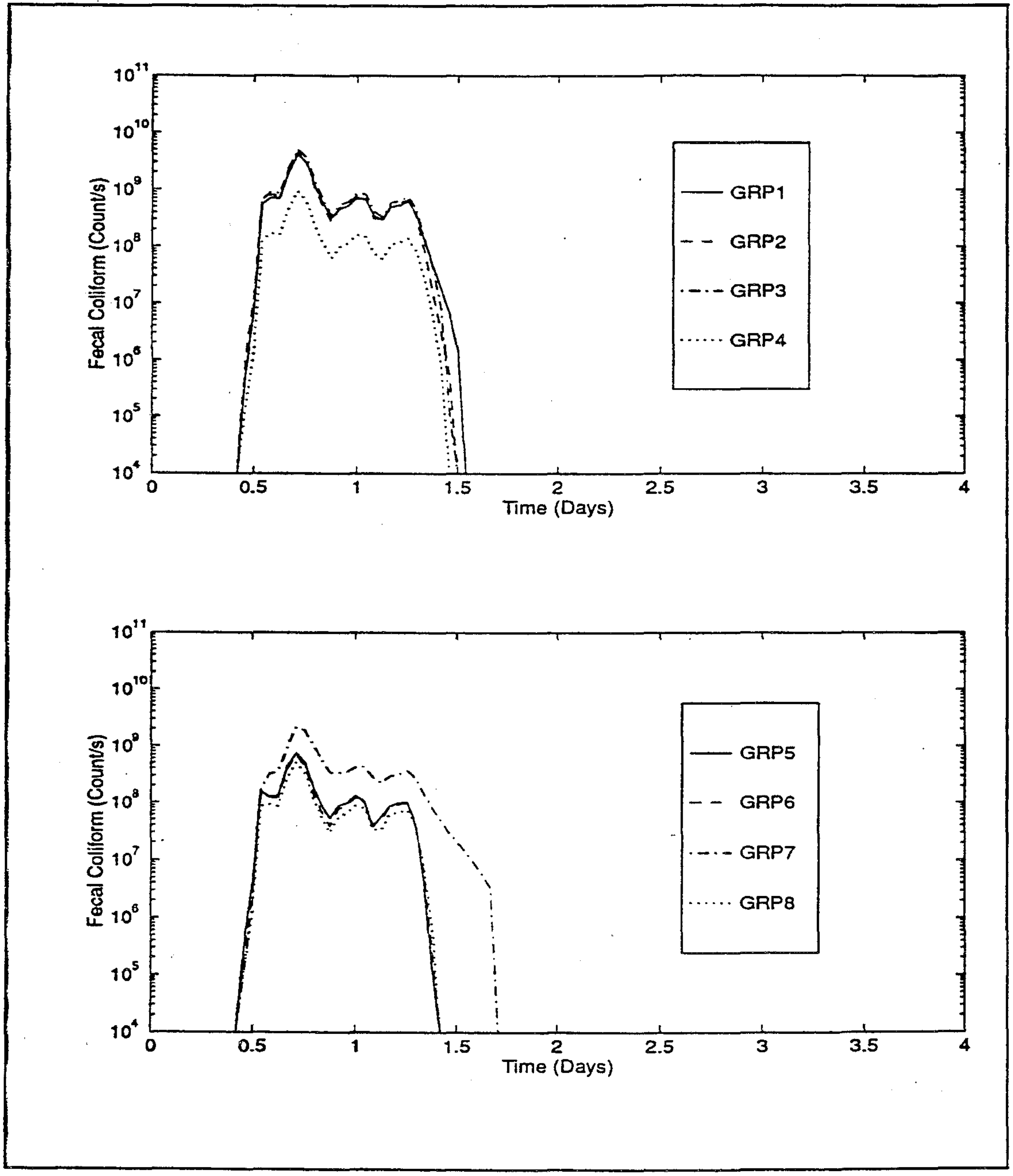


Fig. E.7c1 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

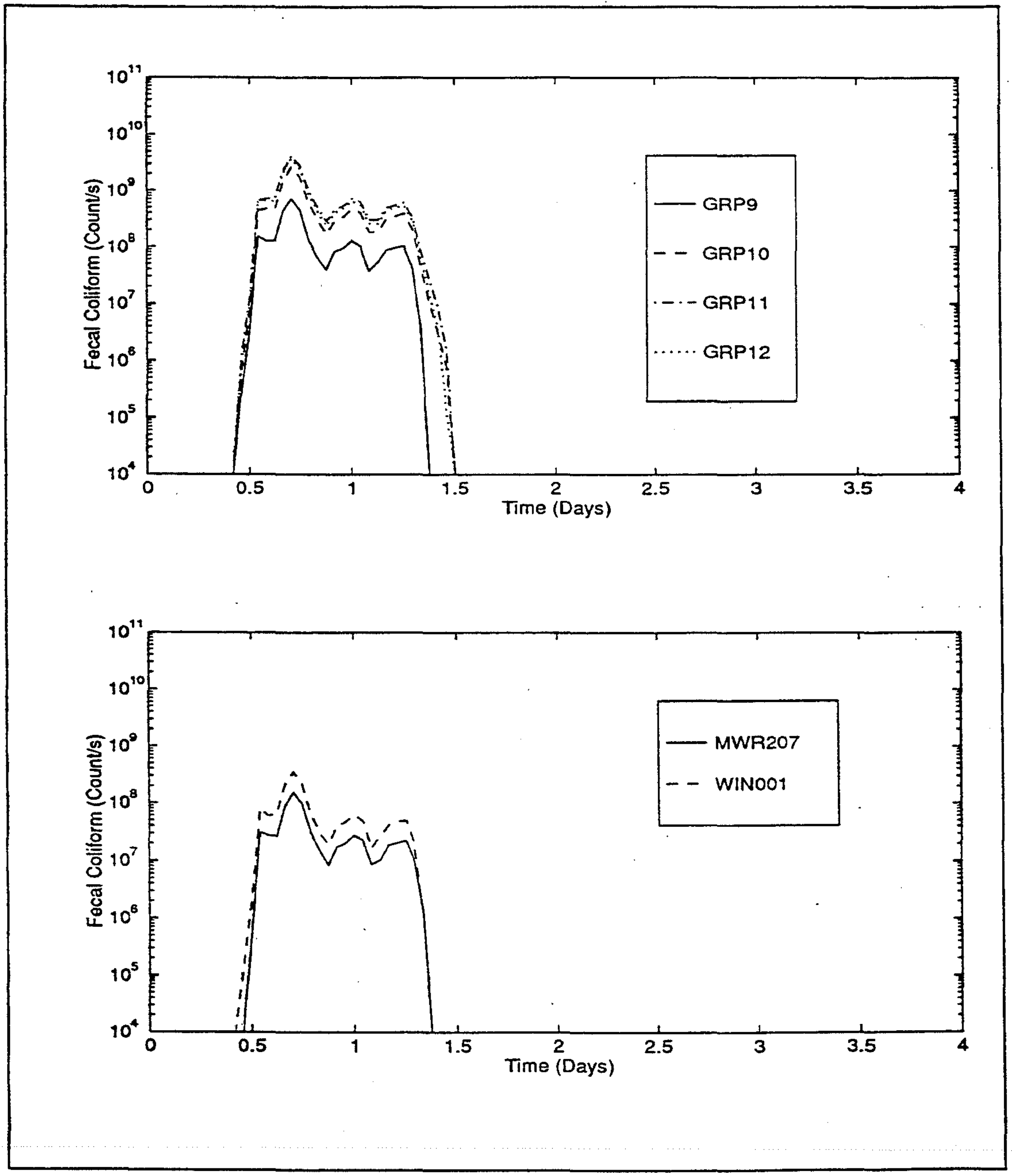


Fig. E.7c2 Harbor Fecal Coliform Loadings versus Time for Each Source–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.

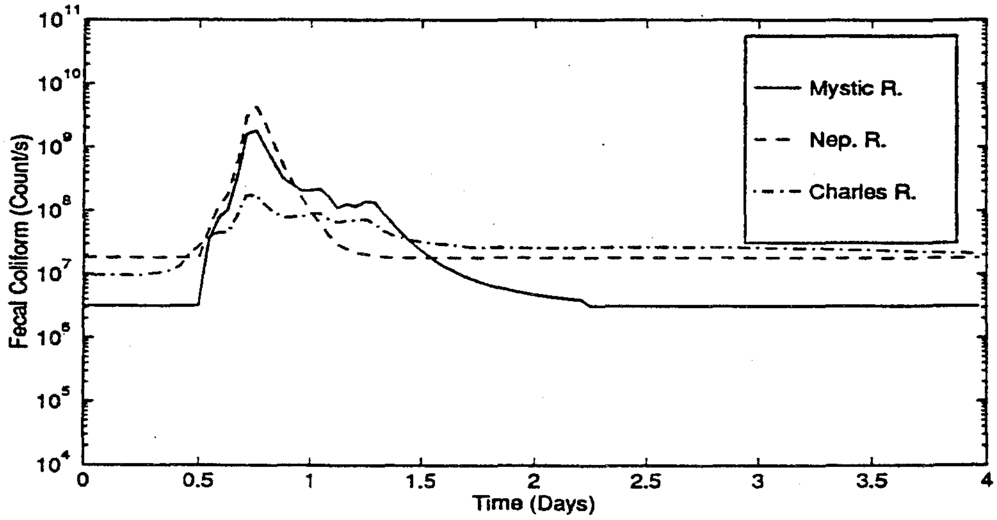


Fig. E.7c3 Harbor Fecal Coliform Psfiles/Loadings versus Time for Each Source–Run 7: Future planned conditions, 1-year design storm, non-CSO sources only.