Boston Harbor Wastewater Conveyance System

Volume I
Draft Supplemental Environmental Impact Statement

United States Environmental Protection Agency
Region I
J.F.K. Federal Building
Boston, Massachusetts 02203
1988

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Draft Supplemental Environmental Impact Statement

Prepared by:

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1988

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4/1/88

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Regional Administrator,
U.S. EPA, Region I

This Draft Supplemental Environmental Impact Statement (SEIS) has been prepared by the U.S. Environmental Protection Agency (EPA) with assistance from the U.S. Army Corps of Engineers. This Draft SEIS identifies and evaluates the environmental impacts of the wastewater conveyance system for Greater Boston's wastewater treatment facility in compliance with Federal and State water pollution control laws.

DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

PROPOSED ACTION:	SITING AND EVALUATION OF CONSTRUCTION METHODS FOR WASTEWATER CONVEYANCE SYSTEM FOR SECONDARY TREATMENT PLANT, BOSTON HARBOR
LOCATION:	BOSTON, MASSACHUSETTS
DATE:	APRIL 1988
SUMMARY OF ACTION:	Draft SEIS considers the environmental acceptability of alternative locations for the wastewater conveyance and outfall systems of the new wastewater treatment facilities for Boston Harbor. The Draft SEIS recommends deep rock tunnels for the inter-island and outfall conduits and a diffuser located at least seven miles east of Deer Island.
VOLUMES:	I. SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT II. APPENDICES
LEAD AGENCY:	U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION I JFK Federal Building, Boston, Massachusetts 02203
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FINAL DATE BY WHICH COMMENTS MUST BE RECEIVED:	May 16, 1988

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Boston Harbor, a valuable regional resource, is being degraded by the discharge of wastewater from 43 cities and towns served by the Massachusetts Water Resources Authority (MWRA) sewerage system. During an average day of operation, MWRA's two existing wastewater treatment plants discharge 450 million gallons of inadequately treated wastewater and 70 dry tons of digested sewage sludge into the harbor (USEPA, 1985b). To remedy this problem, a new wastewater treatment facility is being constructed on Deer Island. This Draft Supplemental Environmental Impact Statement (SEIS) describes the effects construction and operation of an inter-island wastewater conduit and an effluent outfall will have on the environment of Boston Harbor and Massachusetts Bay. The conduit and outfall are critical components of the treatment facilities needed to clean up Boston Harbor.

The rich natural resources of Boston Harbor attracted the attention of man more than 8,000 years ago. Early inhabitants of the area fished, hunted, and gathered shellfish and plants from the harbor and its rivers and estuaries (USEPA Vol. 2, 1984). These same resources, along with sheltered anchorages, attracted Europeans who sailed to the area to begin establishing permanent settlements around the harbor in 1625. Boston grew to become a major port city, trading and exporting fish and shellfish from the harbor and importing commercial goods from around the world.

Today, Boston Harbor covers roughly fifty square miles and supports a wide variety of commercial, recreational, and aesthetic resources. Shellfish and lobster are harvested in the harbor, shoreline parks and beaches provide recreation, commercial shipping facilities handle thousands of vessels per year, and the harbor provides opportunities for boating and panoramic views from downtown Boston and shoreline communities. The Boston Harbor Islands are easily accessible from the city and offer uncrowded parks, historic sites, and natural areas.

The resources of the harbor are seriously endangered by pollution. The wastewater treatment plants, more than 100 combined sewer overflows (CSOs), direct runoff and river discharges from over 322 square miles of urban and suburban lands, discharges from commercial and pleasure boats, oil terminals, and contaminated sediments all pollute Boston Harbor (USEPA Vol. 1, 1984). Pollution results in beach closings when bacteria levels in the water threaten the health of bathers. Flounder and shellfish are contaminated. Excrement and plastic objects from the sewerage system wash up at beaches and parks. Odors and floating wastes detract from the beauty and health of the harbor.

The construction of a new secondary wastewater treatment plant on Deer Island is a critical step in cleaning up Boston Harbor. The new treatment facilities will alleviate a considerable amount of harbor pollution by replacing the two existing, outdated treatment plants, by providing adequate treatment of wastewater, and by eliminating the discharge of sewage sludge into Boston Harbor and Massachusetts Bay (USEPA, Vol. 1 and 2, 1984).

Two key components of the treatment facilities which must be constructed are an inter-island conduit to carry sewage to the new treatment facility, and an outfall to carry treated effluent from the facility for discharge. The inter-island conduit, which will run from the site of the existing Nut Island treatment plant to Deer Island, must be constructed to convey wastewater from the southern portion of the sewerage district to the new treatment plant. The effluent outfall will be constructed from the new treatment plant to a location in Broad Sound east of Deer Island where a diffuser system will disperse treated wastewater into the ocean.

This Draft SEIS evaluates the effects of constructing and operating the proposed inter-island conduit and effluent outfall. It is termed supplemental because it supplements an earlier EIS which focused on treatment plant siting (USEPA 1985). The evaluation described in this document considers various conduit and outfall locations and construction methods, and evaluates the impacts of transporting construction materials and personnel, disposal or reuse of excavated materials from construction, and discharge of effluent to the marine environment.

1.2 HISTORY OF THE PROJECT

Boston's wastewater has been collected and discharged into the harbor since 1885 when the construction of the Main Drainage Works was completed. Construction of the works was undertaken because sewage was being discharged through privately owned drain pipes to shallow areas of the harbor and rivers, causing serious health problems (Sundstrom, 1983). The original system drained wastewater and stormwater from Boston to holding tanks on Moon Island and discharged untreated wastes to the harbor on the outgoing tide.

The Main Drainage Works was expanded over time to eventually provide service to what is now the MWRA Service Area. Discharge of untreated wastewater to the harbor continued until the construction of the primary sewage treatment plants on Nut Island in 1952 and Deer Island in 1968 (MDC, 1976). These treatment plants provide primary wastewater treatment and discharge disinfected effluent and digested sewage sludge to Boston Harbor. The Federal Clean Water Act, passed in 1972, requires secondary sewage treatment and bans most ocean dumping of sewage sludge.

Studies considering the construction of new secondary wastewater treatment facilities began in 1973 when the Metropolitan District Commission (MDC), the agency charged with responsibility for sewage disposal before the creation of MWRA, commissioned the Wastewater Engineering and Management Plan for Boston Harbor/Eastern Massachusetts Metropolitan Area (EMMA Study) (MDC, 1976). The principal recommendations of the EMMA Study were to upgrade the Nut Island and Deer Island treatment plants to secondary treatment, to dispose of sludge by incineration, to eliminate CSOs, to build additional advanced treatment plants on the Charles and Neponset Rivers and to extend and improve the interceptor system. None of these recommendations were implemented by MDC.

EPA issued a Draft Environmental Impact Statement (DEIS) in 1978 which concluded that some of the EMMA Study recommendations were not suitable (USEPA, 1978). The DEIS recommended that all wastewater be treated at a new secondary treatment facility at Deer Island and discharged to Boston Harbor. Sludge disposal through a combination of incineration and landfilling was also recommended, and construction of any other treatment plants was not recommended.

The recommendations of the DEIS caused controversy and negative public comment. At the same time, changes to the Federal Clean Water Act in 1977 included provisions for a waiver of the requirement for secondary wastewater treatment (USEPA Vol 2. 1984). If deemed acceptable by EPA, waivers of secondary treatment requirements were granted for five year periods, and were potentially renewable. The law required that planning for upgrading to secondary treatment had to proceed or be in place if a waiver was not renewed for any five year period.

The controversy surrounding the DEIS and the changes to the Clean Water Act prompted EPA and MDC to reach an agreement that planning for new treatment facilities should proceed in a flexible, segmented fashion to accelerate harbor cleanup by allowing immediate upgrading actions while providing sequential decision-making on an overall harbor clean-up program (USEPA Vol 2. 1984).

MDC filed an application for a waiver of secondary treatment in 1979 (MDC, 1979) and submitted additional application information in 1982. This waiver was tentatively denied by EPA in 1983. An amended waiver application was filed by MDC in 1984 and was denied by EPA in March 1985.

While the initial waiver application was being prepared, planning for wastewater treatment facility upgrading proceeded simultaneously. The first result of this planning was a site options study published by MDC in 1982 (MDC, 1982). The study found that primary treatment at both Nut Island and Deer Island could be an environmentally sound and economically preferable option. Denials of waiver applications by EPA countermanded this finding.

In 1983, EPA and the Commonwealth of Massachusetts began working jointly on an SDEIS to further evaluate and site new treatment facilities on Boston Harbor. The SDEIS (USEPA Vol.1&2, 1984) also served as an Environmental Impact Report to satisfy the requirements of the Massachusetts Environmental Policy Act (MEPA). The SDEIS considered twenty-two treatment site alternatives and selected seven for final evaluation. All of the seven final siting alternatives involved Deer Island, Long Island, and Nut Island, either separately or in combination.

On July 1, 1985, the Massachusetts Water Resources Authority (MWRA) was created by an act of the Massachusetts legislature to take over the sewer and water operations of the MDC. Following extensive public review and comment on the SDEIS, EPA produced a final environmental impact statement (FEIS) (US EPA, 1985b). The FEIS recommended that a secondary treatment facility be constructed on Deer Island and also found that a secondary treatment facility on Long Island or a facility split between Deer and Long Islands would be environmentally acceptable. The FEIS also outlined mandatory mitigation actions required for construction and operation of the treatment facilities.

At the same time, the newly-created MWRA reviewed the SDEIS and produced a final environmental impact report (FEIR) (MWRA, 1985). The FEIR selected Deer Island as the tentative preferred alternative site for a treatment plant. The FEIR and the FEIS had been prepared through cooperative efforts between EPA and MWRA, and both benefitted from a high degree of public and agency input. A number of factors, including outfall location and residuals management, were regarded to not be determinative to treatment plant siting.

Following joint public hearings on the FEIS and FEIR, MWRA made a final selection of Deer Island as the treatment plant site on February 3, 1986 and EPA issued a Record of Decision (ROD) supporting that selection on February 28, 1986. The ROD states that the siting of a treatment facility on Deer Island is EPA's preferred alternative, provided that the mitigation measures outlined in the FEIS are followed. MWRA has formally committed to enacting a series of mitigation measures.

The ROD also concluded that a number of project components, including the water quality and construction impacts of an effluent discharge outfall, and the construction of an under-harbor conduit to convey sewage to the new treatment plant would require additional environmental review. This Draft SEIS performs the required additional review for the inter-island conduit and the effluent outfall. Two sets of MWRA planning documents also deal with these topics. The Deer Island Secondary Treatment Facilities Plan (7 volumes plus appendices) details the alternative designs, construction methods, locations, and impacts of the treatment plant, inter-island conduit, and effluent outfall. The Water Transportation Facilities Plan (10 volumes) deals with the transportation of workers and materials for construction and operation of the treatment plant, inter-island conduit, and outfall, and the impacts of these activities (see references for complete volume and appendix titles).

This Draft SEIS and the MWRA facilities plans were produced through a cooperative effort of EPA and MWRA, sharing common data. The MWRA facilities plans fulfill the requirements for an Environmental Impact Report (EIR) under the Massachusetts Environmental Policy Act (MEPA). This Draft SEIS fulfills Federal environmental review requirements under the National Environmental Policy Act (NEPA) and the Federal Water Pollution Control Act Construction Grants Program. Both documents use as their basis data from the MWRA facilities planning efforts. While avoiding duplication of effort in data gathering, the independent analysis and public review of the Facilities Plan/EIR and the Draft SEIS provides exhaustive review of impacts, and an opportunity to tailor each document to precisely fit the regulatory requirements it seeks to fulfill (MEPA or NEPA).

The ROD also required additional environmental review of residuals (sludge) management and disposal, the construction of piers and staging areas for materials and workers needed to build the treatment plant, the disposal of earthen or dredged materials from construction, the transport and storage of chlorine, and projects to upgrade CSOs, all of which were not considered determinative for treatment plant location. These issues are the specific subjects of separate studies by MWRA and EPA. Since these issues, to a varying degree, are related to the construction and operation of the inter-island conduit and the effluent outfall, they are generally considered where applicable in this EIS.

Since 1982, when the City of Quincy filed suit against MDC charging negligence in operating its treatment plants, litigation has been a part of the effort to halt harbor pollution. Additional lawsuits by citizen groups, cities and towns, and EPA resulted in an aggressive schedule for construction of new treatment facilities being mandated by the Federal District Court. Actions to construct the facilities necessary for harbor cleanup are driven by this schedule, and the Court regularly reviews progress. Major deadlines of this schedule are:

• Initiate construction of new primary treatment facilities	12/90
• Complete construction and commence operation of new primary treatment facilities	7/95
• Initiate construction of outfall	7/91
• Complete construction of outfall	7/94
• Initiate construction of inter-island wastewater conveyance system	4/91
• Complete construction of inter-island wastewater conveyance system	4/94
• Initiate construction of secondary treatment facilities	during 1995
• Complete construction of secondary treatment facilities	during 1999

1.3 DRAFT SEIS FORMAT

Scoping is normally the first step in preparing an EIS or SEIS. Scoping identifies the issues of importance regarding the proposed action. In the case of this Draft SEIS, extensive prior knowledge of the issues surrounding the construction and operation of the inter-island conduit and the effluent outfall was gained through the preparation of the draft and final EISs on treatment plant siting. The siting EIS process generally considered the impacts of conduit and outfall construction, and public comment on these impacts was sought as part of that process (USEPA Vol.1&2, 1984; USEPA, 1985b). Formal scoping sessions for this Draft SEIS were held in December 1986 (Chapter 9). This Draft SEIS, using the issues identified during the siting process and scoping sessions, develops, analyzes, and evaluates conduit and outfall alternatives.

This Draft SEIS consists of:

- An Executive Summary.
- Chapter 1 providing an introduction, background, and project history.
- Chapter 2 outlining the need for the project and describes the planned actions.
- Chapter 3 explaining outfall siting alternatives, outfall and inter-island conduit construction method options and the screening process used to narrow the field of siting alternatives and construction method options.
- Chapter 4 describing the natural and man-made environment affected by the project.

- Chapter 5 describing the environmental consequences of each option surviving screening.
- Chapter 6 providing a description of the cumulative impacts for this and other projects occurring in the project area.
- Chapter 7 comparing the alternatives surviving screening and recommending an effluent outfall site, diffuser design, and effluent and inter-island conveyance construction methods.
- Chapter 8 listing preparers of this document.
- Chapter 9 summarizing public participation.
- References, and an Index, Glossary, and a list of acronyms follow the text.
- The following technical appendices are published in a separate volume:

  A. Physical Oceanography and Water Quality
  B. Marine Geology and Sediment Deposition
  C. Marine Ecosystems
  D. Harbor Resources
  E. Economic Impacts
  F. Screening and Development of Alternatives
  G. Regulatory Conditions
  H. Operational Reliability

CHAPTER 2

PURPOSE AND NEED FOR ACTION

2.1 EXISTING CONDITIONS

Boston Harbor is about 50 square miles in area, the largest harbor serving a major east coast metropolitan area. Its significant national historical prominence, natural resources, and recreational opportunities are threatened by pollution from malfunctioning and overloaded wastewater treatment plants serving eastern Massachusetts at Deer Island and Nut Island.

A detailed description of pollution associated with the Boston Harbor region's wastewater treatment can be found in EPA's treatment plant siting SDEIS (USEPA, Vol. 1, 1984). Effluent and sludge discharges from Deer and Nut Island treatment plants represent over half of the suspended solids and oxygen-consuming matter entering Boston Harbor (USEPA, Vol. 1, 1984). In absolute terms, 135 tons of effluent solids and approximately 70 tons of digested sludge solids are discharged to the harbor daily. Raw wastewater bypassing the harbor treatment facilities in violation of federal and state water pollution control laws puts additional stress on marine life and results in closed beaches and shellfish beds close to the outfall discharges. Therefore, not only has inadequate treatment polluted the harbor but the locations of the Deer and Nut Island outfalls, several of which were built at the turn of the century, have exacerbated the problem.

The siting EIS Record of Decision (ROD) is EPA's final decision on the preferred location of Secondary Wastewater Treatment facilities for Boston Harbor. The ROD responds to MWRA's siting decision and comments on the FEIS. The ROD (USEPA 1986c), in addition to determining that the cleanup of Boston Harbor is best served by consolidation of influent flows to a new secondary wastewater treatment plant at Deer Island, also directed additional environmental review on two necessary elements of a this plan: "the construction of an under-harbor tunnel or pipeline to transport wastewater to the treatment plant" and the construction of "an outfall pipe or pipes through which effluent will be discharged".

This Draft SEIS provides the environmental review for these elements. The under-harbor wastewater conduit is needed to connect Nut Island to Deer Island so that all MWRA sewage will flow to Deer Island and receive secondary treatment. The new outfall is needed to replace the existing outfalls previously discussed to increase capacity and provide a new route to transport and disperse the treated effluent out of Boston Harbor to Massachusetts Bay.

These improvements are part of the overall system improvements which will provide a two-thirds reduction in sewerage solids discharged to Boston Harbor when the entire new treatment system is operational in the year 2000 (USEPA, Vol. 1, 1984). Public benefits include improvements in aesthetics, recreation, public health, and commerce to all those who use the harbor and its shoreline.

Reductions in pollution loadings and cessation of sewage sludge discharge will result in substantial improvements in water quality in the harbor. Immediate effects of improved water quality would improve the recreational value of the harbor by reducing beach closings due to pollution and improving aesthetics throughout the harbor. Over the long term, the biota of the harbor will respond to improved water quality. Finfish and shellfish resources will likely improve in quality, producing greater opportunities for commercial and recreational fishing and reducing the potential for public health risk through ingestion. Such sensitive resources as saltmarsh areas, submerged vegetation, and protected areas will benefit when improved water quality reduces stress on these sensitive systems. Economic benefits derived from water quality improvement include increased value of commercial fisheries, and increased value of recreational activities and such associated services as sightseeing and whale watch cruises, and recreational fishing charters and party fishing boats.

2.2 PROPOSED ACTION

The Proposed Action consists of the following three elements:

- Construction and operation of an effluent diffuser in Massachusetts Bay which provides dispersion of the effluent into the marine environment outside of Boston Harbor;

- Construction and operation of an outfall conduit to transport treated effluent from Deer Island to the diffuser site; and

- Construction and operation of a conduit delivering South System flows from Nut Island to the Deer Island Wastewater Treatment Plant to effect consolidation of wastewater treatment for the entire MWRA service area.

CHAPTER 3

PRINCIPAL ALTERNATIVES: SCREENING AND DESIGN

The purpose of this chapter is to present the selection of the discharge location, outfall and inter-island conduit construction and diffuser configuration alternatives to be evaluated in detail in Chapter 5 of this Draft SEIS. To narrow the alternatives, screening criteria were identified and applied to a full range of options. Following this screening process, options still acceptable were selected as alternatives for detailed evaluation. This chapter summarizes the screening process while Appendix F of this Draft SEIS presents it in detail.

Analyses conducted by MWRA (MWRA, STPF IV and V, 1987) were considered adequate for the screening level analyses of this process. Separate analyses were conducted in Chapter 5 of this Draft SEIS for alternatives selected for detailed evaluation.

3.1 DEFINITION OF "NO ACTION"

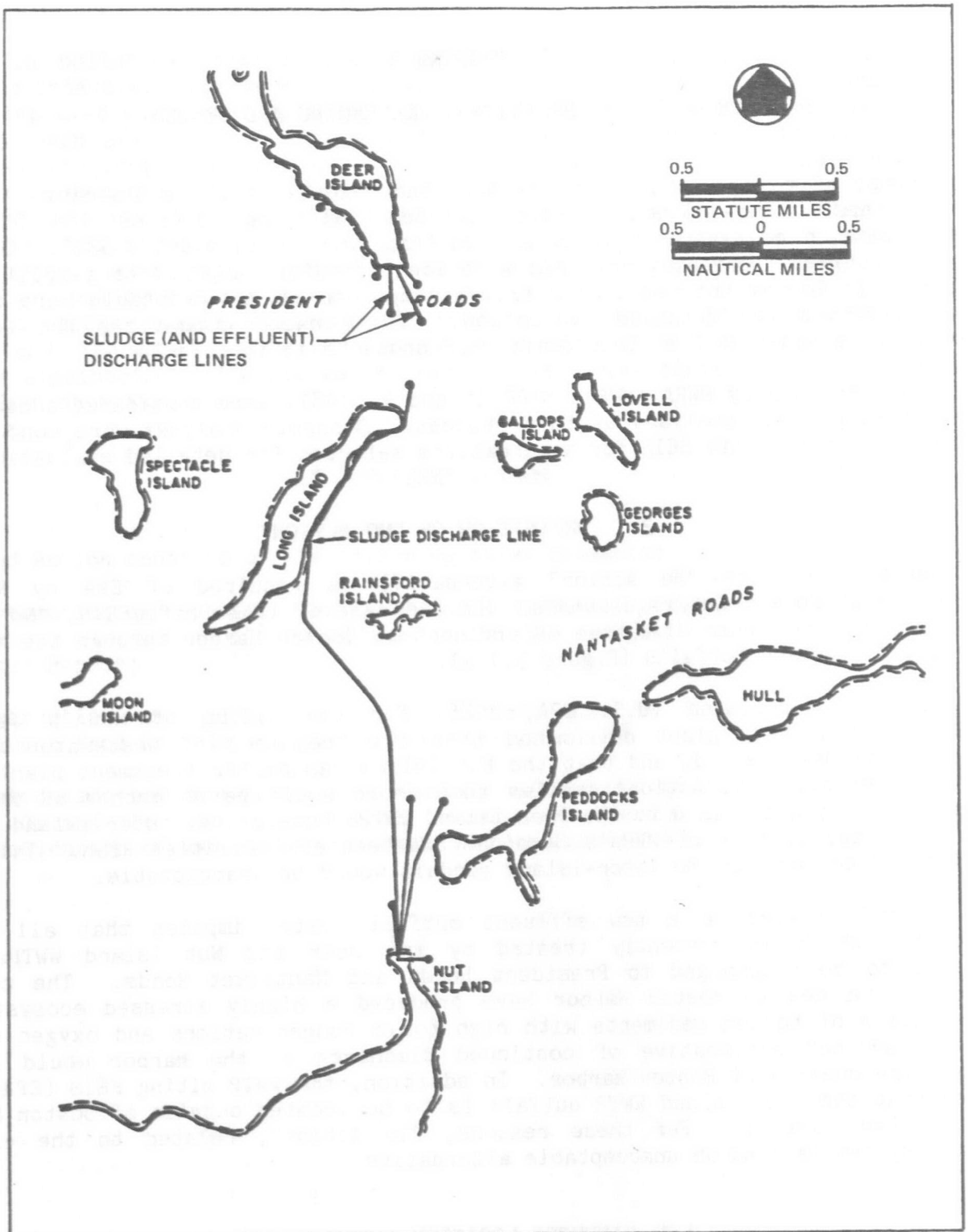
Consideration of the "No Action" alternative is required of EPA by National Environmental Policy Act regulations. In the case of this Draft SEIS, "No Action" refers to the continued discharge of effluent to Boston Harbor through the existing Deer and Nut Island outfalls (Figure 3.1.a).

The Record of Decision (U.S. EPA, 1986) for the siting of MWRA's secondary wastewater treatment plant determined that all treatment of wastewater will be conducted on Deer Island, and that the Nut Island wastewater treatment plant (WWTP) will be removed. "No Action" implies that there would be no method of conveying wastewater from Nut Island to the Deer Island WWTP, however, an inter-island conduit is a necessary feature of MWRA's Secondary Wastewater Facilities Plan. Therefore, "No Action" concerning the inter-island conduit would be unacceptable.

"No Action" related to a new effluent outfall system implies that all of the wastewater which is currently treated by the Deer and Nut Island WWTPs would continue to be discharged to President Roads and Nantasket Roads. The numerous pollution sources to Boston Harbor have produced a highly stressed ecosystem and accumulation of bottom sediments with high toxic concentrations and oxygen demand. The "No Action" alternative of continued discharge to the harbor would further degrade the quality of Boston Harbor. In addition, the WWTP siting FEIS (EPA, 1985) stated that the Deer Island WWTP outfall is to be located outside of Boston Harbor, east of Deer Island. For these reasons, "No Action", related to the effluent outfall system is also an unacceptable alternative.

3.2 DIFFUSER LOCATION ALTERNATIVES

Completion of the EIS for siting of wastewater treatment facilities for Boston Harbor resulted in a decision to build a secondary facility at Deer Island and discharge the effluent east of Deer Island (EPA, 1985). It was concluded that



SOURCE: MWRA STFP V, 1987

FIGURE 3.1.a. EXISTING EFFLUENT AND SLUDGE DISCHARGE LOCATIONS OF THE DEER AND NUT ISLAND WASTEWATER TREATMENT PLANTS

actual designation of the discharge site was not necessary for the determination of the plant location. The EIS did not consider alternative discharge locations but concluded that an acceptable site for discharge of secondary effluent could be designated. The development of alternative locations, evaluation of the alternatives and designation of a recommended discharge site was to be part of the continued NEPA process represented by this Draft SEIS.

3.2.1 SCREENING PROCESS

The screening process began with the entire study area of the marine environment east of Deer Island as defined in the siting FEIS (EPA, 1985). The ability to receive secondary effluent was used to establish the potentially acceptable discharge sites for detailed evaluation since, with the exception of approximately the first five years of operation, the diffuser will discharge secondary effluent. Sites selected for detailed evaluation were analyzed for both primary and secondary effluent discharges in Chapter 5 and Appendices A, B, C and D of this Draft SEIS. This analysis was conducted to determine whether the five-year interim primary effluent discharge should continue at the existing location in Presidents Roads (Site PR) or be relocated to one of the alternative discharge sites (Site 2, 4 or 5). Every step in the screening process had the potential for being iterative. If analyses at any step during screening or detailed evaluation (Chapter 5) contradicted conclusions made during this screening process, then the process would have been repeated.

3.2.1.1 Landward Boundary: Identification of Screening Criteria

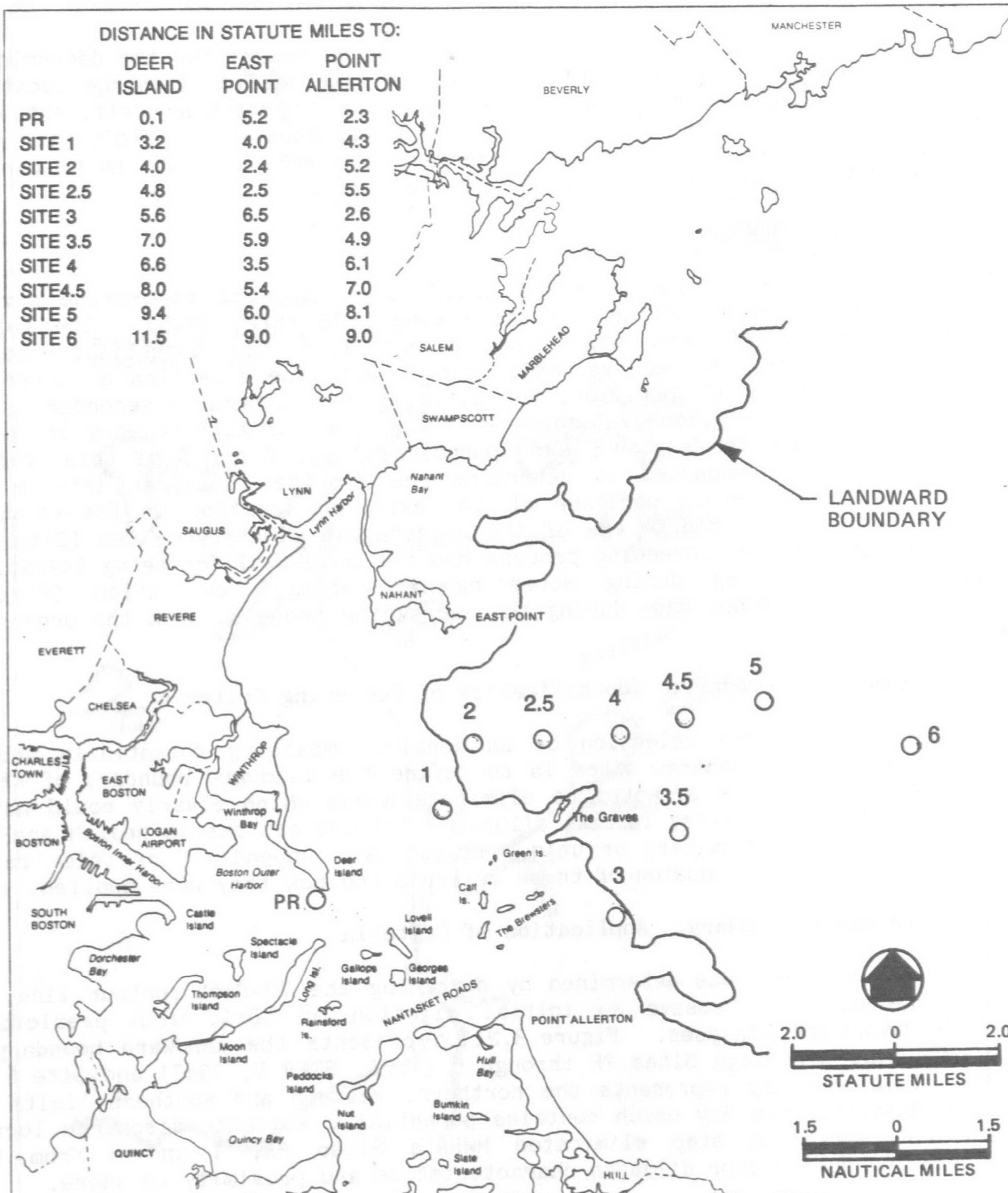
The first step in the selection of an area encompassing potentially acceptable secondary effluent discharge sites is to define the landward boundary of the area. Screening criteria were selected to eliminate areas which clearly could not: (1) provide a minimum specified initial dilution, (2) protect public health and aquatic life, or (3) avoid sensitive or unique resources. Appendix F of this Draft SEIS presents a detailed discussion of these criteria and how they were applied.

3.2.1.2 Landward Boundary: Application of Criteria

The landward boundary was determined by combining the 70-foot contour line, within which effluent will receive an initial dilution of 50:1, with predictions of particle transport analyses. Figure 3.2.1.a presents the landward boundary along with potential discharge Sites PR through 5 (MWRA, STFP V, 1987) and Site 6 (SWIM, 1987). This boundary represents the northern, western and southern limits of the area in Massachusetts Bay which contains potentially suitable discharge locations. This first screening step eliminated MWRA's Sites PR, 1 and 3 from further consideration due to poor dilution characteristics and proximity to shore.

3.2.1.3 Eastern Boundary: Identification of Screening Criteria

The objective of the second secondary effluent site screening step is to define the eastern or offshore boundary of the area encompassing potentially suitable discharge locations. Once established, the eastern boundary can be used with the landward boundary to define the entire area containing potential discharge locations.



	DEER ISLAND	EAST POINT	POINT ALLERTON
PR	0.1	5.2	2.3
SITE 1	3.2	4.0	4.3
SITE 2	4.0	2.4	5.2
SITE 2.5	4.8	2.5	5.5
SITE 3	5.6	6.5	2.6
SITE 3.5	7.0	5.9	4.9
SITE 4	6.6	3.5	6.1
SITE4.5	8.0	5.4	7.0
SITE 5	9.4	6.0	8.1
SITE 6	11.5	9.0	9.0

FIGURE 3.2.1.a. LANDWARD BOUNDARY OF SECONDARY EFFLUENT DISCHARGE IN RELATION TO ALL DISCHARGE SITE OPTIONS

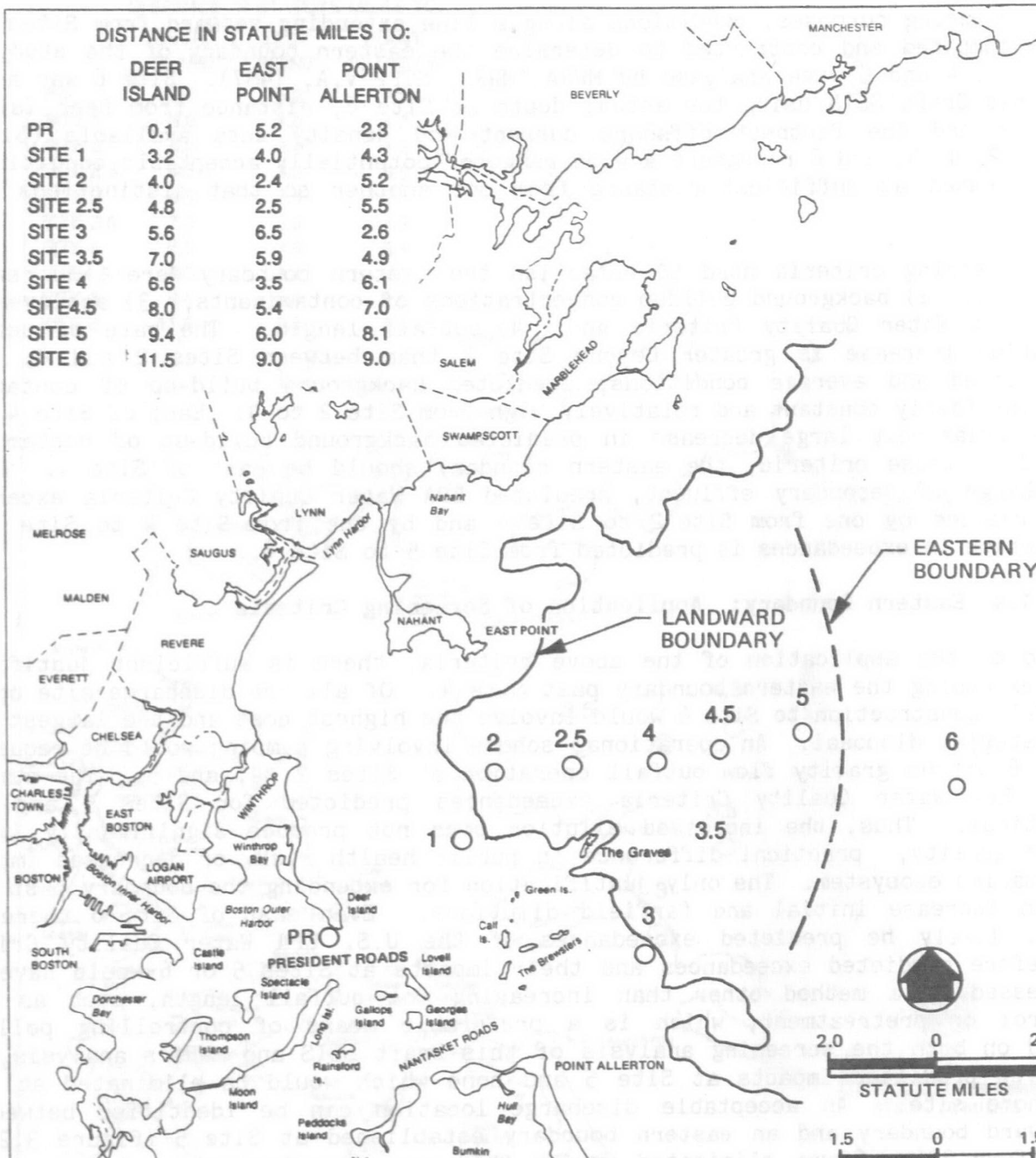
For screening purposes, conditions along a line extending seaward from Sites 2 to 6 were compared and contrasted to determine the eastern boundary of the study area. Sites 2, 4 and 5 were analyzed by MWRA (MWRA, STFP V,A, 1987). Site 6 was analyzed in this Draft SEIS using the actual depth at Site 6, distance from Deer Island to Site 6 and the farthest offshore current and density data available (Site 5). Sites 2, 4, 5, and 6 represent a wide range of potentially acceptable conditions and are located at sufficient distance from one another so that distinctions can be made.

The screening criteria used to establish the eastern boundary were: 1) nearfield dilution, 2) background buildup concentrations of contaminants, 3) achievement of U.S. EPA Water Quality Criteria and 4) outfall length. The rate of nearfield dilution increase is greater beyond Site 4 than between Sites 2 and 4. Under stratified and average conditions, predicted background build-up of contaminants remains fairly constant and relatively high from Site 2 to 4. East of Site 4, there is a relatively large decrease in predicted background build-up of contaminants. Based on these criteria, the eastern boundary should be east of Site 4. For the discharge of secondary effluent, predicted EPA Water Quality Criteria exceedances are reduced by one from Site 2 to Site 4 and by one from Site 4 to Site 5. No reduction in exceedances is predicted from Site 5 to Site 6.

3.2.1.4 Eastern Boundary: Application of Screening Criteria

Based on the application of the above criteria, there is sufficient justification for extending the eastern boundary past Site 4. Of all the discharge site options, outfall construction to Site 6 would involve the highest cost and the largest amount of material disposal. An operational scheme involving pumping would be required at Site 6 versus gravity flow outfall operation at Sites 2, 4, and 5. The number of U.S. EPA Water Quality Criteria exceedances predicted for Sites 5 and 6 are identical. Thus, the increased dilution does not produce significantly improved water quality, practical difference in public health risk, or decreased impact on the marine ecosystem. The only justification for extending the boundary past Site 5 is to increase initial and farfield dilutions. Even east of Site 6 there would still likely be predicted exceedances of the U.S. EPA Water Quality Criteria. Therefore predicted exceedances and their impacts at Sites 5 or 6 would have to be addressed by a method other than increasing the outfall length, such as source control or pretreatment, which is a preferable means of controlling pollution. Based on both the screening analysis of this Draft SEIS and MWRA's analysis, there are few predicted impacts at Site 5 and none which would be eliminated at a more offshore site. An acceptable discharge location can be identified between the landward boundary and an eastern boundary established at Site 5 (Figure 3.2.1.b). Therefore, Site 6 was eliminated during this screening analysis. A more detailed presentation of this analysis is included in Appendix F.

If the discharge site was based exclusively on achieving U.S. EPA Water Quality Criteria, the discharge site could be identified much farther from Deer Island than the sites investigated. Since east of Site 6 there would still likely be predicted exceedances of the U.S. EPA Water Quality Criteria, then predicted exceedances will have to be addressed by a method other than increasing the outfall length, such as source control or pretreatment, where are preferable means of controlling pollution.



DISTANCE IN STATUTE MILES TO:

	DEER ISLAND	EAST POINT	POINT ALLERTON
PR	0.1	5.2	2.3
SITE 1	3.2	4.0	4.3
SITE 2	4.0	2.4	5.2
SITE 2.5	4.8	2.5	5.5
SITE 3	5.6	6.5	2.6
SITE 3.5	7.0	5.9	4.9
SITE 4	6.6	3.5	6.1
SITE4.5	8.0	5.4	7.0
SITE 5	9.4	6.0	8.1
SITE 6	11.5	9.0	9.0

FIGURE 3.2.1.b. AREA OF POTENTIALLY ACCEPTABLE SECONDARY EFFLUENT DISCHARGE LOCATIONS

3.2.1.5 Final Site Screening Step: Alternative Discharge Locations

The goal of the final site screening step is to identify locations within the area defined during the previous steps for detailed evaluation and comparison. One objective is to ensure that the range of physical oceanographic, geologic, biologic and water quality conditions are represented by the alternative locations. Another important objective is to establish alternative discharge locations which differ enough to permit meaningful comparisons. Sites which were investigated by MWRA (MWRA, STFP V,A, 1987) and which also passed the first screening steps were reviewed. If discharge locations met the two objectives discussed above, they was selected for detailed evaluation.

Sites investigated by MWRA within the area of potential suitability outfall locations include Sites 2, 2.5, 3.5, 4, 4.5 and 5. The extremes in range of conditions within the area are represented at Sites 2 and 5. Therefore, these two sites will be among those evaluated in detail. There is no large change in predicted dilution or water quality conditions between Sites 2 and 2.5. Since expected differences between these two stations are less acute than the sensitivity of the analytical tools, Site 2.5 was eliminated. Site 4 represents a distinct change in depth dilution and potentially other characteristics from both Sites 2 and 5. Therefore, it was chosen for detailed evaluation. Sites 3.5 and 4.5 fall within the range of oceanographic conditions represented by Sites 2,4 and 5. They provide no unique characteristics such as increased depth, distance from a resource, current regime or reduced construction costs. Therefore, they were not evaluated in detail.

Based on the three step screening process, the sites chosen for detailed evaluation were Sites 2, 4 and 5 (Figure 3.2.1.c) which represent a reasonable range of alternatives.

3.2.1.6 Interim Discharge Screening Location: Identification of Criteria

A necessary step in implementing the required Deer Island secondary wastewater treatment plant is to discharge primary effluent during the construction period of approximately five years. The goal of this screening is to determine the potentially acceptable locations of the five-year interim discharge of primary effluent. The existing Deer Island discharge site in President Roads (Site PR) was compared to the sites selected for detailed analysis in this Draft SEIS (Sites 2, 4 and 5) to determine if the primary effluent discharge at Site PR should continue or occur only at one of the three selected alternative discharge locations. The criteria used in this screening included: 1) achievement of U.S. EPA Water Quality Criteria, 2) compliance with Massachusetts Surface Water Quality Standards, 3) shoreline impacts of pollutants and 4) cumulative impacts.

3.2.1.7 Interim Discharge Screening: Application of Criteria

It is clear that discharge of effluent at President Roads should be discontinued once the new effluent outfall system is constructed (Appendix F). Discharging primary effluent at Sites 2, 4 or 5 rather than at Site PR would offer the benefits of increased achievement of water quality criteria at the edge of the mixing zone; decreased percentages of effluent at the shorelines of Winthrop, Hull and Nahant;

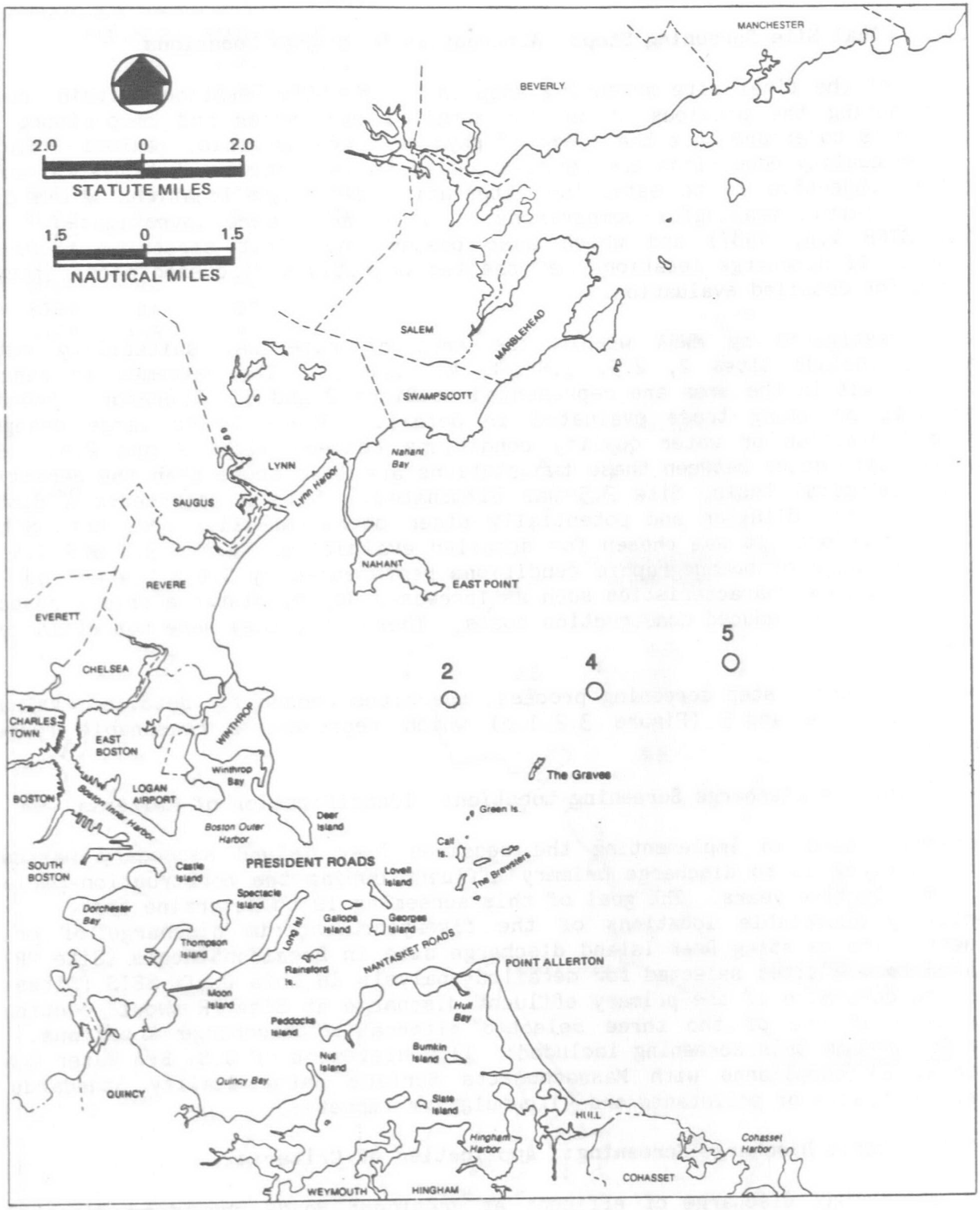


FIGURE 3.2.1.c. ALTERNATIVE DISCHARGE LOCATIONS

increased compliance with the state dissolved oxygen concentration standard; and less chance of further stressing the Boston Harbor ecosystem. Therefore, discharge of primary effluent to President Roads during the five-year interim period is eliminated from further consideration. Discharge of primary effluent for the five-year interim period is evaluated for Sites 2, 4 and 5 in this Draft SEIS.

3.2.2 DESCRIPTION OF DISCHARGE LOCATION ALTERNATIVES FOR DETAILED EVALUATION

Sites chosen for further evaluation are Sites 2, 4 and 5 (Table 3.2.2.a). Although the alternative discharge locations are called "sites", they also represent regions within Massachusetts Bay in which an outfall could be located. Since these sites are already known to the public and agencies by these names, this Draft SEIS retains these names.

3.2.3 CRITERIA FOR DETAILED EVALUATION

Alternative discharge sites were evaluated in detail in Chapter 5 and Appendices A, B, C and D using the criteria in Table 3.2.3.a. These criteria are discussed in further detail in Appendix F.

3.3 EFFLUENT CONVEYANCE MODE

3.3.1 SCREENING PROCESS

Effluent from the new Deer Island wastewater treatment plant will be transported by a submarine ocean outfall and discharged to a site in Massachusetts Bay. Three potential outfall systems were screened using a set of relevant criteria. The alternative(s) with the least predicted impacts was selected for detailed evaluation.

The three construction technologies for the effluent outfall conveyance systems proposed and evaluated by MWRA were marine pipeline, sunken tube and deep rock tunnel. These outfall construction technologies represent a reasonable range of alternatives and were screened in this Draft SEIS.

3.3.1.1 Identification of Screening Criteria

The criteria developed for screening the effluent outfall system include: 1) impacts on the marine ecosystem, 2) impacts on commercial and recreational resources, 3) disposal of dredged or tunnelled material, 4) constructability 5) institutional constraints and 6) cost.

3.3.1.2 Application of Screening Criteria

Based on the application of the above criteria (Appendix F), the deep rock tunnel construction alternative would have least impact on environmental quality and harbor resources, be most adaptable to future uses of the harbor, be easiest to construct, have the least institutional constraints, and be the least costly of the three effluent outfall alternatives (Table 3.3.1.a). Therefore, tunnel construction was the only alternative selected for further evaluation.

TABLE 3.2.2.a DESCRIPTIONS OF THE ALTERNATIVE DISCHARGE LOCATIONS

Site	Description	Water Depth (ft. MLW)	Distance From Deer Island (miles)	Distance From Nahant (miles)	Distance From Hull (miles)	Average Depth of Diffuser (feet)	Total Tunnel Length (feet)	Tunnel Inside Diameter (feet)	Total Construction Time (months)	Project Cost ($ Million)
2	Broad Sound	75	4.0	2.4	5.2	75	28,000	22	47	276
4	Broad Sound	90	6.6	3.6	6.1	90	43,000	24	51	389
5	Massachusetts Bay	100	9.4	6.0	8.1	100	54,000	25	56	468

Source: MWRA STFP V, 1987

TABLE 3.2.3.a CRITERIA FOR THE EVALUATION OF ALTERNATIVE DISCHARGE SITES

Criteria	Description	Measure
WATER QUALITY		
Ability to Meet EPA Aquatic Water Life Quality Criteria	Each alternative discharge site was evaluated to determine its ability to achieve EPA Aquatic Life Water Quality Criteria goals as defined in Quality Criteria for Water, U.S. Environmental Protection Agency, May 1, 1986, EPA 440/5-86-001.	Exceedances of EPA Aquatic Life Water Quality Criteria
Conformance with Mass Water Quality Standards	Alternative discharge locations were assessed based on the ability of both primary and secondary effluents to comply with Massachusetts Surface Water Quality Standards with emphasis on dissolved oxygen concentration.	Violations of Massachusetts Surface Water Quality Standards expected at each site
Impacts of Pollutants at Shoreline	Percentage of effluent pollutant concentrations at the shoreline were calculated for discharge at Sites 2, 4, and 5.	Predicted percentages at shoreline
SEDIMENT QUALITY		
Sediment Toxicity	The potential impacts on marine biota due to the the accumulation of toxics in sediment were assessed.	Toxic concentrations were assessed based on values found in literature
Sediment Enrichment	Impacts on benthic organisms due to organic loadings from the discharge were examined.	<0.1 gC/m^2/day = "No Noticeable Effect"; 0.1 to 1.5 gC/m^2/day = "Changed Benthic Communities"; >1.5 gC/m^2/day = "Degraded Benthic Communities"
MARINE ECOSYSTEMS		
Adverse Effects Due to Water Column Enrichment	Impacts due to nutrient enrichment of the water column will be assessed.	<0.14 mg/l = "No Effect"; 0.14 to 0.5 mg/l = "Changed"; >0.5 mg/l = "Degraded"

TABLE 3.2.3.a (Continued) CRITERIA FOR THE EVALUATION OF ALTERNATIVE DISCHARGE SITES

Criteria	Description	Measure
Safeguarding Protected Species from Habitat Modifications	The potential for adverse impacts on habitats of protected species was assessed.	Relative ratings of "Minor", "Moderate", "Extensive"
Avoidance of Sensitive and/or Important Habitat	The potential for affecting areas which would be highly susceptible to impacts of sewage discharge, including submerged vegetation and shellfish areas, was assessed.	Relative ratings of "Minor", "Moderate", "Extensive"
HARBOR RESOURCES		
Protection of Offshore Recreation and Aesthetics	The potential to protect recreation and aesthetics in the open waters and along the shorelines of Massachusetts Bay and to protect and restore recreation and aesthetics of the open waters and along the shoreline of Boston Harbor was assessed.	Relative ratings of "Minor", "Moderate", "Extensive"
Protection of Cultural and Historical Resources	The potential to protect areas of cultural or historical value was assessed for each alternative discharge location. Included in this assessment are potential impacts on archaeology and historic resources such as shipwrecks.	Relative ratings of "Minor", "Moderate", "Extensive"
Protection of Commercial Fishing Activities	Potential interference with commercial fishing activities such as dragging, trawling, gillnetting and lobstering and preemption of fishing areas in Massachusetts Bay was examined	Relative ratings of "Minor", "Moderate", "Extensive"
Protection of Commercial and Recreational Species	The potential for maintenance of potentially harvestable stocks of commercially and recreational aquatic species was examined.	Relative ratings of "Minor", "Moderate", "Extensive"
Water Traffic	Interference with commercial and recreational marine traffic as a result of construction at each of the alternative discharge sites was examined.	Relative ratings of "Minor", "Moderate", "Extensive"

TABLE 3.2.3.a (Continued) CRITERIA FOR THE EVALUATION OF ALTERNATIVE DISCHARGE SITES

Criteria	Description	Measure
PUBLIC HEALTH		
Ability to Meet EPA Public Health Water Quality Criteria	The ability of discharge sites to insure the protection of public health was evaluated. This criterion involves examining data on existing and projected levels of pathogens and carcinogens in water, sediment and seafood.	Exceedances of EPA Public Health Water Quality Criteria
ENGINEERING FEASIBILITY		
Constructibility	The difficulty and risk associated with locating the diffuser at each of the alternative discharge sites were assessed. Included in this criterion are adverse impacts of weather and construction technologies required to reach a specific site.	Relative ratings of "Minor", "Moderate", "Extensive"
COST		
Capital Cost	Capital cost represents the sum of the costs required to construct and operate the project and is presented as a single investment. Capital cost includes construction and operation and maintenance costs of the project through the year 2020.	Millions of Dollars
MATERIALS DISPOSAL		
Disposal of Excavated Material	Both quantity and quality of excavated or tunnelled material were estimated to determine the potential difficulties associated with disposal of the material.	Volume of material to be disposed; degree of difficulty associated with disposal

TABLE 3.2.3.a (Continued) CRITERIA FOR THE EVALUATION OF ALTERNATIVE DISCHARGE SITES

Criteria	Description	Measure
INSTITUTIONAL		
Construction Duration	The relative difficulty which a specific discharge location is expected to have, based on the expected time required to complete outfall construction, was estimated.	Time required for completion
Permitting	The number of permits required and the relative difficulty in obtaining these permits for each alternative was assessed.	Relative ratings of "Moderate", "Extensive"
Demand for Unique or Scarce Construction Resources	The relative demand that an alternative may put on scarce resources or resources not available in the local area was assessed. These resources include labor and construction materials which may be in heavy demand due to other major local construction projects.	Relative ratings of "Moderate", "Difficult"

TABLE 3.3.1.a SUMMARY OF EFFLUENT CONVEYANCE MODE SCREENING

Screening Criteria	Tunnel	Sunken Tube	Pipeline
Marine Ecosystem	No Impact (0)	Negative Impact (-)	Negative Impact (-)
Resources	No Impact (0)	Negative Impact (-)	Negative Impact (-)
Disposal of Excavated Material	Difficult (-)	Difficult (-)	Difficult (-)
Constructibility	Difficult (-)	Difficult (-)	Difficult (-)
Institutional Constraints	Possible (0/-)	Definite (-)	Definite (-)
Cost	Expensive (0)	More Expensive (-)	More Expensive (-)

3.3.2 DESCRIPTION OF OUTFALL CONDUIT ALTERNATIVE FOR DETAILED EVALUATION

A single effluent conveyance mode has been selected for detailed evaluation in this Draft SEIS. This outfall alternative involves deep rock tunnelling from Deer Island to the discharge location. It includes a 30-foot by 15-foot rectangular vertical access shaft on Deer Island and a 25-foot finished inside diameter concrete-lined tunnel connected to the access shaft (MWRA, STFP V,E, 1987). The tunnel could either end below the beginning of a pipeline diffuser or below the last diffuser riser of a tunnelled diffuser. The length of the tunnel would be between 28,000 and 54,000 ft., depending upon the diffuser design and discharge location. A vertical shaft will be excavated on Deer Island from grade to the tunnel. The vertical shaft will be excavated deep enough to allow for a 0.25 percent (or less) positive sloping tunnel and to assure a minimum of 60 feet of bedrock overlying the outfall tunnel.

The outfall conduit would be mined using a tunnel boring machine (TBM) and, where necessary, drill and blast techniques (MWRA, STFP V,E, 1987). Tunnel spoils will be removed through the access shaft. A medium-hard rock, Cambridge argillite, is the most common rock type in Boston Harbor/Massachusetts Bay. It is anticipated that the TBM will progress an average of 50 to 70 feet/day in the tunnel construction and that approximately 15 percent of the tunnel will require rock bolting and grouting. These estimates are based upon the available data and may be revised pending MWRA's detailed geologic investigations planned for spring 1988. The tunnel system would be lined with reinforced concrete to provide a smooth conduit wall and thus, minimize friction head loss.

3.3.3 CRITERIA FOR DETAILED EVALUATION

The tunnelled outfall alternative is evaluated in detail in Chapter 5 using the selection criteria discussed in Appendix F and presented in Table 3.3.2.a.

3.4 DIFFUSER TYPES

3.4.1 SCREENING PROCESS

MWRA proposed and evaluated three diffuser alternatives (MWRA, STFP V,D, 1987) representing a range of diffuser construction technologies. This Draft SEIS examines the diffuser alternatives discussed by MWRA, combining two of MWRA's diffuser options into one option for the screening analysis.

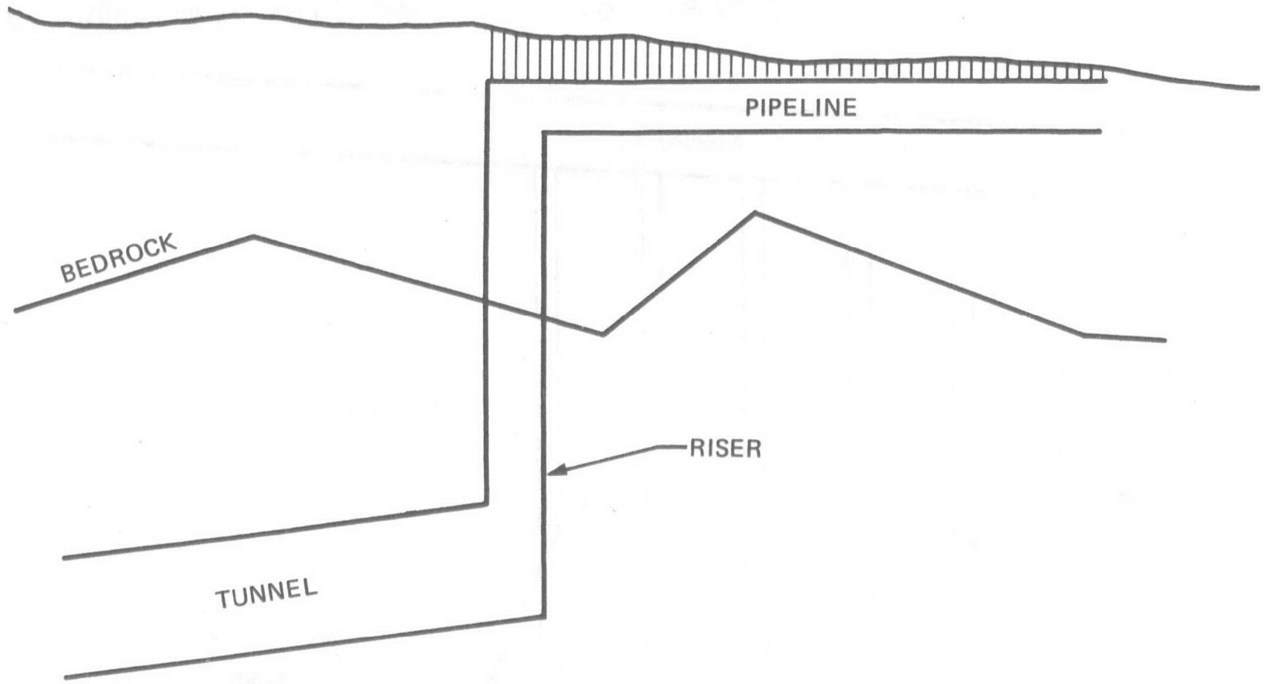
The first of the two diffuser options to be screened in this Draft SEIS is a pipeline situated within an excavated trench connected to the deep rock tunnel outfall by one (Figure 3.4.1.a) to ten (Figure 3.4.1.b) risers. Ports or nozzles would either be cast into or attached to the pipe. Each individual riser would connect the tunnel to a diffuser pipe extending in the direction of the outfall (for a one riser system) or extending about 100 meters in opposing directions (for a multiple riser system). The second diffuser option involves many risers (approximately 80) with each riser fitted with a multi-port cap (between 8 and 10 ports) (Figure 3.4.1.c).

TABLE 3.3.2.a CRITERIA FOR THE EVALUATION OF THE EFFLUENT CONVEYANCE ALTERNATIVE

Criteria	Description	Measure
ENVIRONMENTAL		
Air Emissions Control	The potential for generating air emissions and odor during conduit construction was qualitatively addressed.	Relative ratings of "Mitigable", "Not Mitigable"
Noise Control	The noise due to construction of the shaft on Deer Island was assessed.	Quantitative prediction of noise; relative ratings of "Minor", "Moderate", "Extensive" based on those predictions
ENGINEERING FEASIBILITY		
Reliability	The ability of the conduit system to continuously operate over the expected range of conditions during the life of the design was examined.	Relative ratings of "Reliable", "Not Reliable"
Constructibility	The difficulty and risk associated with constructing the conduit system was assessed. Included in this criterion are adverse impacts of weather and construction technology involved.	Relative ratings of "Minor", "Moderate", "Extensive"
COST		
Capital Cost	Capital cost presents the sum of costs required to construct and operate the project through the year 2020 as a single investment.	Millions of Dollars
MATERIALS DISPOSAL		
Disposal of Tunnelled Material	Both quantity and quality of tunnelled material were be estimated to determine potential difficulties associated with this plan for disposal.	Volume of material to be disposed; degree of difficulty associated with disposal

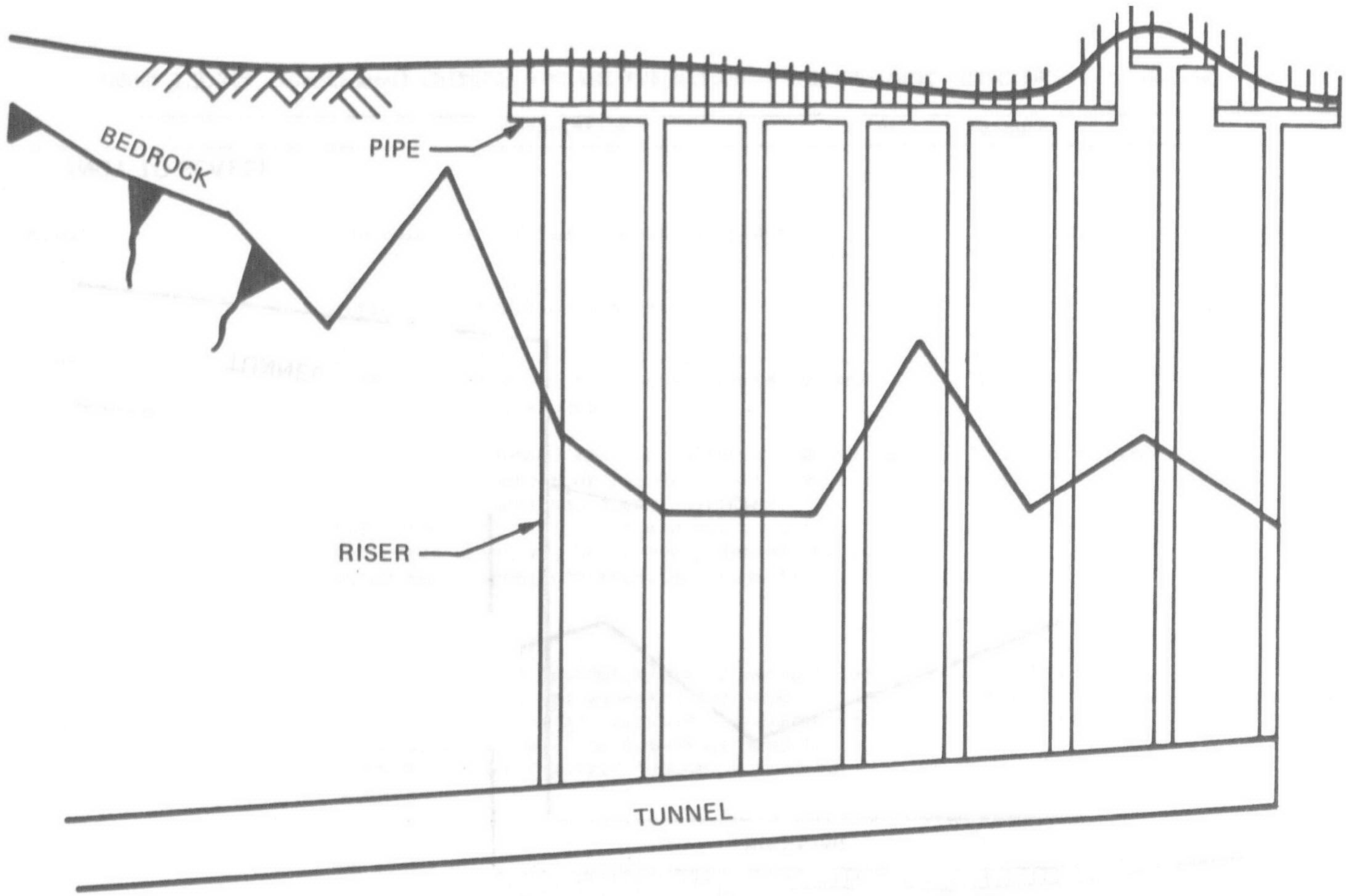
TABLE 3.3.2.a (Continued) CRITERIA FOR THE EVALUATION OF THE EFFLUENT CONVEYANCE ALTERNATIVE

Criteria	Description	Measure
INSTITUTIONAL		
Construction Duration	The relative difficulty which a specific construction technology is expected to have based on the expected time required to complete outfall construction was examined.	Time required for completion
Permitting	The number of permits required and the relative difficulty in obtaining these permits for the alternative was assessed.	Relative ratings of "Moderate", "Extensive"
Demand for Unique or Scarce Construction Resources	The relative demand that the alternative may put on scarce resources or resources not available in the local area was assessed. These resources include labor and construction materials which may be in heavy demand due to other major local construction projects.	Relative ratings of "Moderate","Difficult"
HARBOR RESOURCES		
Protection of Cultural and Historical Resources	The potential to protect areas of cultural or historical value was assessed for each alternative discharge location. Included in this assessment will be potential impacts on archaeology and historic resources such as shipwrecks.	Relative ratings of "Minor", "Moderate", "Extensive"
Water Traffic	Interference with marine traffic as a result of construction was examined.	Relative ratings of "Minor", "Moderate", "Extensive"



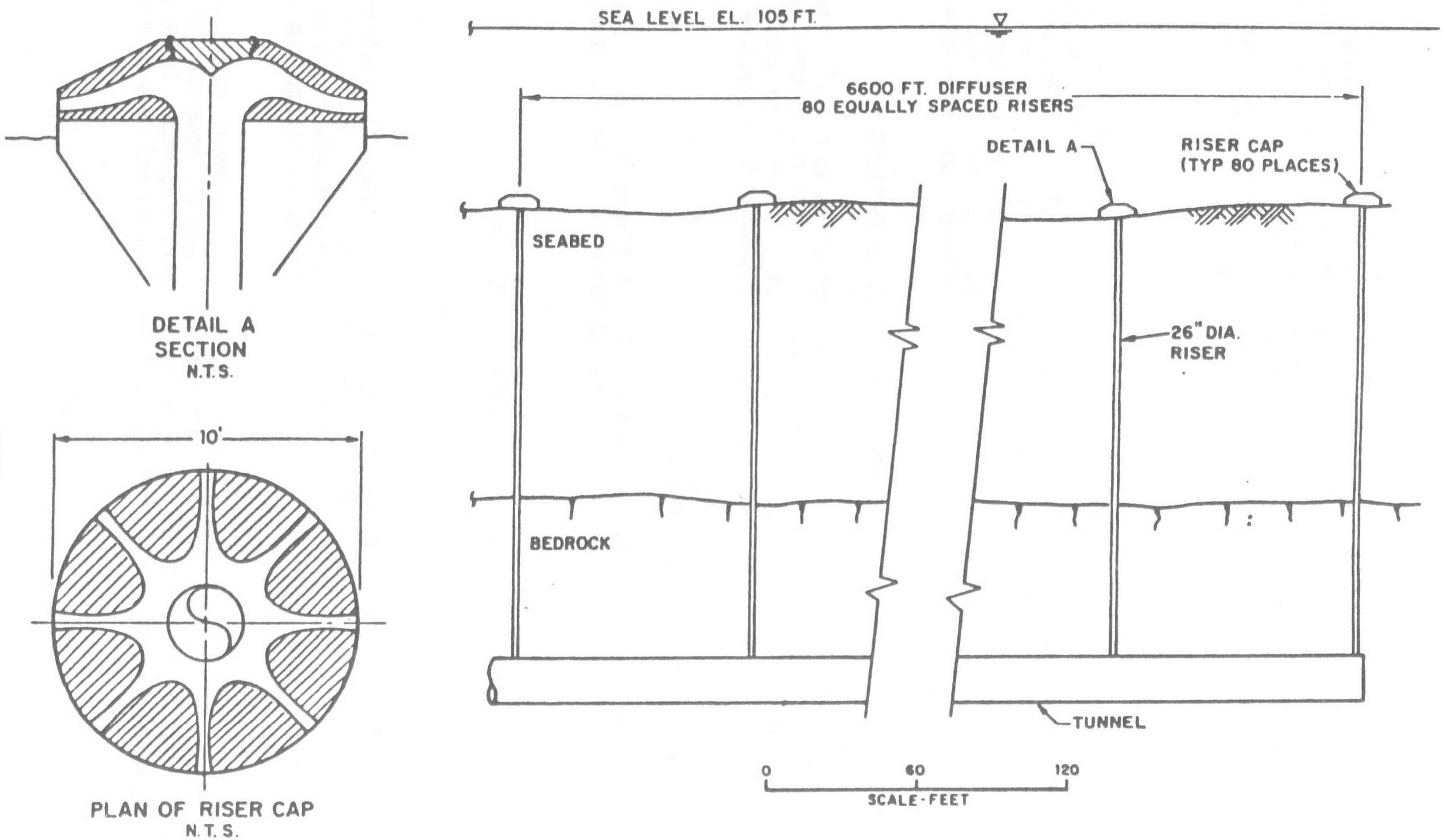
(NOT TO SCALE)

FIGURE 3.4.1.a. PROFILE VIEW OF PIPELINE DIFFUSER WITH ONE RISER



SOURCE: MWRA, STFP V, 1987 (NOT TO SCALE)

FIGURE 3.4.1.b. PROFILE VIEW OF PIPELINE DIFFUSER WITH EIGHT TO TEN RISERS



SOURCE: MWRA STFP V, 1987

FIGURE 3.4.1.c. PLAN AND PROFILE VIEWS OF TUNNELLED DIFFUSER WITH MULTIPLE RISERS

3.4.1.1 Identification of Screening Criteria

Operation of the two diffuser options would be identical (MWRA, STFP V,A, 1987), thus, only construction impacts were addressed by the diffuser system screening criteria. Costs for alternative diffuser systems cannot be determined without site-specific geotechnical information. Therefore, costs are not used to compare alternatives in this Draft SEIS. The screening criteria are: 1) operational complexity, 2) impacts on marine ecosystems, 3) impacts on commercial and recreational resources, 4) disposal of dredged material, 5) constructability and 6) institutional constraints.

3.4.1.2 Application of Screening Criteria

The diffuser construction alternative involving 80 risers drilled through bedrock and connected to the tunnelled outfall would have the least marine ecosystem and harbor resources impacts of the alternatives (Table 3.4.1.a). However, based on the application of the other screening criteria (Appendix F), it is difficult to choose only one preferred option. Both diffuser construction options are expected to be difficult to construct, costly, and require permitting through various agencies. Therefore, neither diffuser construction technologies was eliminated during screening.

3.4.2 DESCRIPTION OF DIFFUSER ALTERNATIVES FOR DETAILED EVALUATION

Two general diffuser construction alternatives are evaluated in detail in this Draft SEIS. The first alternative is a tunnelled diffuser with 80 risers drilled through the overlying sediment and bedrock and attached to the tunnelled outfall. The second diffuser alternative is a tunnelled outfall connected to a pipeline diffuser by one to ten risers.

3.4.3 CRITERIA FOR DETAILED EVALUATION

Selection criteria are discussed in Appendix F and listed in Table 3.4.3.a are applied in the detailed evaluations of the diffuser alternatives presented in Chapter 5.

3.5 INTER-ISLAND CONVEYANCE MODE

3.5.1 SCREENING PROCESS

Wastewater entering the South System of the MWRA collection and treatment system will receive some initial treatment for removal of grit and bulk solids at the proposed headworks on Nut Island. From Nut Island, the wastewater will be conveyed to Deer Island, the location of the new wastewater treatment plant, via an inter-island conveyance system.

Three potential inter-island conveyance systems were screened using a set of criteria identical to those used to screen potential outfall construction options. The screening ratings of the three possible systems were compared. These potential conveyance systems of pipeline, sunken tube and deep rock tunnel were proposed and

TABLE 3.4.1.a SUMMARY OF DIFFUSER TYPE SCREENING

Screening Criteria	Alternative 1: Tunnel with One Riser to Pipeline Diffuser with Multiple Ports or Nozzles	Alternative 2: Tunnel with ≃ Ten Risers To Ten Pipe Diffusers	Alternative 3: Tunnel with ≃ 80 Risers Through Bedrock Multi-Port Riser Caps (8 Ports)
Marine Ecosystem	Negative Impact (-)	Negative Impact (-)	Less Negative Impact (0)
Resources	Negative Impact (-)	Negative Impact (-)	Less Negative Impact (0)
Constructibility	Difficult (-)	Difficult (-)	Difficult (-)
Operational Complexity (Purging/External Damage)	Minimal Purging Required/ External Damage Possible (+/-)	Purging Required/ External Damage Possible (-/-)	Purging Required/ Least External Damage (-/+)
Institutional Constraints	Probable (-)	Probable (-)	Probable (-)

TABLE 3.4.3.a. CRITERIA FOR THE EVALUATION OF THE DIFFUSER TYPE ALTERNATIVES

Criteria	Description	Measure
ENVIRONMENTAL		
Noise Control	Noise impacts due to excavation and drilling during diffuser construction were assessed.	Quantitative predictions of noise; ratings of "Minor", "Moderate", "Extensive" based on those predictions
ENGINEERING FEASIBILITY		
Reliability	The ability of the diffuser system to continuously operate over the expected range of conditions during the life of the design was assessed.	Relative ratings of "Reliable", "Not Reliable"
Constructibility	The difficulty and risk associated with constructing the diffuser system was assessed.	Relative ratings of "Minor", "Moderate", "Extensive"
MATERIALS DISPOSAL		
Disposal of Excavated Material	Both quantity and quality of tunnelled material were estimated to determine potential methods of and difficulties associated with this plan for disposal.	Volume of material to be disposed; degree of difficulty associated with disposal
INSTITUTIONAL CRITERIA		
Construction Duration	The relative difficulty which a specific diffuser construction technology is expected to have in maintaining the court ordered schedule was examined.	Time required for completion
Permitting	The number of permits required and the relative difficulty in obtaining these permits for each alternative was assessed.	Relative ratings of "Moderate", "Extensive"

TABLE 3.4.3.a. (Continued) CRITERIA FOR THE EVALUATION OF THE DIFFUSER TYPE ALTERNATIVES

Criteria	Description	Measure
Demand for Unique or Scarce Construction Resources	The relative demand that an alternative may put on scarce resources or resources not available in the local area was assessed. These resources include labor and construction materials which may be in heavy demand due to other major local construction projects.	Relative ratings of "Moderate", "Difficult"
MARINE ECOSYSTEM		
Protection of Water Quality	Since construction of the diffuser has the potential to disturb bottom sediments, causing them to resuspend and to increase turbidity, the relative impact which the diffuser options have on water quality was assessed.	Relative ratings of "Minor", "Moderate", "Extensive"
Protection of Sensitive Biota and Habitat	The extent to which sensitive biota and habitat will be affected by resuspension of bottom sediments and loss of habitat due to construction of the diffuser was assessed.	Relative ratings of "Minor", "Moderate", "Extensive"
HARBOR RESOURCES		
Protection of Cultural and Historical Resources	The potential to protect areas of cultural or historical value was assessed for each diffuser alternative. Included in this assessment are potential impacts on archaeology and historic resources such as shipwrecks.	Relative ratings of "Minor", "Moderate", "Extensive"
Water Traffic	Interference with marine traffic as a result of construction was examined.	Relative ratings of "Minor", "Moderate", "Extensive"
Protection of Commercial Fishing Activities	Potential interference with commercial fishing activities such as dragging, travelling, gillnetting and lobstering and preemption of fishing areas was examined.	Relative ratings of "Minor", "Moderate", "Extensive"

examined by MWRA (MWRA, STFP IV, 1987). These alternatives use the same construction technologies as were presented for the effluent outfall system. These inter-island construction modes represent a reasonable range of alternatives and were used in this Draft SEIS.

Since President Roads (between Long Island and Deer Island) is a major shipping lane of Boston Harbor, construction of either a pipeline or a sunken tube across President Roads would have to be coordinated with the U.S. Coast Guard to prevent unsafe conditions in the harbor. In addition, construction involving a pipeline or sunken tube may impact the harbor's islands and therefore, may require coordination with various agencies. For these reasons, only tunnelled conveyance construction is considered for the President Roads portion of the inter-island conduit.

3.5.1.1 Identification of Screening Criteria

Criteria developed for screening the inter-island conduit construction options for the remainder of the conduit (Nut Island to Long Island) are identical to those used screen potential effluent outfall construction options (Section 3.3 and Appendix F).

3.5.1.2 Application of Screening Criteria

Based on the application of the criteria, the deep rock tunnel construction alternative would least impact environmental quality and harbor resources, be most adaptable to future uses of the harbor, be easiest to construct, have the least institutional constraints, and be the least costly of the three inter-island conduit alternatives (Table 3.5.1.a). Therefore, tunnel construction from Nut Island to Deer Island was the only alternative selected for further evaluation.

3.5.2 DESCRIPTION OF INTER-ISLAND CONDUIT ALTERNATIVE FOR DETAILED EVALUATION

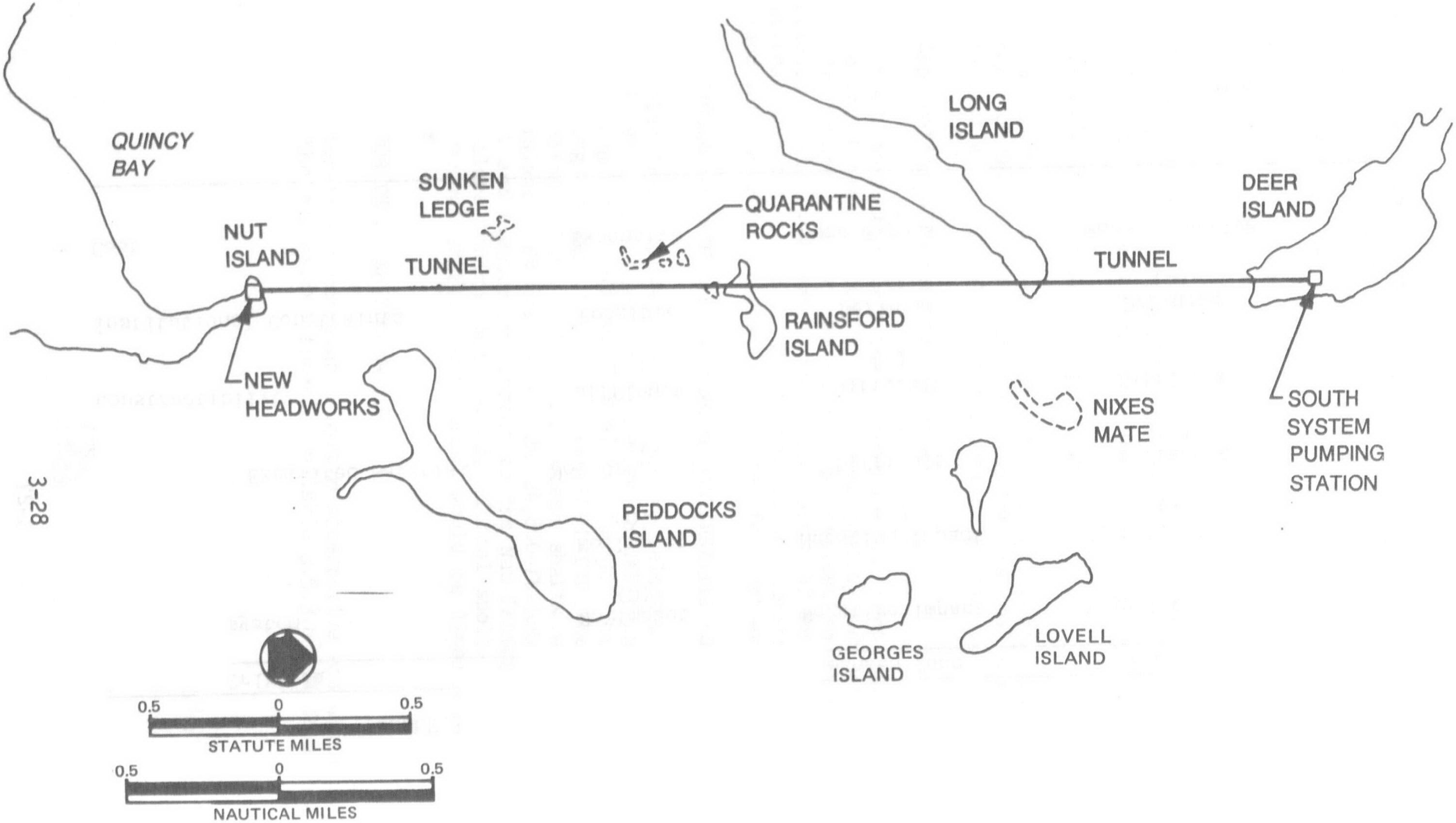
The single inter-island conveyance alternative selected for detailed evaluation is an 11-ft finished inside diameter deep-rock tunnel from Nut Island to Deer Island (Figures 3.5.2.a and 3.5.2.b) (MWRA, STFP IV, 1987). This alternative would involve similar tunnelling methods to those described for the tunnelled outfall system alternative (Section 3.3.2). Vertical access shafts would be excavated on Deer Island and Nut Island. Excavation of the 24,800-ft-long tunnel would begin at the Deer Island shaft and eventually connect to the Nut Island shaft. The tunnel would have a positive slope towards Nut Island. Tunnel spoils would be removed through the Deer Island access shaft. The tunnel would be lined with reinforced precast concrete sections.

3.5.3 CRITERIA FOR DETAILED EVALUATION

The tunnelled inter-island conveyance system alternative was evaluated in detail in Chapter 5 using the selection criteria in Table 3.5.3.a and described in detail in Appendix F.

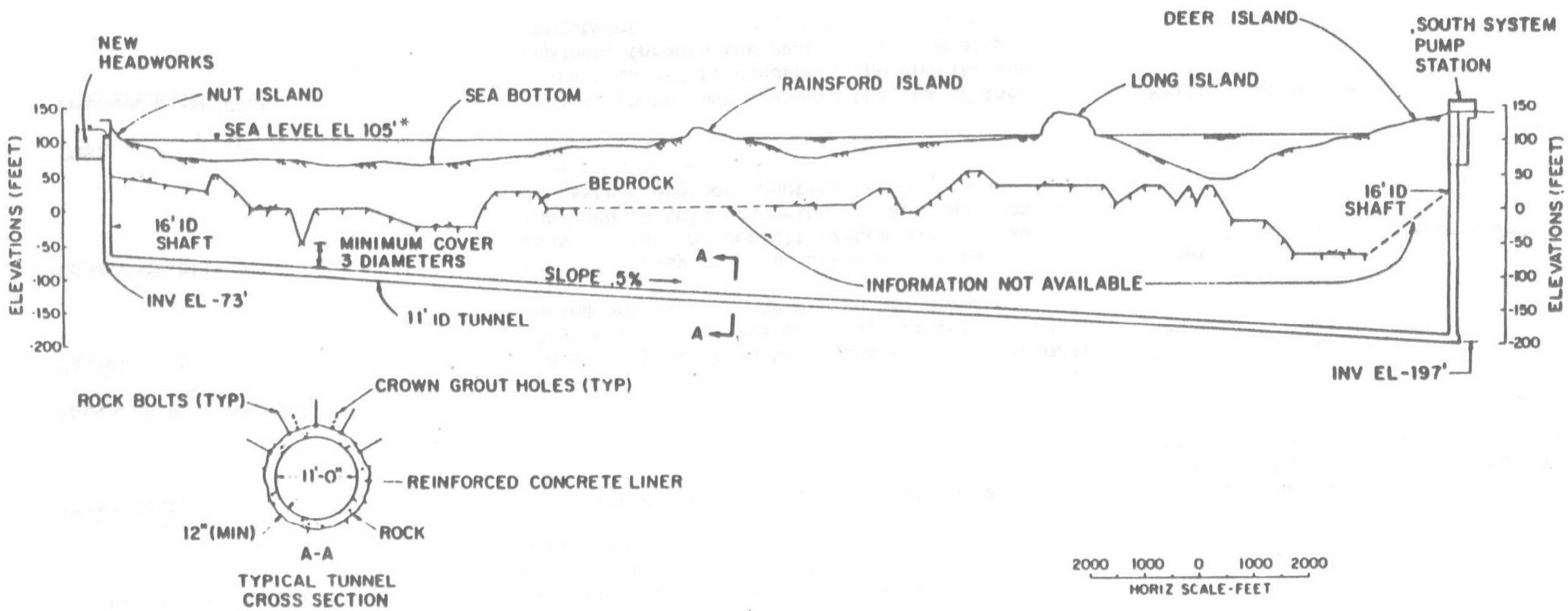
TABLE 3.5.1.a SUMMARY OF INTER-ISLAND CONVEYANCE MODE SCREENING

Screening Criteria	Tunnel	Sunken Tube	Pipeline
Marine Ecosystem	No Impact (0)	Negative Impact (-)	Negative Impact (-)
Resources	No Impact (0)	Negative Impact (-)	Negative Impact (-)
Disposal of Excavated Material	Not Difficult (+)	Difficult (-)	Difficult (-)
Constructibility	Difficult (-)	Difficult (-)	Difficult (-)
Institutional Constraints	Possible (0/-)	Definite (-)	Definite (-)
Cost	Expensive (0)	More Expensive (-)	More Expensive (-)



SOURCE: MWRA STFP IV, 1987

FIGURE 3.5.2.a. PLAN VIEW OF INTER-ISLAND CONVEYANCE SYSTEM ALTERNATIVE



*METROPOLITAN DISTRICT COMMISSION STANDARD ADDS 105 FEET TO ACTUAL ELEVATION.

SOURCE: MWRA STFP IV, 1987

FIGURE 3.5.2.b. PROFILE VIEW OF INTER-ISLAND CONVEYANCE SYSTEM ALTERNATIVE

TABLE 3.5.3.a CRITERIA FOR THE EVALUATION OF INTER-ISLAND CONVEYANCE ALTERNATIVE

Criteria	Description	Measure
ENVIRONMENTAL		
Air Emissions Control	The potential for generating air emissions and odor during conduit construction was qualitatively addressed.	Relative ratings of "Mitigable","Not Mitigable"
Noise Control	The noise due to conduit construction was assessed.	Quantitative prediction of noise; ratings of "Minor", "Moderate", "Extensive" based on those predictions
ENGINEERING FEASIBILITY		
Reliability	The ability of the conduit system to continuously operate over the expected range of conditions during the life of the design was examined.	Relative ratings of "Reliable", "Not Reliable"
Constructibility	The difficulty and risk associated with constructing the conduit system was assessed. Included in this criterion are adverse impacts of weather and construction technology involved.	Relative ratings of "Minor", "Moderate", "Extensive"
COST		
Present Worth Cost	Present worth cost presents the sum of the costs required to construct and operate the project, through the year 2020, as a single investment.	Millions of Dollars
Project Cost	Project cost includes the capital cost of constructing facilities, equipment replacement costs during the planning period plus 35 percent to cover construction contingencies and administrative, engineering and legal costs.	Millions of Dollars

TABLE 3.5.3.a (Continued) CRITERIA FOR THE EVALUATION OF INTER-ISLAND CONVEYANCE ALTERNATIVE

Criteria	Description	Measure
MATERIALS DISPOSAL		
Disposal of Tunnelled Material	Both quantity and quality of tunnelled material were estimated to determine potential difficulties associated with this plan for disposal.	Volume of material to be disposed; degree of difficulty associated with disposal
INSTITUTIONAL		
Construction Duration	The relative difficulty a specific construction technology is expected to have based on the expected time required for completion of construction was examined	Time required for completion
Permitting	The number of permits required and the relative difficulty in obtaining these permits for the alternative was assessed.	Relative ratings of "Moderate", "Extensive"
Demand for Unique or Scarce Construction Resources	The relative demand that the alternative may put on scarce resources or resources not available in the local area was assessed. These resources include labor and construction materials which may be in heavy demand due to other major local construction projects.	Relative ratings of "Moderate", "Difficult"
HARBOR RESOURCES		
Protection of Cultural and Historical Resources	The potential to protect areas of cultural or historical value was assessed for each alternative discharge location. Included in this assessment will be potential impacts on archaeology and historic resources such as shipwrecks.	Relative ratings of "Minor", "Moderate", "Extensive"
Water Traffic	Interference with marine traffic as a result of construction was examined.	Relative ratings of "Minor", "Moderate", "Extensive"

CHAPTER 4

AFFECTED ENVIRONMENT

4.1 INTRODUCTION

4.1.1 PROJECT SETTING

This chapter presents an overview of environmental conditions and marine resources in the area that will potentially be affected by the construction and operation of the effluent conveyance and diffuser system and the inter-island conduit structure. The effluent conveyance structure alignment will approximate a straight line from Deer Island to the diffuser location while the inter-island conduit structure will approximate a straight line between Nut Island and Deer Island. In general, the affected environment includes the area of Massachusetts Bay within approximately 10 miles of Boston Harbor, portions of Boston Harbor itself, and in the case of affected marine resources, the associated shoreline as well.

Specific technical disciplines discussed in this chapter include physical oceanography, water quality, marine geology and marine biology. Harbor resources such as shipping, fisheries and recreation are also discussed. Information presented include data collected by MWRA in support of the outfall siting decision (MWRA, STFP V, 1987) as well as data from previous studies.

4.1.2 SERVICE AREA

Since 1847, Boston Harbor has been receiving all domestic, commercial and industrial wastewater and stormwater from the Boston metropolitan area. At present, the area's two wastewater treatment plants at Nut Island and Deer Island treat wastewater collected from a network of almost 5,000 miles of sewers, conduits and pipes servicing 1.9 million people in 43 metropolitan cities and towns (Figure 4.1.2.a). The Deer Island and Nut Island plants provide primary treatment to the North and South Metropolitan Sewer Service Areas respectively. Some communities are serviced by both plants (MWRA, STFP I, 1987).

4.2 SUMMARY OF ENVIRONMENTAL CONDITIONS

4.2.1 PHYSICAL OCEANOGRAPHY

The water quality analyses conducted to evaluate the alternative discharge sites require as input physical oceanography parameters describing the currents and vertical stratification in the affected area of Massachusetts Bay. Although the effluent discharge flow rate will be large, its impact on these parameters will be only local and existing physical oceanography conditions can be used for the predictive water quality analyses. The specific parameters of importance are first discussed, as well as their role in the processes which control the fate of the effluent. The data sources and the information which they can provide relative to these needs are then reviewed, followed by analyses of the data to provide the specific information which will be used in the water quality predictions.

SOURCE: MDC, 1979

FIGURE 4.1.2.a. MWRA SEWERAGE SERVICE AREA

4.2.1.1 Processes and Controlling Parameters

4.2.1.1.1 Nearfield. Immediately following its discharge through the multiport diffuser, in a region called the discharge nearfield, the effluent will undergo rapid initial dilution with ambient water. The essentially freshwater effluent will form a buoyant plume rising through the water column (Figure 4.2.1.a). Both the initial dilution and final height of rise depend on the current speed, direction relative to the diffuser and water column stratification.

4.2.1.1.2 Farfield. Following initial dilution, the effluent will be carried somewhat passively by the ambient current, undergoing slower dispersion by ambient turbulence. In tidal situations, the effluent plume may return over the diffuser, resulting in the development of a background build-up in the discharge area. The magnitude of this background build-up is dependent on the tidal current patterns and the net drift. Tidal current patterns control the trajectory and short-term dispersion of the effluent; tidal currents, however, do not result in any net transport away from the discharge area. Net transport is provided by the net drift, which may result from a number of factors, including large-scale weather patterns, freshwater discharges, local topography and wind. Net drifts are therefore variable in time and intensity. As the background build-up develops only slowly, the persistence of net drifts is important. The background build-up is also dependent on the stratification which can trap the effluent in the lower layer and, by limiting its vertical and horizontal extent, can cause higher concentrations of pollutants.

In the water quality analyses conducted to evaluate the impacts of the discharge, horizontally, two-dimensional models were used to calculate background build-ups. This type of model relies on the fact that concentrations are approximately uniform over the water depth (or in the upper and lower layers when the water is stratified) and only horizontal variations are resolved. The models calculate vertical averages of the currents and concentrations. Two models were involved: a hydrodynamic model, TEA, to calculate the current speeds and directions as a function of time, and a transport model, ELA, to calculate constituent concentrations. Calibration of the hydrodynamic model requires measured tidal currents and net drifts. The transport model, ELA, requires the specification of a dispersion coefficient. This parameter can be specified based in the literature, but preferably should be calibrated by comparison with field measurements. The measurements needed are concentrations of a tracer corresponding to a known source (Appendix A).

In the long term, the effluent will disperse over much of Massachusetts Bay and eventually leave it for the open ocean. These processes are controlled by large-scale circulation patterns in Massachusetts Bay, including the exchange of waters between the Bay and the Gulf of Maine.

4.2.1.1.3 Shoreline Impacts. Superimposed upon the general flow patterns are local and generally transient current events which are primarily driven by winds. Depending on the location of the discharge in relation to shoreline resources, these events may occasionally transport effluent to the shoreline in relatively short times, resulting in elevated concentrations there.

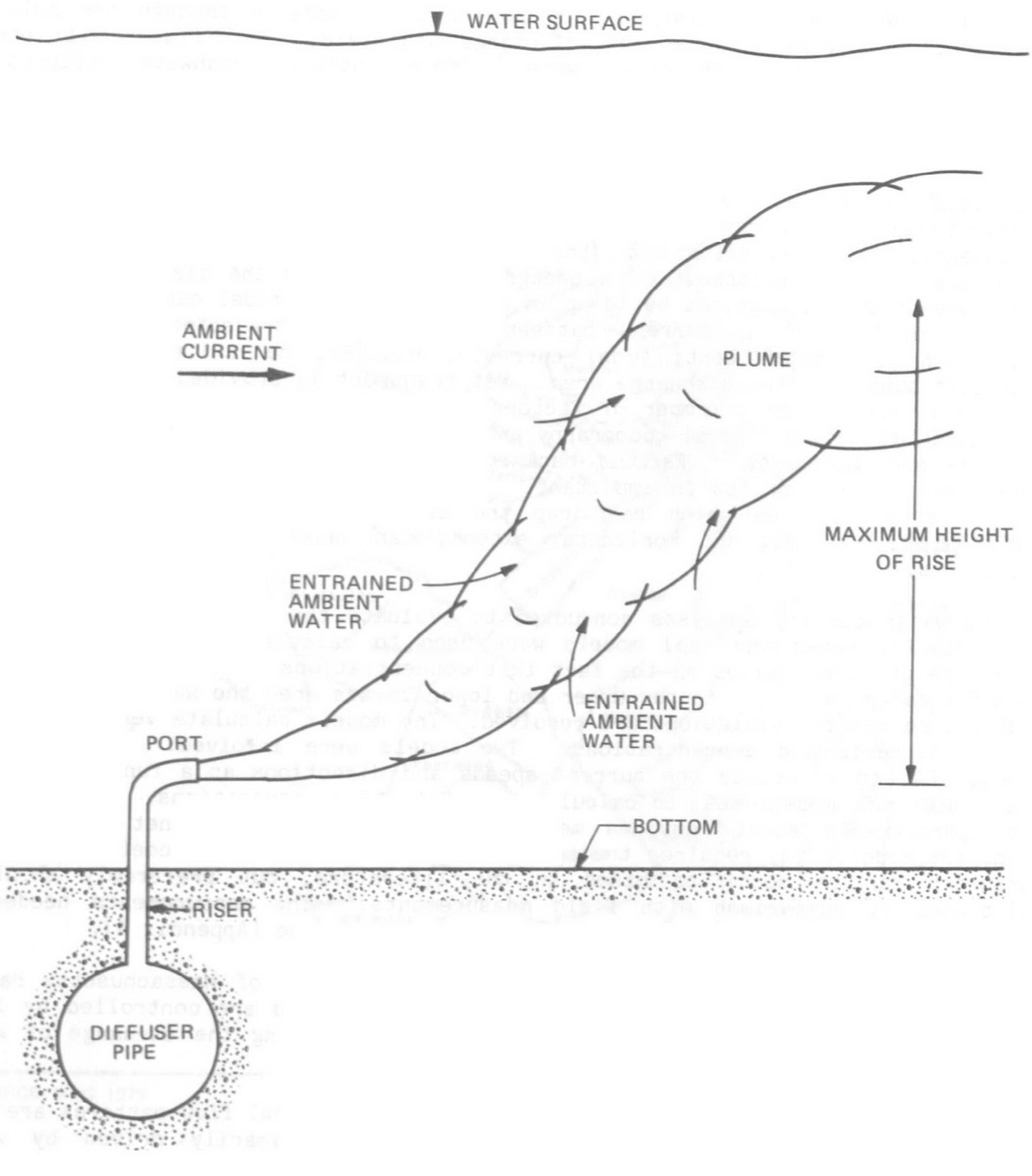


FIGURE 4.2.1.a SCHEMATIC EFFLUENT PLUME IN THE NEARFIELD

4.2.1.1.4 Sedimentation and Resuspension. Sedimentation is controlled by the size of the particles, their concentration in the water column (which affects flocculation) and the level of ambient turbulence. Resuspension is dependent on the bottom currents, and turbulence. In coastal situations, high bottom currents likely to produce resuspension are generated by waves. For this Draft SEIS, no correlation between waves and resuspension was attempted. Rather, resuspension was assessed from direct measurements and sediment thickness analyses.

4.2.1.1.5 Summary. This brief review of effluent fate processes pointed to the following controlling parameters, which are required for direct input into the water quality analyses and for calibration of elements thereof.

- Tides
- Instantaneous currents, magnitude and direction
- Tidal current patterns
- Net drift magnitude, direction and persistence
- Sustained shoreward currents
- Stratification profiles

4.2.1.2 Data Sources

Massachusetts Bay has been the subject of numerous physical oceanography studies, each with a rather narrow focus, however. These studies include Bigelow (1927), Bumpus (1974), Manohar-Maharaj and Beardsley (1973), NOAA (1974), Butman (1977), EG&G (1976), Mayer (1975), NEA (1975), Fitzgerald (1980), Metropolitan District Commission (1978, 1979, 1982, 1984), Butman (1987) and MWRA (1986, 1987). A review of these studies relative to the water quality prediction needs of this project was conducted by MWRA (MWRA, STFP V,A, 1987). Salient features are summarized below.

The combined Massachusetts and Cape Cod Bays form a body of water enclosed by land along 75 percent of its perimeter. It is bounded on the north by Cape Ann and on the south by Cape Cod. It has an area of approximately 3600 square kilometers with depths of up to 90 m. A characteristic feature is the submarine ridge called Stellwagen Bank which lies in the middle of the Cape Ann-to-Provincetown line. The average depth of Stellwagen Bank is about 30 m with depths as low as 20 m. On either side, between the bank and the tips of Cape Ann and Cape Cod are deeper channels.

Currents in Massachusetts Bay, and particularly in the proposed discharge sites area, are in a large part tidally driven. The tides are primarily semi-diurnal (two high water tides in one day). Different semi-diurnal tides exist, depending on their origin. The dominant tide in Massachusetts Bay has a period of 12.42 hours. Diurnal variations are also observed but with a much lower amplitude. The tidal range (difference between high and low water levels) varies during the lunar month (27.3 days), with two spring tides (higher range) and two neap tides (lower range). The average tidal range is on the order of 2.6 meters along the Gloucester-Provincetown line which separates Massachusetts Bay from the Gulf of Maine. The tidal range in Boston Harbor is 2.7 meters, with a lag of approximately 1 minute compared to Provincetown (NOAA, 1987). The volume of water flowing in and out of the Bay during each tide cycle (tidal prism) is therefore on the order of 9.5 billion cubic meters, approximately 6 percent of the mean volume of the Bay. In the proposed discharge sites area, the tidal currents are predominantly east-west with a maximum speed on the order of 10 cm/s. Much higher velocities occur in some constricted passages such as President Roads and Nantasket Roads, with speeds of up to 60 cm/sec.

Non-tidal currents in Massachusetts Bay have been the subject of several studies. Bigelow (1927) first proposed the existence of a cyclonic gyre (counterclockwise circulation) in Massachusetts Bay, as an extension to the Gulf of Maine eddy. More recent studies by Butman (1977) indicate a more complicated situation. Winds and freshwater inflows, particularly from the Merrimack River also affect large-scale flow patterns in Massachusetts Bay. And indeed, available data indicate net drifts of varying direction and amplitude.

The exchange of water between Massachusetts Bay and the Gulf of Maine controls the rate at which dissolved constituents discharged through the diffuser are removed from the Bay. It was noted above that the tidal prism represents approximately 6% of the volume of the Bay. The corresponding flushing time scale is 8.5 days. This time scale is a measure of the time needed for the Bay to adapt to changes of loading. Some of the water leaving the Bay during ebb, however, returns during the following flood and the actual flushing time scale is larger. Values from 9 days to 2 months were estimated by Butman (1971).

Most of Massachusetts Bay stratifies during the summer months. Starting in June, surface waters warm up due to surface heating. In July, a stable stratification has developed with two distinct layers separated by a pycnocline at a depth on the order of 10 m. The upper layer is warmer than the lower layer and little exchange occurs between the layers. In July, the temperature difference between the layers is on the order of 10°C. In August, the pycnocline deepens to 15 to 25 m. The temperature difference, however, remains on the order of 10°C. During September, the upper waters start to cool and the pycnocline becomes more diffuse. The fall overturn occurs during November. These thermal effects are strengthened by the freshwater discharges into the upper layer, which also decrease surface water density. Large freshwater inflows during the spring can cause transient stratification periods.

Several of the physical oceanography data needed for the water quality analyses must be specific to the proposed discharge sites. Data are also needed for parameters which are not directly measured but must be extracted from the measurements. For these, it is important to have the data in a form which allows easy input into a computer. The MWRA data meet this requirement and, therefore, form much of the specific basis of the present analyses. The data from previous studies was used to provide a framework of interpretation of the MWRA data and to complement it where needed.

4.2.1.2.1 MWRA Field Data. A preliminary Phase I survey was conducted in 1986 to guide in the selection of sites and in the specification of the Phase II program conducted in 1987.

The Phase I data collection consisted of:

- Drogue tracking of short duration (4.5 to 8.5 hours),
- Vertical density profiling,
- Dissolved oxygen profiling and Secchi disk measurements of turbidity,
- Surface and sea bed drifter recovery tracking.

The Phase II data gathering was a more detailed study lasting from mid-March to September 1987 and including the following measurements:

- Tidal elevations at Gloucester, on Cape Ann and Provincetown, on Cape Cod, to provide boundary conditions to the farfield hydrodynamic model TEA,
- Continuous current speeds and directions at 10 different stations shown in Figure 4.2.1.b. Some of these stations included two current meters, designated U and L for upper and lower, designed to be above and below the pycnocline in the summer. Details of the current meter coverage are given in Figure 4.2.1.b. These data were used for the nearfield modeling and to calibrate the farfield hydrodynamic model TEA,
- Continuous CTDO (Conductivity, Temperature and Dissolved Oxygen) at some of the current meter stations, with the coverage also indicated in Figure 4.2.1.b. These data were used to characterize the ambient water quality in Massachusetts Bay,
- Vertical CTDO profiles along two transects shown in Figure 4.2.1.c, to characterize the vertical stratification cycle in Massachusetts Bay,
- Long-term drogue tracking (4 days), to provide data on large-scale transport patterns from the proposed discharge sites,
- Wind speeds, to provide input to shoreline impact assessments,
- Chemical tracer concentrations, to validate the farfield water quality model.

All the data gathered during these programs were plotted and analyzed by MWRA (MWRA, STFP V,A and G, 1987). The data were also transcribed to magnetic tapes and made available for the present analyses. These analyses are described in the following sections and further details are provided in Appendix A. Their objectives were to refine the understanding of local and global processes in Massachusetts Bay and to fulfill the specific data needs of the water quality analyses.

4.2.1.3 Tides

Water surface elevations along the Gloucester-Provincetown line are needed to drive the hydrodynamic model, TEA. Continuous measurements at 10 to 15 minute intervals were conducted at Gloucester and Provincetown and referenced to the National Geodetic Vertical Datum (NGVD).

FIGURE 4.2.1.b. LOCATION OF MWRA CURRENT METER STATIONS IN RELATION TO ALTERNATIVE DIFFUSER SITES

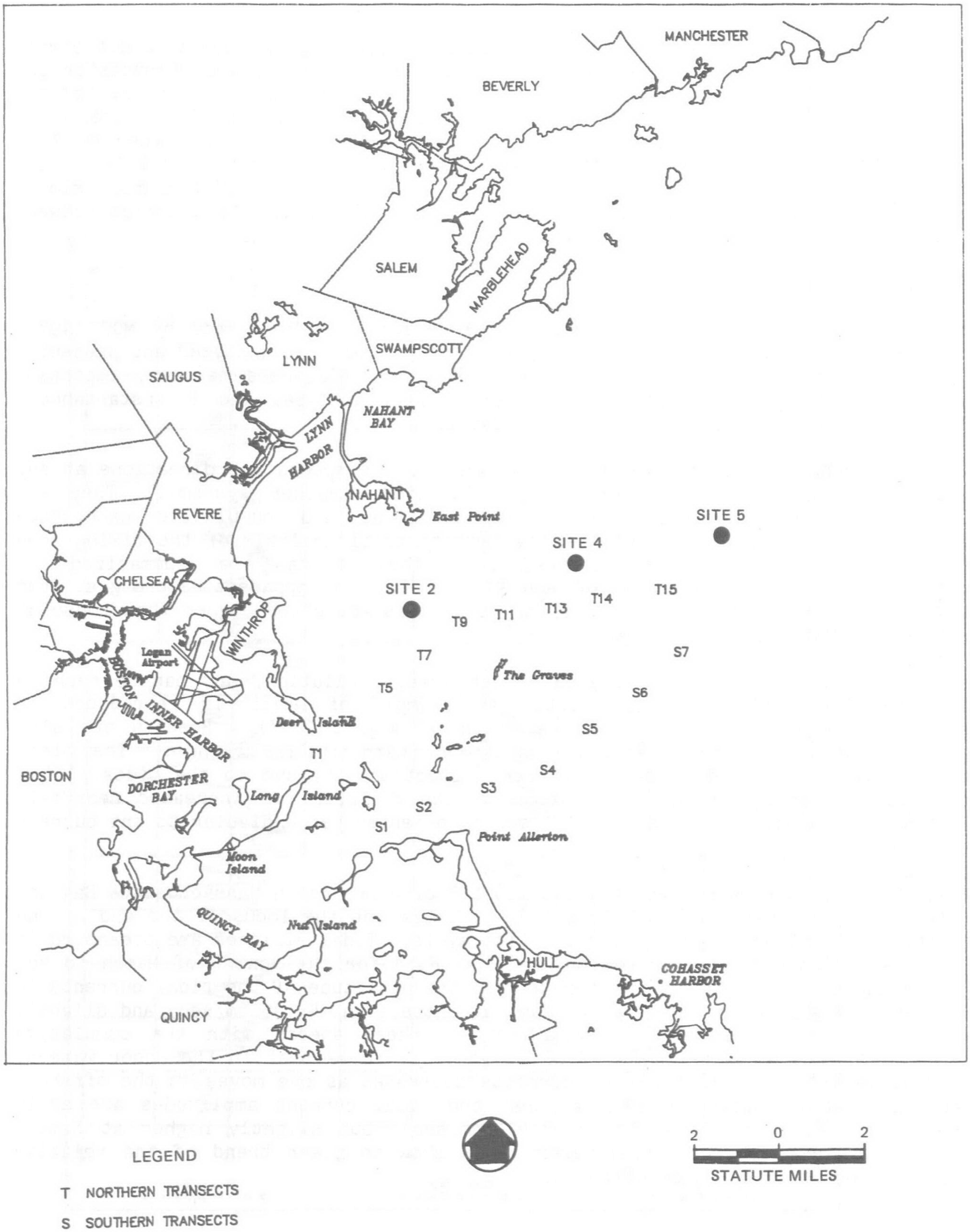


FIGURE 4.2.1.c. LOCATIONS OF MWRA SURVEY TRANSECTS

It can be hypothesized that net drifts in Massachusetts Bay are due to a difference in mean water levels (i.e., exclusive of tidal variations) between Gloucester and Provincetown. This water level difference is referred to as the boundary "tilt". The water surface elevation records at Provincetown and Gloucester filtered to remove tidal variations show fluctuations with a time scale on the order of 7 to 10 days, which is the period of sub-tropical storms (Figure 4.2.1.d). The difference in filtered water levels, or tilt, however, varies with a much slower time scale, on the order of several months. In general, the tilt varies between +10 cm and -10 cm, with extremes on the order of 15 cm.

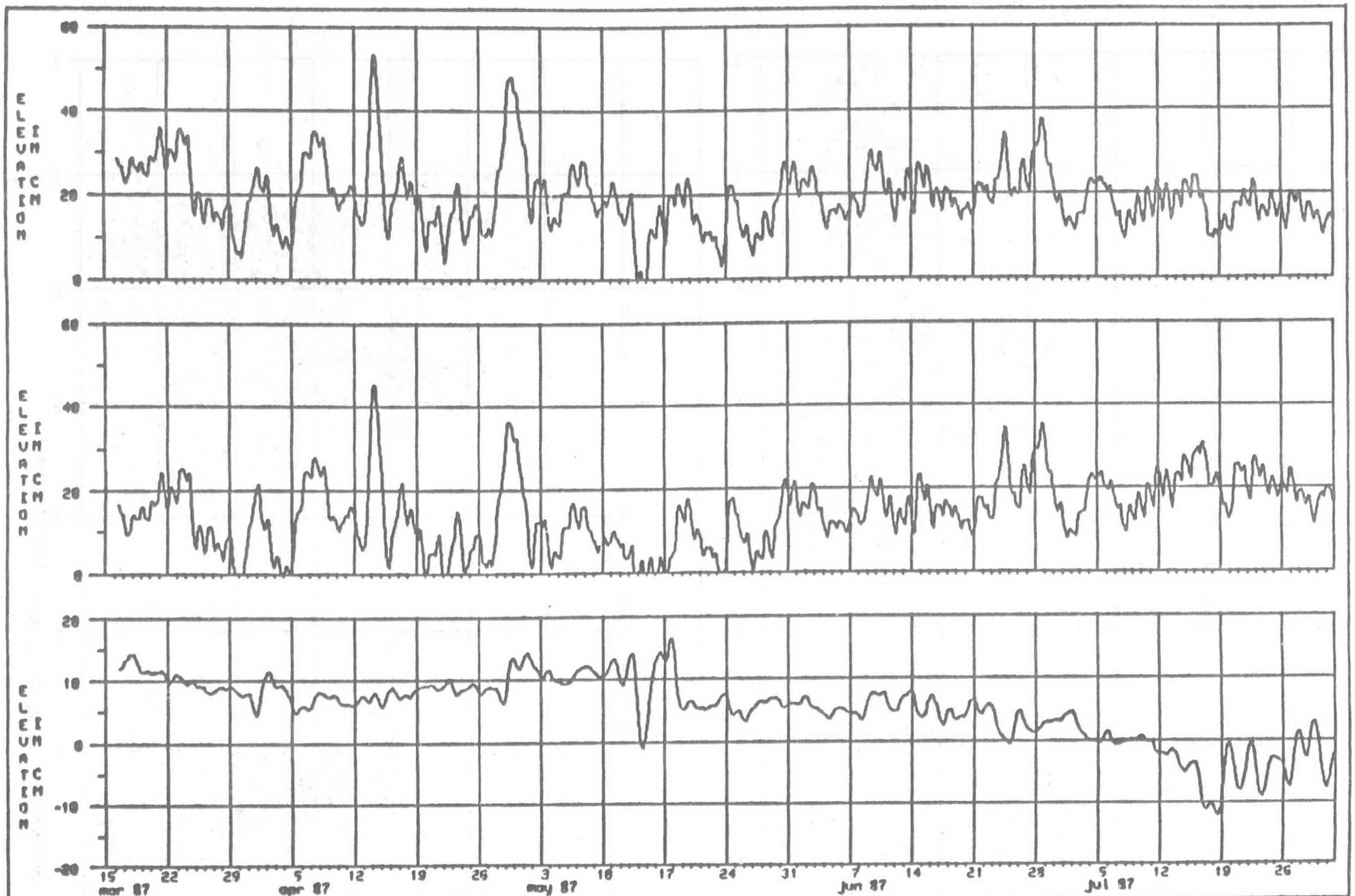
4.2.1.4 Currents

Extensive current measurements in Massachusetts Bay were conducted by MDC (1979, 1984a and b), Butman (1987) and MWRA (1987). The latter were analyzed and presented in a variety of ways, (MWRA, STFP V,G, 1987). As discussed earlier, important features of the current relative to water quality analyses are i) instantaneous values, ii) tidal components and iii) net drifts.

4.2.1.4.1 Instantaneous Currents. These are current speeds and directions at any instant, regardless of their origin (tidal, wind, weather system). They are important for the initial dilution calculations, and cumulative exceedence frequencies of current speeds will allow a statistical analysis of the mixing zone water quality criteria concentrations. These data are summarized in Table 4.2.1.a. A slight increase of current velocities is apparent as one goes from Site 2 to 4 to 5. Note that lower meter velocities are often higher than those at the corresponding upper current meters.

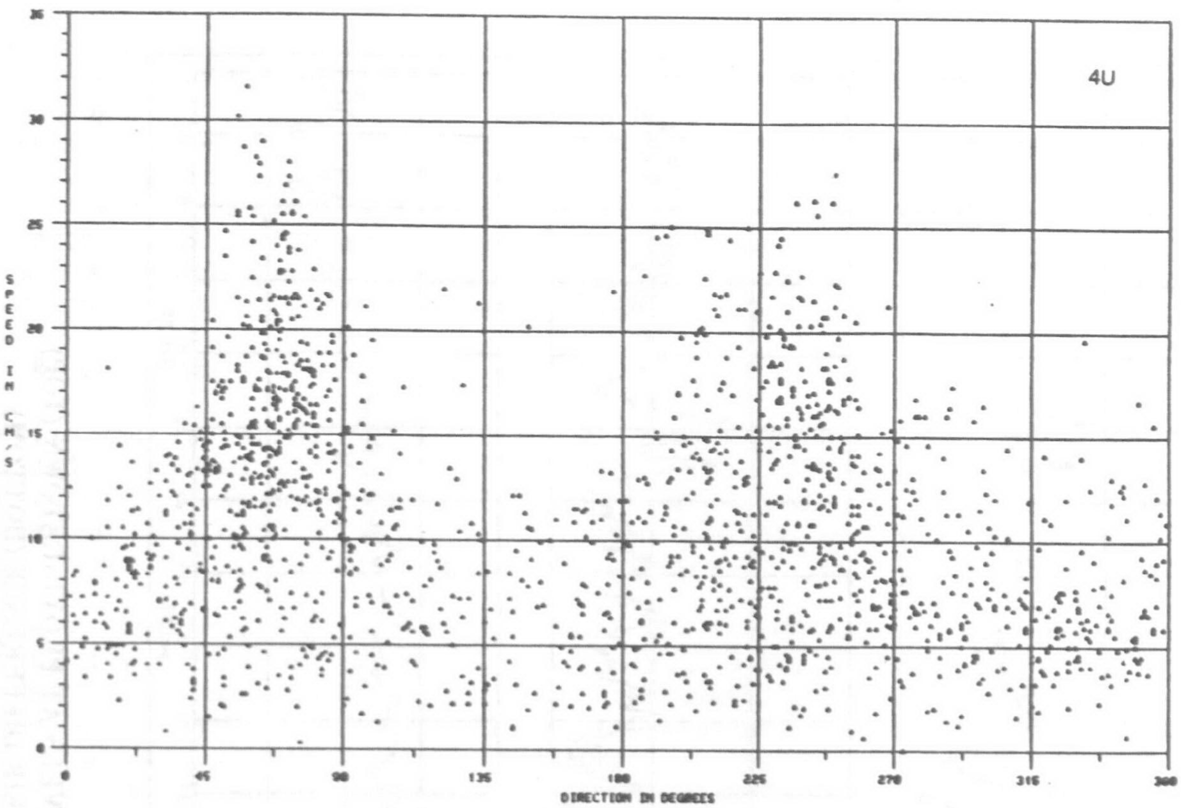
Instantaneous current directions also affect initial dilution, and can be seen in the magnitude-direction scatter plots (an example of which is reproduced in Figures 4.2.1.e for Station 4 for the month of August 1987). Results are also available for other time periods and stations, with similar trends. The plots clearly show a preferred east-west current directionality due to the tides. This factor is important for the orientation of the diffuser, as increased nearfield dilutions can be obtained when the diffuser is oriented perpendicular to the current direction.

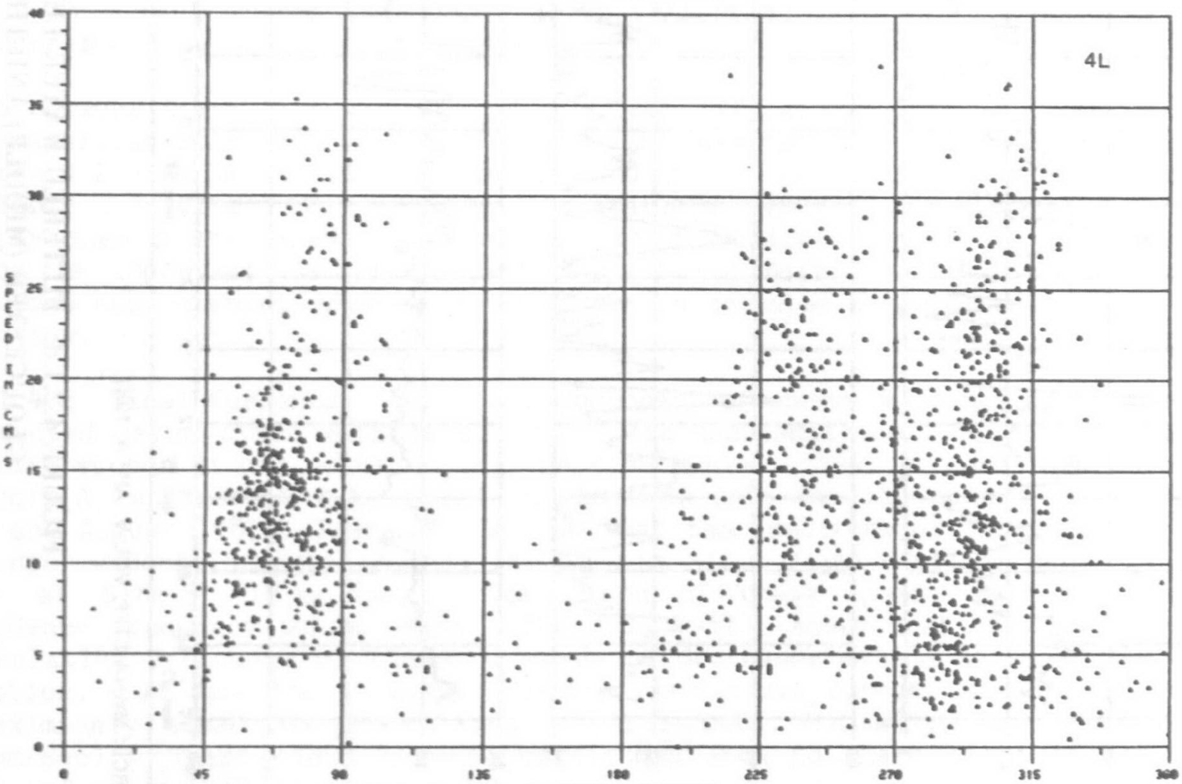
4.2.1.4.2 Tidal Currents. The tidal component of currents in Massachusetts Bay can be studied using tidal ellipse plots. These represent the locus of the end of the velocity vector at one point during the tide cycle. Tidal ellipses are presented in Appendix A, Attachment A.b, based on the MWRA data for the months of March to May 1987 and August 1987. These plots show that the amplitude of the tidal currents in the upper waters is approximately the same at Sites 2 and 4 (15 cm/sec) and slightly lower at Site 5 (12 cm/sec). Comparison of these speeds with the cumulative exceedence frequency plots (MWRA, STFP V,G, 1987), shows that in the upper waters, the relative influence of tides on currents decreases as one moves in the offshore direction. At the lower current meters, the tidal current amplitudes are again approximately equal at Sites 2 and 4 (12 cm/sec), but slightly higher at Site 5 (15 cm/sec). These tidal current magnitudes show no clear trend of the relative tidal influence with distance offshore.



SOURCE: MWRA STFP, VOL V, APP A, 1987

FIGURE 4.2.1.d. FILTERED WATER LEVELS AT PROVINCETOWN (TOP) GLOUCESTER (MIDDLE) AND THEIR DIFFERENCE (BOTTOM)





SOURCE: MWRA STFP, VOL V, APP G, 1987

FIGURE 4.2.1.e. MAGNITUDE-DIRECTION SCATTER PLOT FOR STATION 4, AUGUST 1987

TABLE 4.2.1.a STATISTICS OF 1987 MWRA CURRENT METER MEASUREMENTS

Meter Station	Vector Mean: Speed (cm/sec)	Vector Mean: Direction (degrees true)	Speeds (cm/s): Maximum	Speeds (cm/s): 10%[a]	Speeds (cm/s): 50%[a]	Speeds (cm/s): 90%[a]
1	1.12	240	23.3	1.9	6.2	11.9
2u	2.05	209	33.3	3.6	10.2	18.5
2l	2.65	160	31.6	3.0	9.5	15.8
3u	1.68	180	56.3	4.2	11.5	20.1
3l	2.05	256	47.6	4.4	11.6	22.0
4u	1.07	99	31.6	3.6	9.6	18.5
4l	3.94	336	38.7	4.4	12.8	23.2
5u	1.39	252	35.0	5.1	11.5	19.7
5l	1.48	29	45.5	4.4	11.9	21.3
6u	2.90	260	40.0	3.4	9.2	17.5
6l	1.50	300	30.8	2.3	7.1	13.6
7u	3.13	131	40.7	4.5	11.0	20.5
7l	1.73	50	83.5	3.1	10.0	21.0
9	5.46	34	105.0	2.4	21.0	50.9
10	1.15	303	101.0	5.2	28.6	52.5

Source: MWRA STFP, Vol. V, App. A, 1987

(a) These figures represent the percent of time during which measured current speeds are lower than the indicated values: eg. for Station 1 currents are lower than 1.9 cm/s for 10% of the time; lower than 6.2 cm/s for 50% of the time; and lower than 11.9 cm/s for 90% of the time.

The tidal ellipse plots also were used for the calibration of the two-dimensional hydrodynamic mathematical model of Massachusetts Bay, (TEA).

4.2.1.4.3 Net Drifts. Progressive vector plots based on current measurements show that net drifts are highly variable in time, with periods of practically no net drift and periods of sustained high net drift (MDC 1984a and b; Butman 1987; MWRA, STFP V, 1987). Spacially, net drifts are also very variable, as can be seen on maps of monthly averaged current speeds shown in Appendix A, Attachment A.a. The plots show that there is no coherence between the different current meter locations, and upper and lower current meters often give significantly different net drifts. This display of the data does not support the gyre model discussed earlier and would tend to indicate that net drifts are largely due to localized wind events and perhaps to density effects resulting from freshwater inflows.

In order to gain additional perspective on net drifts and their persistence, net drifts over 10 complete tidal cycles were computed and plotted versus time, representing, in a sense, a vector running average of the currents. These plots are presented in Appendix A, Attachment A.c. They clearly show a periodicity of high net drifts with a period on the order of 7 to 10 days.

During the stratified summer months, the net drifts are often significantly different at the upper and lower current meters. In general, the upper meters gave larger net drifts, except at Station 4, where the lower net drifts were larger. The directions of the upper and lower layer net drifts are also often different.

4.2.1.5 Stratification

As discussed earlier, Massachusetts Bay stratifies in the summer due to surface heating. The MWRA field program included measurements of temperature and salinity, from which density is determined, along two transects at several times during the spring and summer of 1987. The resulting vertical density contours are provided in Appendix A, Attachment A.d. These show a pycnocline during the summer months at a depth of 10 to 15m, with large variations during the tide cycle. Vertical density profiles based on these measurements were used for the initial dilution analyses.

The continuous density records produced by MWRA clearly show the tidal variations, particularly in the bottom-to-top meter density differences, which are a measure of the stratification. The average bottom to top density difference varies during the summer due to the surface heating/cooling cycles and wind mixing, but never vanishes. This indicates that effectively distinct top and bottom layers exist, with significantly reduced interchange. Relative to water quality analyses, this suggests that models recognizing the existence of these layers are desirable. This was done in this Draft SEIS by simulating the lower layer separately during stratified months.

During the spring, the continuous density measurements indicate that strong stratification can develop following major runoff events. This stratification, however, is not uniform and is of relatively short duration so that prolonged blockage of the effluent plume in a lower layer would not be expected.

4.2.2 WATER QUALITY

4.2.2.1 Constituents and Criteria

Water quality is measured by the concentrations of dissolved and suspended constituents in the water column, as well as other more subjective measures such as aesthetics or odor. The list of constituents and factors to be considered can be established based on applicable water quality standards and criteria. Those standards are the Massachusetts Surface Water Quality Standards and the U.S. EPA Water Quality Criteria for Aquatic Life and Human Health. These standards and criteria are reviewed below, with the objective of determining the constituents which should be considered as measures of water quality and to characterize present conditions and impacts due to the discharge alternatives.

The Massachusetts Surface Water Quality Standards are defined in the Code of Massachusetts Regulations, Title 314. They involve minimum criteria applicable to all waters, listed in Table 4.2.2.a, and additional criteria for specific classes of waters, defined on the basis of their use. The waters of the Outer Boston Harbor are classified as SA, consistent with the following uses: protection and propagation of fish, other aquatic life and wildlife; primary and secondary contact recreation such as swimming and boating; and shellfish harvesting without depuration in approved areas. The additional criteria pertaining to SA class waters are listed in Table 4.2.2.b.

Many of the minimum criteria are based on avoidance of objectionable effects and are therefore qualitative. Quantitative criteria corresponding to these effects, such as aquatic toxicity, are provided by the EPA criteria discussed below. Quantitative criteria are provided for SA Class waters for Oxygen, pH, and Coliform bacteria.

The EPA Water Quality Criteria are provided in the so-called "Gold Book" (USEPA 1986a). These criteria include aquatic life and human health criteria, the latter including toxicity, carcinogenicity (from fish consumption) and taste and odor criteria.

Aquatic life criteria are further discussed in the "Technical Support Document for Water Quality-Based Toxics Control" (USEPA, 1985c). Two approaches are proposed to assess and control toxicity to organisms, the chemical-specific approach, which is used here, and the whole effluent approach which will be considered when the necessary data become available.

The chemical-specific approach is based on published laboratory bioassay test results involving each chemical independently. This approach has the advantage of requiring no effluent-specific bioassay, but it assumes that the composition of the effluent is known (so that the concentrations of chemicals can be determined), that the toxicity of separate toxicants is not additive, and that those toxicants are bioavailable in the effluent.

Acute and chronic concentration levels are determined. The acute (short-term) concentration, called the Criterion Maximum Concentration, or CMC, is the concentration which must not be exceeded at a specified point with a frequency of more than 1 hour every 3 years. However, it is recognized that this is unenforceable and, therefore, the frequency of occurrence, for enforcement purposes,

TABLE 4.2.2.a COMMONWEALTH OF MASSACHUSETTS SURFACE WATER QUALITY STANDARDS* MINIMUM CRITERIA APPLICABLE TO ALL WATERS

Parameter	Criteria
1. Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: a) Settle to form objectionable deposits; b) Float as debris, scum, or other matter to form nuisances; c) Produce objectionable odor, color, taste, or turbidity; or d) Result in the dominance of nuisance species
2. Radioactive Substances	Shall not exceed the recommended limits of the United States Environmental Protection Agency's National Drinking Water Regulations.
3. Tainting Substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4. Color, Turbidity, Total Suspended Solids	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
5. Oil and Grease	The water surface shall be free from floating oils, grease and petrochemicals; and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin the maximum allowable discharge concentration is 15 mg/l.
6. Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
7. Other Constituents	Waters shall be free from pollutants alone or in combinations that: a) Exceed the recommended limits on the most sensitive receiving water use; b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life; or c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.

*310 CMR 4.03.

TABLE 4.2.2.b COMMONWEALTH OF MASSACHUSETTS SURFACE WATER QUALITY STANDARDS*
ADDITIONAL CRITERIA FOR MARINE CLASS SA WATERS

Parameter	Criteria
1. Dissolved Oxygen	Shall be a minimum of 6.0 mg/l
2. Temperature	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3. pH	Shall be in the range of 6.5-8.5 standard units and not more than 0.2 units outside of the naturally occurring range.
4. Total Coliform Bacteria	Shall not exceed a median value of 70 MPN per 100 ml, and not more than 10% of the samples shall exceed 230 MPN per 100 ml in any monthly sampling period.

*310 CMR 4.03

is increased to 1 day every 3 years. The chronic (long-term) concentration, called the Criterion Continuous Concentration, or CCC, is the concentration which must not be exceeded with a frequency of more than 4 consecutive days in 3 years. CMC's and CCC's are provided for a range of chemicals in the "Gold Book". These values are provided in Table 4.2.2.c for the chemicals of concern. These are the same as were considered by MWRA in their analyses. The process by which this list of chemicals was established included the following steps, starting from the list of chemicals detected in the influent to the plant:

1. Remove those chemicals for which no water quality criterion exists,

2. Remove those constituents that already meet the criteria in the influent,

3. Remove those chemicals detected in the influent infrequently,

4. Add chemicals for which the detection limit is greater than the criteria.

Human health criteria include human toxicity criteria, carcinogenicity criteria and taste and odor criteria. The carcinogenicity criteria are based on risks of 1 in 100,000 (10^{-5}), 1 in 1,000,000, (10^{-6}) or 1 in 10,000,000 (10^{-7}) chances of contracting cancer or suffering genetic mutation in a lifetime given assumed intakes of contaminated fish. The Division of Water Pollution Control of the Massachusetts Department of Environmental Quality Engineering (DEQE) typically utilize a risk factor of 10^{-5} or lower, which it believes allows for acceptable protection of the public's health and is

TABLE 4.2.2.c SALTWATER AQUATIC LIFE AND HUMAN HEALTH WATER QUALITY CRITERIA (μg/l)

Chemical	Toxicity to Saltwater Aquatic Life (Acute) CMC (1)	(Chronic) CCC (2)	Toxicity to Humans (3)	Carcinogenicity (4) 10^{-5}	10^{-6}	Taste and Odor
VOLATILES						
benzene	5,100	700	--	400.	40.	--
bromomethane	12,000	6,400	--	157.	15.7	--
chloroform	--	--	--	157.	15.7	--
ethylbenzene	430	--	3,280	--	--	--
methyl chloride	12,000	6,400	--	157	15.7	
styrene	430	--	3,280	--	--	--
tetrachloroethylene	10,200	450	--	88.5	8.85	--
ACID BASE NEUTRALS & PAHs						
anthracene	300	--	--	0.311	0.0311	--
benz[a]anthracene	300	--	--	0.311	0.0311	--
benz[b]fluoranthene	300	--	--	0.311	0.0311	--
benz[k]fluoranthene	300	--	--	0.311	0.0311	--
benz[g,h,i]fluoranthene	300	--	--	0.311	0.0311	--
benzO[a]pyrene	300	--	--	0.311	0.0311	--
bis(2-ethylhexyl)phthalate	2,944	3.4	--	500,000.	50,000.	--
butylbenzyl phthalate	2,944	3.4	--	--	--	--
chrysene	300	--	--	0.311	0.0311	--
dibenz[a,h]anthracene	300	--	--	0.311	0.0311	--
3,3-dichlorobenzidine	--	--	--	0.2	0.02	--
2,4-dichlorophenol	--	--	3,090	--	--	0.3
di-n-octyl phthalate	2,944	3.4	--	--	--	--
fluorene	300	--	--	0.311	0.0311	--
hexachlorobenzene	160	129	--	0.0074	0.00074	--
indeno(1,2,3-cd)pyrene	300	--	--	0.311	0.0311	--
naphthalene	2,350	--	--	--	--	--
phenanthrene	300	--	--	0.311	0.0311	--
pyrene	300	--	--	0.311	0.0311	--
METALS						
arsenic	69	36	--	0.175	0.0175	--
beryllium	--	--	--	1.17	0.117	--
cadmium	43	9.3	--	--	--	--
chromium	1,100	50	--	--	--	--
copper	2.9	--	--	--	--	1,000

Continued

TABLE 4.2.2.c SALTWATER AQUATIC LIFE AND HUMAN HEALTH WATER QUALITY CRITERIA (µg/l) (Continued)

Chemical	Toxicity to Saltwater Aquatic Life (Acute) CMC (1)	(Chronic) CCC (2)	Toxicity to Humans (3)	Carcinogenicity (4) 10^{-5}	10^{-6}	Taste and Odor
METALS (continued)						
lead	140	5.6	--	--	--	--
mercury	2.1	0.025	0.146	--	--	--
nickel	75	8.3	--	--	--	--
selenium	760	--	--	--	--	--
silver	2.3	--	--	--	--	--
zinc	170	58	--	--	--	5,000
PESTICIDES						
aldrin	1.3	--	--	0.00079	0.000079	--
chlordane	0.18	0.004	--	0.0048	0.00048	--
dieldrin	0.41	0.0019	--	0.00076	0.000076	--
heptachlor	0.053	0.0036	--	0.0029	0.00029	--
toxaphene	0.21	0.0002	--	--	--	--
OTHER CHEMICALS						
PCBs	--	0.03	--	0.00079	0.000079	--

Source: From the EPA Gold Book as published in May, 1986, and updated in 1986 and again in May, 1987.

1. Criterion Maximum Concentration (CMC) = one-hour average not to be exceeded more than once in three years.

2. Criterion Continuous Conentration (CCC) = four-day average not to be exceeded more than once in three years.

3. Human Health Toxicity = Ambient water criterion not to be exceeded to protect humans from the toxic properties of a chemical ingested via consumption of contaminated aquatic organisms.

4. Carcinogenicity = 10^{-5} and 10^{-6} risk levels which may result in an incremental increase in cancer from lifetime consumption of aquatic organisms contaminated with the given concentration of a chemical.

5. Taste and odor = Maximum level not to be exceeded to avoid undesirable taste and odor.

attainable and enforceable. For this project, the Division recommended that the MWRA utilize the 10^{-6} risk factor but that it may consider use of a risk factor of 10^{-5} in certain situations. Those situations must be reviewed with the Division prior to utilization (May 15, 1987 letter of T.C. MacMahon to M. Gritzuk). Criteria concentrations corresponding to both risk factors are listed in Table 4.2.2.c.

Additional discussion of the water quality criteria, focused on their interpretation relative to the water quality analyses, is provided in Section 5.1.1.

4.2.2.2 Dissolved Oxygen

Numerous and extensive dissolved oxygen (DO) measurements have been conducted in Boston Harbor and Massachusetts Bay. Review of those prior to 1984 indicated that in Boston Harbor, and even in the vicinity of the existing discharges, DO levels rarely go below 6 mg/l (MDC, 1984). The data from 1978 and 1979 MDC surveys at multiple depths indicated that in the vicinity of the Deer Island discharge, 90 percent of the measurements exceeded 7 mg/l and the lowest DO recorded was 6.2 mg/l. In the vicinity of the Nut Island discharge 80 percent of the measurements exceeded 7 mg/l and the lowest DO recorded was 5.9 mg/l. Of the 1400 measurements obtained at stations surrounding the discharges, only one was less than 6 mg/l.

Extensive discrete DO measurements were also gathered by MDC in the Site 5 area in July and August, 1978 and 1979. Summer represents worst case conditions relative to DO since the saturation DO concentration is lower and bottom waters are isolated from the water surface by the pycnocline. Indeed, strong vertical variations of DO were observed, with supersaturation (indicating photosynthetic activity) in the top waters and below saturation concentrations in the bottom waters. Out of all the measurements, approximately 83 percent exceeded 7 mg/l and 1 percent were below 6 mg/l. The average DO in the bottom 10 meters was 7.6 mg/l.

The MWRA field program included continuous measurements of dissolved oxygen at several stations and depths. Because these measurements were continuous, they had the potential for detecting unusual events which may have been missed by the earlier shorter-term surveys. Such an event was recorded on June 6, 1987, when DO levels dropped to 5 mg/l at Station 3. Unfortunately, meters at other nearby stations were not operative at this time and the validity of these measurements cannot be corroborated. The wind and current records indicate nothing unusual on that date, and, therefore, the origin of these measurements remains unclear. Other than this event, the MWRA data tends to confirm the earlier surveys, with high dissolved oxygen values in the upper waters, up to 12.5 mg/l, and somewhat lower values in the bottom waters. Out of the 4,056 DO measurements in the lower layer during June-August 1987, the lowest value was 7.8 mg/l and only 4 measurements were below 8 mg/l.

Water quality data collected in September 1986, however, indicated DO concentrations in the lower layer ranging from 5.9 mg/l to 6.8 mg/l. Similarly, in October 1987, MWRA measurements indicated low dissolved oxygen values for a period of about two weeks at the lower meters. At Station 4, the lower meter DO concentrations showed high semi-diurnal fluctuations (on the order of 3 mg/l) with an average of approximately 6.5 mg/l (Kolb, personal communication). The lower meter depth was 17m (MLW) and the water depth was 20m. The large semi-diurnal fluctuation indicates that the meter was alternatively in the upper layer and lower layer during tidal variations. This is confirmed by strong temperature variations at the same frequency. Vertical density profiles are not available to locate the pycnocline, but the foregoing observations indicate that it was at a depth comparable to that of the lower meter, i.e. 17m. The lower layer depth would then become very small (3m or less) and it is possible that the low DO concentrations recorded were due to resuspension oxygen demand caused by breaking internal waves at the pycnocline. This aspect is important because it affects the selection of ambient DO concentrations for the impact analyses (Appendix A, Section A.3.8.1).

4.2.2.3 pH

The pH is a measure of the acidity or alkalinity of water and is determined from the concentration of hydrogen ions in the water. A pH of 7.0 corresponds to neutral conditions; acidic conditions have a pH below 7.0 and basic conditions have a pH above 7.0. In the ocean, pH is controlled primarily by carbonate and bicarbonate (bases) and carbonic acid.

Measurements of pH conducted by MDC in summer 1979 in the Site 5 area ranged from 7.9 to 8.1, with an average of 8.0. Harbor values were similar but with greater variability, especially due to freshwater inputs. The pH was sometimes noticeably lower in the inner harbor and nearshore areas than in the outer harbor, but on other days, there was little variation among stations (MDC, 1984a and b).

As part of its field program, MWRA conducted pH measurements in April 1987 in Broad Sound. The measured pH values ranged from 8.1 at the surface to 7.9 at a depth of 30m (MWRA, STFP V,A 1987). These measurements confirm the earlier data.

4.2.2.4 Suspended Solids

Extensive measurements of suspended solids were conducted during the MDC secondary treatment waiver applications process in Boston Harbor and in the general area of the proposed discharge sites (MDC, 1984a and b). In the harbor, great variability was encountered, in particular in response to runoff events. In the proposed discharge sites area, total suspended solids ranged from 1 mg/l to 12 mg/l, with an average concentration of 4.5 mg/l. These measurements were conducted in the summer and reflect high primary productivity.

Suspended solids concentrations were also measured during the MWRA field program, at two stations shown in Figure 4.2.2.a. These measurements, which were made in April 1987, gave total suspended solids concentrations on the order of 2.5 mg/l at Station B2, which is between Sites 2 and 4, and 1.5 mg/l at Station H1, located at the edge of Stellwagen Bank (MWRA, STFP V,M, 1987).

4.2.2.5 Toxic Chemicals

Much of the existing data on toxic chemical concentrations in Massachusetts Bay were collected in Boston Harbor. Those are therefore largely influenced by the present discharges from Deer Island and Nut Island Treatment Plants and the CSO's.

Concentrations of dissolved and particulate metals in the water column have been measured at two stations in Massachusetts Bay (Figure 4.2.2.a), as part of the MWRA field program (MWRA, STFP V,B, 1987) and are summarized in Table 4.2.2.d. These concentrations are generally low, and well below the CMC and CCC values, except for copper (average concentration of 0.4 µg/l) which is on the same order of magnitude as the CMC (2.9 µg/l).

FIGURE 4.2.2.a. LOCATIONS OF THE SUSPENDED SOLIDS, METALS, AND PCB SAMPLING STATIONS

TABLE 4.2.2.d METAL CONCENTRATION IN WATER COLUMN AT TWO STATIONS IN MASSACHUSETTS BAY

Station	Depth (m)	Phase	As µg/l	Cd µg/l	Cr µg/l	Cu µg/l	Hg[1] ng/l	Ni µg/l	Pb µg/l	V µg/l	Zn µg/l
H1	11.8	Diss.	0.42	0.023	0.26	0.37	1.97	0.22	0.045	1.11	0.64
		Part.	0.014	0.001	0.055	0.039	1.63	0.127	0.050	<0.045	0.086
		Tot.	0.43	0.024	0.31	0.41	3.61	0.35	0.096	1.11	0.73
	22.2	Diss.	0.50	0.025	0.26	0.30	2.07	0.57	0.056	1.30	0.72
		Part.	0.013	0.001	0.056	0.027	0.97	0.376	0.043	<0.045	0.072
		Tot.	0.51	0.026	0.32	0.33	3.11	0.95	0.099	1.30	0.79
	48.7	Diss.	0.53	0.026	0.27	0.36	2.01	0.38	0.048	1.33	0.85
		Part.	0.012	0.001	0.051	0.026	2.10	0.081	0.032	<0.043	0.069
		Tot.	0.55	0.027	0.32	0.38	4.11	0.47	0.078	1.33	0.92
B2	8.6	Diss.	0.04	0.030	0.19	0.46	1.64	0.53	0.069	1.25	1.16
		Part.	0.010	0.002	0.075	0.060	0.50	0.153	0.058	<0.044	0.262
		Tot.	0.41	0.031	0.26	0.52	2.13	0.68	0.128	1.25	1.60
	19.4	Diss.	0.50	0.027	0.19	0.36	1.3	0.45	0.031	1.25	0.91
		Part.	0.013	0.001	0.093	0.035	0.48	0.051	0.067	0.032	0.156
		Tot.	0.51	0.028	0.29	0.39	1.8	0.50	0.098	1.27	1.06
	24.4	Diss.	0.49	0.025	0.25	0.46	2.12	0.65	0.106	1.39	1.02
		Part.	0.022	0.001	0.167	0.063	1.53	0.504	0.083	0.055	0.154
		Tot.	0.051	0.026	0.42	0.45	3.65	1.1	0.189	1.44	1.17
CCC Concentration			36	43	1100		0.025	7.1	5.6		58
CMC Concentration			69	9.3	50	2.9	2.1	140	140		170

Source: MWRA, STFP V,B, 1987
(1) Note different unit.

Concentrations of dissolved and particulate PCB's were measured at the same stations for samples collected in April, 1987 (Battelle, 1987). These measurements indicate detectable dissolved and particulate PCB concentrations (calculated as Aroclor 1254) with a maximum value of 0.0073 µg/l for dissolved PCB (Table 4.2.2.e).

4.2.3 MARINE GEOLOGY

4.2.3.1 Overview

The assessment of existing conditions in the vicinity of the proposed diffuser sites is based on available information on the geology and bottom sediments in the Massachusetts Bay region. No field data collection program was conducted as part of this Draft SEIS project; however, extensive data are available from previous investigations. The most recent bottom sediment data were collected in conjunction with the Deer Island Secondary Treatment Facilities Plan (MWRA, STFP V, 1987). These and other data presented herein have been used to establish existing conditions. Appendix B of this Draft SEIS provides more detailed information on existing marine bottom conditions. This information is used as the basis for projecting sediment deposition impacts due to the proposed discharge (Section 5.1.2).

4.2.3.2 Geological Setting

The inner Massachusetts Bay region is at the margin of the Boston Basin, a structural and topographic feature. Structurally, it consists of folded and faulted sedimentary and volcanic rocks. There are several east-northeast trending folds that project seaward from Boston Harbor, plunging at less than 20 degrees in the same direction. The bedrock is dominated by slightly metamorphosed agrillite (Cambridge Formation), which is commonly thinly bedded and fine grained. Many dikes and sills of trap rock (basalt or diabase) intrude into the agrillite in the Harbor area. The bedrock surface is highly irregular in the area east-northeast of Deer Island, varying from bottom outcrops to 250-foot (MSL) depths.

4.2.3.3 Bottom Sediment Distribution

There is little consistency in the available data on existing sediment conditions. This is the result of extreme variability in bottom sediment types on several scales. This conclusion was reached by Tetra-Tech (1984) in a technical review of sediment data from the 1984 MDC waiver of secondary treatment. MWRA (STFP V,N, 1987) concluded that the area consisted of "very patchy...benthic environments." MWRA (STFP V,R, 1987) sampled sediments at 15 sites on three separate cruises, taking three replicates at each site (Figure 4.2.3.a). An analysis of variation between replicates and cruises showed that there is often more variation in sediment types between replicates than over time or area. Bottom types were described in MWRA (STFP V N and O 1987) based on imaging from a remotely operated vehicle. These transects are useful in that they describe changing bottom conditions over a small area.

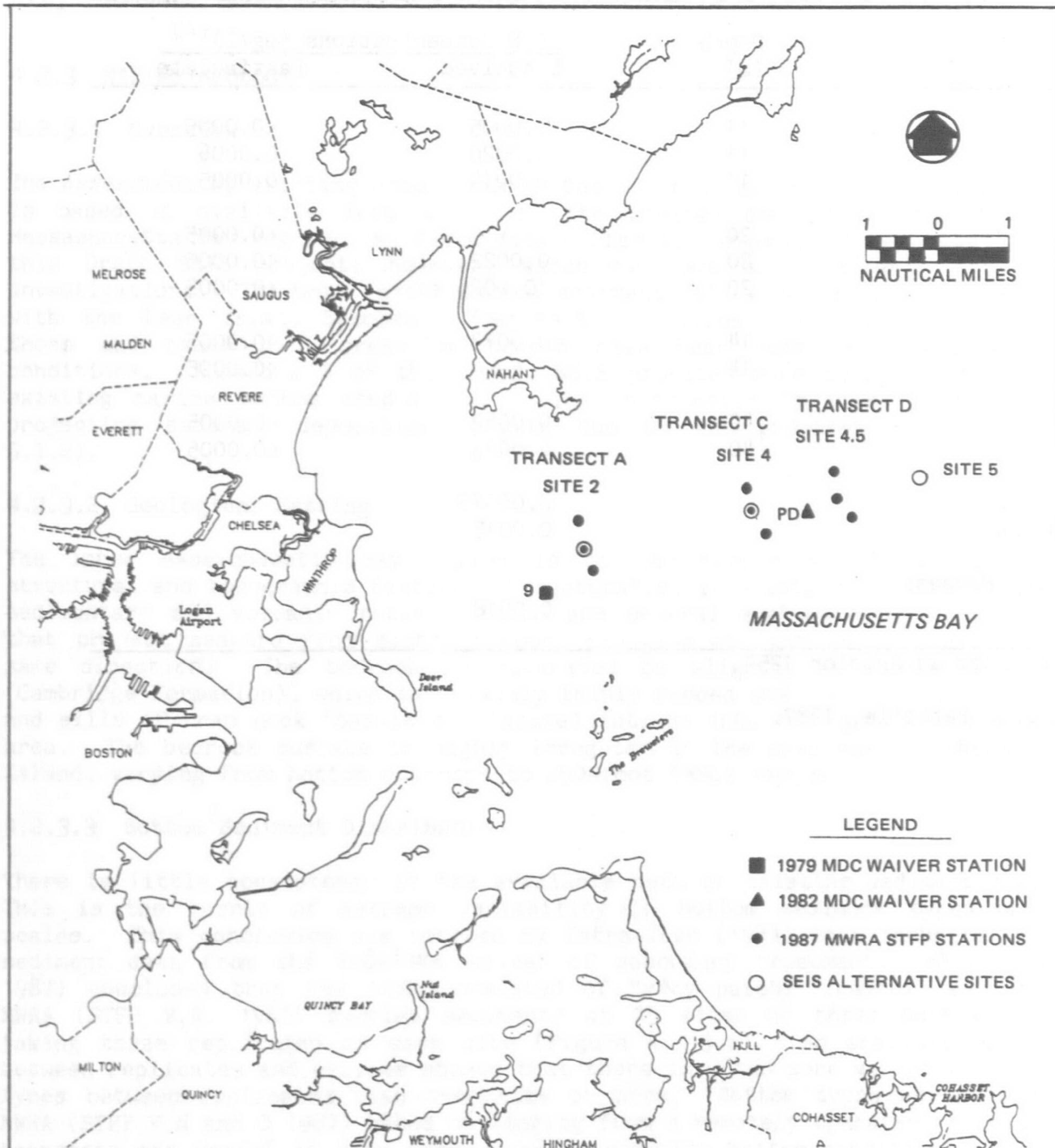
The available data indicate that bottom sediment types in the study area include silt, clay, mud, sand, gravel and rock. The bottom sediment types can vary on a scale of tens of meters; therefore, it is difficult to generalize bottom characteristics. The available data do, however, define the types and ranges of sediments encountered. In general, nearshore (Sites 2 and 2.5), have predominantly

TABLE 4.2.2.e CONCENTRATIONS OF PCB IN SEAWATER COLLECTED AT TWO STATIONS IN MASSACHUSETTS BAY IN APRIL, 1987

Station	Depth (m)	PCB Concentrations (µg/l)(1)	
		Dissolved	Particulate
B2	11	0.0005	<0.0005
B2	11	0.0020	0.0006
B2	11	0.0014	0.0005
B2	20		<0.0005
B2	20	0.0022	<0.0005
B2	20	<0.0025	<0.0005
H1	14	0.0073	<0.0005
H1	14		<0.0005
H1	40	0.0062	<0.0005
H1	40	0.0033	<0.0005
Field Blank		0.00075	
Field Blank		0.0015	
Laboratory Process Blank		0.0018	

1. Calculated as Aroclor 1254.

Adapted from Battelle, 1987.



SOURCE: ADAPTED FROM MWRA, STFP, VS, 1987 AND MDC WAIVER VOL. 1, 1984

FIGURE 4.2.3.a. GENERAL STATION LOCATIONS FOR SEDIMENT SAMPLING

silty sediments. Farther offshore (Sites 4 and 5), rocky bottom is more common than nearshore. Results of 1987 ROV surveys (MWRA, STFP V,O, 1987) show that areas at Sites 4 and 5 are generally covered with nearly equal areas of rocky and silty sediments with Site 5 having slightly more rocky area than Site 4. Table 4.2.4.b in section 4.2.4.1.1 of this Draft SEIS shows in greater detail the variability in sediment types between and within sites.

Several factors indicate that much of the bottom in the area of the alternative discharge sites can be characterized as non-depositional. This includes areas where no deposition is taking place, and areas where there is scour, or net removal of pre-existing bottom sediments. These areas of nondeposition may include a veneer of underlying sediments that have been reworked by recent marine processes.

A seasonal depositional cycle has been suggested by MWRA (STFP V,P, 1987) in locations where biogenically-bound mud covering exposed rock surfaces was observed in the summer. The same surfaces were free of mud in the winter. The death of tubiculous species that bound the mud, as well as increased turbulence, was cited as responsible for the loss of material. The same process was identified by Butman (1978; 1987) through bottom photographs and turbidity measurements. It was shown that the resuspension was a short-term, storm-related process in the winter months. Butman's data demonstrated that bottom velocities associated with winter storms ranged from 5 cm/sec in Stellwagen Basin to 40 cm/sec in inshore areas.

4.2.3.4 Sedimentation Rates

Existing sedimentation rates have been estimated in a number of past studies which have examined bottom sediments at various locations. The broad areas of clean gravel which cover much of Massachusetts Bay suggested to Fitzgerald (1980) that sediment accumulation has been negligible since glacial times. The rise in sea level has transferred the shoreline over the present inner shelf area. This has resulted in a reworking of glacial deposits, distributing a "skin" of marine sand and gravel over much of the area (Fitzgerald, 1980).

In the deeper water east of the Graves, Fitzgerald used the thickness of marine sediments and an average submergence time of 10,000 years to estimate that the average sedimentation rate was on the order of 0.006 cm/year. This rate accounted for all material overlying a Blue Clay deposit. Bothner (1987) estimated modern sedimentation rates to be 0.2 to 0.6 cm/year in Massachusetts Bay at a location 7 nautical miles east of Deer Island (Appendix B). This large range of accumulation rates in Massachusetts Bay is attributed to factors such as bioturbation and lateral sediment transport (Appendix B).

The larger topographic basins in deeper water, such as Stellwagen Basin, are dominated by relatively smooth surfaces and fine sediments (Schlee et al., 1973; MWRA, STFP V F and Q, 1987). These areas are likely areas for deposition of suspended sediments. Tucholke and Hollister (1973; in Butman, 1978) suggested that most of this deposition occurred just after the glacial retreat, and that the sedimentation rate has steadily decreased since then, with the current deposition rate in Stellwagen Basin estimated to be 0.001 to 0.002 cm/year.

Using the thickness of sediments inside Boston Harbor, Fitzgerald (1980) estimated sedimentation rates to be 0.014 and 0.016 cm/year, which probably represent a minimum Holocene sedimentation rate in the Harbor. A maximum rate was estimated to be 0.1 cm/year. This was based on an assumed 10,000 year period of deposition, which may render these estimates low. Pb-210 sedimentation rates were calculated by Fitzgerald (1980) at the entrance to Boston Inner Harbor (0.27 cm/year) and at the Inner Harbor in the vicinity of Fort Point Channel (0.4 cm/year). This approach was compared to a Corps of Engineers estimate of accumulation of 0.2 cm/year based on the volume of material collected between successive dredging operations in the Inner Harbor. Fitzgerald (1980) concluded that modern sedimentation rates were 0.2 to 0.3 cm/year in Boston Harbor. Using Pb-210 methods, one site in the Harbor showed a modern accumulation rate of 2 cm/year (Bothner, 1987).

In summary, available data indicate a wide variation in background sedimentation rates, although there is a general trend of higher sedimentation in Boston Harbor and lower sedimentation in deeper offshore basins (Table 4.2.3.a). In the area of the alternative discharge sites, the available data indicate deposition rates of 0.2 to 0.6 cm/yr (Bothner, 1987) and 0.006 cm/yr (Fitzgerald, 1980). As discussed in Appendix B, this is a wide range of values and it is possible that the higher rates are artificially high due to factors such as Pb-210 methods, bioturbation and lateral deposition. For this Draft SEIS a background sedimentation rate of 0.05 cm/yr was used since it is approximately one order of magnitude above and below the lowest and highest measurements, respectively. MWRA assumed that the background deposition rate was 0.1 cm/year (MRWA, STFP V,C, 1987). This higher background sedimentation rate would have the effect of diluting the concentration of any contaminants in the effluent particulates which reach the bottom. The lower rate used for this Draft SEIS (0.05 cm/year) is more conservative (i.e., provides less dilution of toxic compounds from the effluent).

TABLE 4.2.3.a SUMMARY OF REPORTED MASSACHUSETTS BAY AND BOSTON HARBOR SEDIMENTATION RATES

Location	Est. Method	Source	Rate (cm/yr)
Boston Harbor	Sediment Thickness	Fitzgerald, 1980	0.014-0.1
Boston Harbor	Pb-210	Fitzgerald, 1980	0.12-0.50
Boston Harbor	Dredging	USACE	0.2
Boston Harbor	Pb-210	Bothner 1987	2.0
Boston Harbor	Carbon Dates	Rosen, in progress	1.0
Mass Bay	10,000 yr cores	Fitzgerald, 1980	0.006
Mass Bay	Pb-210 and Artifact	Bothner, 1987	0.2-0.6
Stellwagen Basin	Various	Tucholke and Hollister, 1973	0.001-0.002
Mass Bay	-	MWRA, STFP V,C, 1987	0.1
Mass Bay	Lit. Rev.	This Draft SEIS	0.05

4.2.3.5 Sediment Chemistry

The contaminants for which effluent deposition impacts were assessed are summarized in Table 4.2.3.b. This list was developed using the effluent contaminant screening process developed in MWRA's STFP (MWRA, STFP V,A, 1987) and further screening as presented in Section 5.1.3 of this Draft SEIS.

TABLE 4.2.3.b CONTAMINANTS FOR ASSESSMENT OF SEDIMENT DEPOSITION IMPACTS

Compound		Class I Sediments threshold (ppm)[2]
PCB Compounds (total)		0.5
Metals		
	Arsenic	10
	Copper	200
	Mercury	0.5
	Nickel	50
	Selenium	--
	Silver	--
	Zinc	200
Pesticides		
	Aldrin	--
	4,4 - DDT[1]	--
	Dieldrin[1]	--
	Heptachlor	--
Acid, Base Neutrals		
	Butylbenzyl phthalate	--
	Di-n-octyl phthalate	--

1. Analyzed for public health impacts only
2. Barr (1987)

TABLE 4.2.3.c SUMMARY OF SEDIMENT PCB MEASUREMENTS

	Total PCB Concentration (ppm dry weight)[a]	
	Range	Average
Transect A (Site 2)	0.001-0.033	0.012
Transect C (Site 4)	<0.001-0.042	0.018
Transect D (Site 4.5)	<0.001-0.047	0.011

a. MWRA, STFP V,S, 1987.

Available data from MWRA (STFP V,S, 1987) and MDC (1984a and b) were used to assess background chemical concentrations in the existing bottom sediment. This information is summarized in Tables 4.2.3.c and 4.2.3.d for PCB's and metals. In general, little variation in PCB concentrations occurred between and within sites. All measured PCB concentrations are below the threshold of 0.5 ppm for Class I sediments using Massachusetts Division of Water Pollution Control (DWPC) dredged material classification (Barr, 1987). Class I sediments have the lowest chemical dredged material disposal restrictions (Appendix B). The highest concentrations for all metals generally occurred at Site 4. Concentrations of metals measured at all Sites fall below the DWPC Class I threshold for dredged materials and therefore are relatively clean by this standard (Appendix B). Appendix B provides additional information on these data.

The pesticides aldrin, 4,4-DDT, dieldrin and heptachlor were not analyzed by the MWRA. However, pesticide samples were collected at Station PD (Table 4.2.3.a) in 1982 (MDC, 1984a). Additional pesticide samples were collected in 1984; however, no sampling stations were located in the present study area (MDC, 1984a). For the 1982 data, no pesticides were detected using a detection limit of 0.040 ppm. Therefore, for this Draft SEIS analysis, background bottom sediment concentrations of 0.040 ppm were used for aldrin, 4,4-DDT, dieldrin and heptachlor.

Bis (2-ethylhexyl) phthalate, butylbenzyl phthalate and di-n-octyl phthalate were not measured in the STFP or by MDC (1984a). Thus for these compounds the effect of bioturbation mixing of effluent particulate cannot be fully evaluated. For the Draft SEIS a background concentration of zero in the existing sediments for these compounds was used to assess bioturbation mixing effects and to make relative comparisons among sites. The actual bottom sediment concentration after mixing will be higher if acid-base neutral compounds are present in the existing bottom sediments.

4.2.3.6 Bioturbation Mixing Depth

One of the processes which influences the impact of effluent suspended solids deposition is the mixing of bottom sediments by benthic organisms known as bioturbation. By this process the effluent particulates are incorporated and dispersed into the existing bottom sediments. As part of the MWRA, STFP (MWRA, STFP V P and Q, 1987) sediment profiling was used to measure the depth to which the fine grained bottom sediments are oxidized. This depth can be interpreted as a conservative indicator of biological mixing depth. In general, this depth varied from 2 to 4 cm, with occasional deeper measurements and frequent zero measurements due to rocky bottom. This range is consistent with measured values in similar temperate marine systems (Appendix B). For the purpose of assessing the impact of biological bottom mixing on the concentration of settled effluent particulates, a bioturbation mixing depth of 3 cm was used in this Draft SEIS. This value is reasonable and generally conservative based on the available data (Appendix B). Available data also indicate that the background bottom sediments are of lower chemical concentration than the effluent particulate, therefore, the greater the mixing depth, the greater the dilution of effluent particulate chemicals.

As an alternative, more conservative case, the impact of a zero mixing depth was also assessed. This situation might occur in a rocky bottom area where there is minimal soft bottom sediment but where periods of deposition may occur between resuspension events.

TABLE 4.2.3.d SUMMARY OF SEDIMENT METALS MEASUREMENTS

	Total Metal Concentration (ppm dry weight)[a] Range			Average
Transect A (Site 2)				
Arsenic	0.41	-	3.89	2.87
Copper	1.73	-	63.28	12.56
Mercury	0.02	-	0.38	0.15
Nickel	1.87	-	7.88	4.66
Selenium	NA			NA
Silver				2.4[b]
Zinc	9.70	-	47.32	26.12
Transect C (Site 4)				
Arsenic	4.30	-	6.76	5.53
Copper	9.15		44.62	17.88
Mercury	0.04	-	0.44	0.17
Nickel	5.27	-	13.97	9.24
Selenium	NA			NA
Silver	NA			NA
Zinc	30.03	-	152.51	47.55
Transect D (Site 4.5)				
Arsenic	3.17	-	7.24	4.62
Copper	1.09	-	16.84	6.71
Mercury	0.19	-	1.04	0.11
Nickel	2.30	-	8.85	4.88
Selenium				<2.0[c]
Silver				<0.1[c]
Zinc	11.45	-	107.6	25.03

(a) MWRA, STFP V,S, 1987, unless otherwise noted
(b) 1979 MDC Waiver Data, Station 9 (MDC, 1984).
(c) 1982 MDC Waiver Data, Station PD (MDC, 1984a).
(d) NA - not analyzed

4.2.4 MARINE ECOSYSTEM

This section presents information on baseline biological conditions in the area potentially affected by the operation of the effluent conveyance and dispersion structures. Biological communities described include infaunal and epifaunal benthic communities, phytoplankton, zooplankton, fish, marine mammals, turtles and seabirds. These communities are described in detail in Appendix C. Data used to describe these communities include data collected by MWRA (STFP V and Appendices, 1987) as well as historical data. Fig. 4.2.4.a presents the locations of the MWRA 1987 survey stations. The area under most intense evaluation in this section is the general transect starting nearshore at MWRA Site 2 and extending to MWRA Site 5.

4.2.4.1 Macrobenthos

The marine macrobenthic community is likely to be one of the better indicators of long-term environmental conditions of a marine or estuarine ecosystem because the adult stages of this community are relatively non-motile and long-lived. The benthos, therefore, can reflect the more long-term environmental conditions of the water and sediments prior to the time of sampling while planktonic organisms often reflect more short-term conditions indicative of the time of sampling. Although fish have a relatively long life span, they are mobile and often migratory and seasonal and can avoid an area which may be less suitable due to a transient condition such as lack of food. This section on macrobenthos presents a general description of benthic epifaunal species composition in the study area followed by a description of infaunal species composition.

4.2.4.1.1 Benthic Epifauna. The seafloor of Massachusetts Bay is very heterogeneous due to irregular changes in sediment ranging from patches of mud to areas of cobbles and boulders (Appendix B). Mobile and sessile epifauna generally exist where pebbles, cobbles and boulders are most prevalent (hard bottom areas), while infaunal communities generally exist in the soft bottom mud patches. Hard bottom areas are generally more prevalent at MWRA Sites 5 and 3.5 while soft bottom areas are generally more common nearshore at MWRA Sites 2 and 2.5. Typical epifaunal species in Massachusetts Bay include sessile species such as sponges, hydroids and bryozoans as well as several motile species including seastars, lobster and fish, such as cunner and ocean pout. A more complete description of epifauna in the study area is found in MWRA, (STFP V T, N and O 1987).

Extensive epifaunal surveys were conducted by MWRA in 1987 (MWRA, STFP V N,O,P,Q, and T, 1987). These surveys indicate that variations in epifaunal community structures between different sites relate to differences in bottom types in the study area. The heterogenous seafloor in Massachusetts Bay ranges from mud to sand to cobble to boulders. Different epifaunal assemblages are associated with these different bottom types. At least six different bottom types and associated epifaunal assemblages can be characterized from review of the MWRA 1987 Remotely Operated Vehicle (ROV) surveys. Table 4.2.4.a presents a summary of this information. Fig. 4.2.4.b shows where in the study area these bottom types are known to occur. In general, soft bottom areas (categories I and II; Table 4.2.4.a) have very few sessile epifaunal species with some motile species. Sessile epifauna are generally associated with rocks. Motile epifauna also tend to be more abundant in areas where rocks are present since the rocks provide shelter.

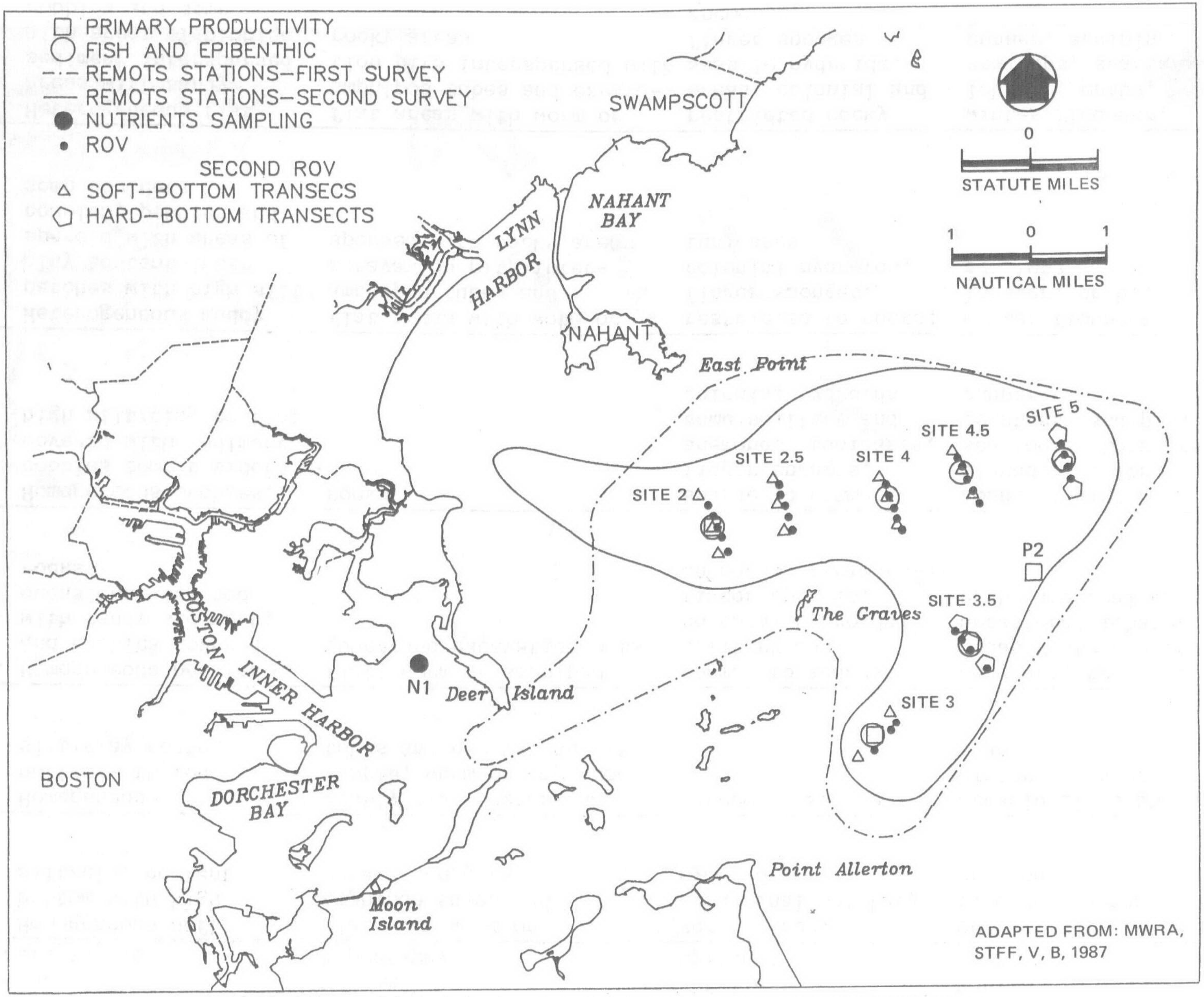
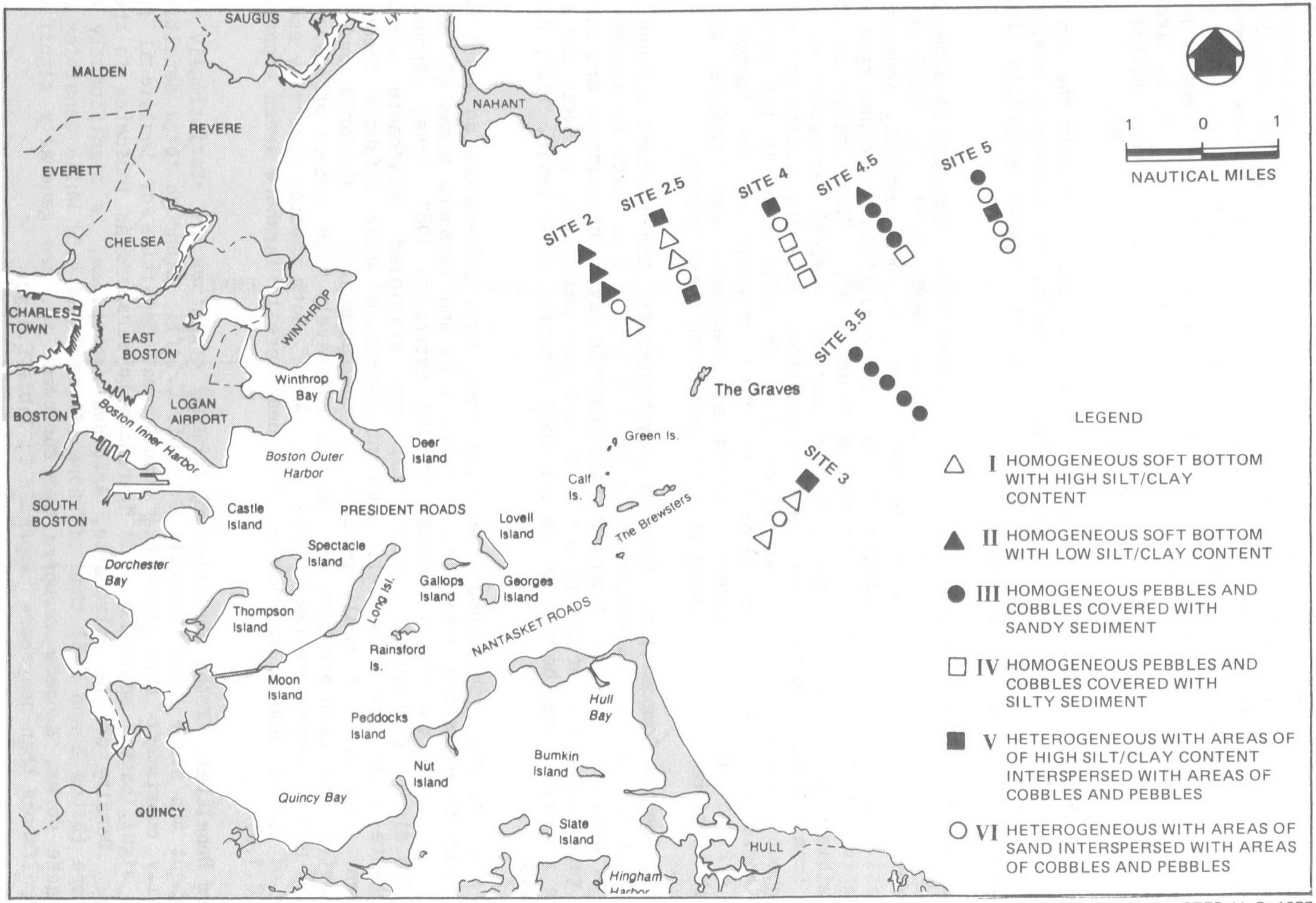


FIGURE 4.2.4.a. LOCATION OF MWRA SAMPLING LOCATIONS

TABLE 4.2.4.a SUMMARY OF GENERAL BOTTOM TYPES AND ASSOCIATED EPIFAUNAL ASSEMBLAGES

Sediment Characteristics	Bottom Topography	Sessile Epifauna	Motile Epifauna
I. Homogeneous soft bottom with high silt/clay content	flat with worm or amphipod tubes and excavation pits	very sparse; occasional solitary hydroid	occassional winter flounder, Jonah crab, scallop
II. Homogeneous soft bottom with low silt/clay content	Mostly flat, occasional ripple; worm or amphipod tubes and excavation pits	extremely sparse	occasional to abundant winter flounder, Jonah crab
III. Homogeneous pebbles and cobbles covered with sandy sediment; occasional exposed rocks	flat; worm or amphipod tubes and excavation pits	common to abundant solitary and colonial hydroids, finger sponges, anemones, cerianthids	seastars, sculpin, Ocean Pout, cunner, occasional lobster, crabs and scallops
IV. Homogeneous pebbles, cobbles some boulders covered with sediment high silt/clay content	rocky	sparse to common finger sponges, anemones, tunicates, some solitary and colonial hydroids	abundant winter flounder, crabs, scallops. Lobsters, seastars, sculpin, cunner
V. Heterogeneous muddy patches with high silt/ clay content inter- spersed with areas of cobbles, pebbles and some boulders	flat areas with worm or amphipod tubes and excavation pits inter- spersed with rocky areas	restricted to rocks; finger sponges, colonial hydroids, tunicates	winter flounder, lobster, crabs, scallops
VI. Heterogeneous flat areas with sandy sediment interspersed with areas of pebbles, cobbles and some boulders	flat areas with worm or amphipod tubes and excava- tion pits interspersed with rocky areas	restricted rocky areas; colonial and sessile hydroids, finger sponges anemones	winter flounder, lobster, crabs, scallops, seastars, cunner, sculpin



DATA SOURCE: MWRA, STFP, V, O, 1987

FIGURE 4.2.4.b. BOTTOM TYPES IN THE STUDY AREA

The epifauna biomass in the study area and Massachusetts Bay in general appears to increase between winter and summer. This increase in biomass is due to build-up of dense aggregations of tubiculous species on rock surfaces during periods of low energy. During these periods, almost all hard surfaces are covered with biologically-bound, silt-clay size material. This biogenically-bound mud contains some species that are otherwise typically infaunal. This phenomenon has been observed in several surveys (MWRA, STFP V O, P, Q, and S, 1987). It is likely that this animal sediment complex builds up in the low-energy summer months and is periodically removed during periods of high wave energy (Appendix B).

4.2.4.1.2 Benthic Infauna. The benthic infauna generally inhabit the mud or soft bottom patches in the study area. This community is generally dominated by polychaete worms capable of consuming particulate organic materials that have accumulated in the bottom sediments.

Evaluation of the most comprehensive data set (soft bottom sampling at Sites 2, 2.5, 3, 3.5 and 4; Fig. 4.2.4.a) for the study area (MWRA, STFP V,T, 1987) shows two distinct infaunal communities within the study area One community appears to be indicative of nearshore conditions (Sites 2 and 2.5) while the other type is more indicative of farshore conditions (Sites 4 and 4.5). This change in infaunal communities is due to differences in physical and chemical parameters as well as depth from nearshore to farshore along the transect. This distinction may not occur throughout Massachusetts Bay, but it has been shown to occur in the study area. This could be due to the deposit of fine material at the Harbor mouth. Table 4.2.4.b summarizes general trends at nearshore and farshore areas in Massachusetts Bay. The following is a discussion of these trends.

Infaunal Species Composition. Spionid polychaetes are the dominant infaunal taxon throughout the study area (Appendix C; Table C.1.d). This taxon is abundant in a range of sediment types and depths in Massachusetts Bay. The spionids are sedentary worms generally characterized by a pair of elongate palpi used to sweep the surface of the substratum and bottom waters for food (Gosner, 1971; Levin, 1981; Dauer et al., 1981).

While spionids occur throughout the study area, some differences do exist between other taxa in nearshore areas (Sites 2 and 2.5) and farshore areas (Sites 4 and 4.5). This was especially evident in the extensive 1987 survey (Appendix C; Table C.1.d). Cirratulid, capitellid, and aricidiad polychaete worms and oligochaete worms are relatively abundant nearshore while offshore these taxon represent only a very small portion of the community. Maldanid and syllid polychaetes, amphipods and bivalves occur in relatively high numbers offshore and in very low numbers nearshore (MWRA, STFP V,T, 1987). Both species diversity and total number of species appear to increase from nearshore to farshore areas (Appendix C; Table C.1.e).

Species Densities. Total densities of infaunal organisms are statistically similar throughout the study area (Appendix C; Table C.1.f). Although total densities are spatially consistent throughout the study area, densities of individual species differ significantly spatially from nearshore to farshore as indicated in the 1987 survey. Density of the polychaete, ***Aricidea catherinae***, is significantly higher nearshore (Sites 2 and 2.5) than offshore (Sites 4 and 4.5) while densities of the polychaete worms, ***Exogene verugera*** and ***Euclymene*** sp. are generally significantly higher offshore than nearshore (Appendix C; Table C.1.g).

TABLE 4.2.4.b GENERAL CHARACTERIZATION OF NEAR SHORE AND FAR SHORE PARAMETERS IN MASSACHUSETTS BAY

	Bottom Type	Depth (m)	Water Column Nutrients	Density of Organisms	Dominant Taxa	Infaunal Temporal Patterns	Evidence of Stress
Nearshore (Sites 2, 2.5)	Sand and silt prevalent	Shallower (22-26)	Higher	Not significantly different from far shore	*Aricidiad*, Cirratulids, Spionids	Total densities decline by end of summer	Elevated metal and PAH concentrations; higher abundance of opportunistic species
Farshore (Sites 4, 4.5)	Cobbles and pebbles prevalent	Deeper (28-32)	Lower	Not significantly different from near shore	Spionids, Syllids, Amphipods	Total densities decline by end of summer	None

Temporal Patterns. The information on infaunal benthic communities in the study area and Massachusetts Bay in general is only available from spring and summer. Although no real changes in sediment type or species composition appear to occur throughout the spring and summer, densities of organisms apparently decline between spring and summer. This decline appears to be the result of changes in densities of dominant species. Nearshore (Sites 2 and 2.5), the densities of the dominant species *Aricidea catherinae, Prionospio steenstrupi,* and *Tharyx acutus* declined gradually throughout the summer in 1987. Offshore (Sites 4 and 4.5), the dominant species *Prionospio steenstrupi* and *Exogone verugera* also declined in density from spring to summer (MWRA, STFP V,T, 1987). The decline in densities of these dominant species is likely the results of two factors: one is reduced recruitment as evidenced by large declines in smaller animals (MWRA, STFP V,T, 1987), the other factor appears to be mortality of all size classes, perhaps due to predation.

Evidence of Stress. The relatively high levels of PAH's and certain metals in nearshore areas (MWRA, STFP V,S 1987; Appendix B) may be indicative of a somewhat stressed benthic environment in this area. Species known to be opportunistic or pollution-tolerant (Pearson and Rosenberg, 1978) are not highly dominant in the study area as a whole; however, two pollution tolerant taxa, the polychaete, *Mediomastus californiensis* and oligochaete worms are relatively common nearshore (MWRA, STFP V,T, 1987). This may indicate that the nearshore area may be somewhat stressed. Also, pollution sensitive species such as amphipods (Maughan, 1986; Pearce, 1972; Bottom, 1979; Steimle, 1982) are more abundant offshore than nearshore, indicating that conditions offshore may be relatively less stressed than nearshore.

4.2.4.1.3 **Benthic Communities in Boston Harbor.** The benthic communities in Boston Harbor generally consist of two distinct communities. One type of community inhabits the southern portion of the harbor while the other occurs in the northern portion. The community in the southern part of the Harbor (near Nut Island) is generally characterized by moderately dense communities with a high number of taxa, high evenness and diversity and with relatively high numbers of pollution sensitive amphipods (MDC, 1984a and b).

The northern part of the Harbor, in the vicinity of Deer Island and west of Deer Island, is characterized by a benthic community that appears to be more impacted by pollution than the southern community. The benthic community at Deer Island Flats (west of Deer Island) and the mouth of the Inner Harbor exhibits several ecological community indices which are indicative of a stressed macrobenthic community, including low species diversity, dominance by a few opportunistic species and few amphipods (MDC, 1984a and b; MDC, 1979; Rowe et al., 1972).

4.2.4.2 Plankton

4.2.4.2.1 **Phytoplankton.** Several studies on phytoplankton and primary productivity have been conducted in the Gulf of Maine and its coastal embayment, Massachusetts Bay. The following is a description of general phytoplankton distribution in the Gulf of Maine and Massachusetts Bay.

General. Marshall and Cohn (1984) summarized several years of National Marine Fisheries Service (NMFS) Marine Monitoring Assessment Program (MARMAP) phytoplankton cruises in the northeastern continental shelf. Phytoplankton populations over the northeastern shelf where found to consist of a diverse assemblage of species that differ seasonally in composition across the shelf. The most abundant phytoplankters can be divided into three major groups: the small-sized diatoms, the phytoflagellates, and the nannoplankton (mainly 2 to 10 μ size range). The small diatoms were seasonally associated with the spring and fall bloom periods, with highest concentrations close to large estuary systems. According to Marshall and Cohn (1984), lower diatom densities generally occurred seaward with patches of high densities associated with Georges Bank. The phytoflagellates occurred in high numbers in late spring and summer. The nannoplankton component of the phytoplankton was generally non-flagellate. This community is generally abundant and widespread over the continential shelf, (Marshall and Cohn, 1984).

Phytoplankton communities of low densities (approximately 50,000 cells per liter) generally dominated by dinoflagellates or diatoms, occur from November to February in the Gulf of Maine and Massachusetts Bay (TRIGOM, 1974). From February to June various diatoms bloom. Spring blooms in Massachusetts Bay generally occur by April. These blooms result in densities of over a million cells per liter. Summer blooms of small-sized coccolithophores are common in open basins of the Gulf of Maine while certain diatoms may bloom in early fall in the more coastal areas. Secondary late summer and fall blooms of some diatoms occur in Massachusetts Bay (TRIGOM, 1974).

Massachusetts Bay Studies. Similar to the general pattern described above, maximum phytoplankton densities in Massachusetts Bay occur during spring (March to May) and fall (September to October) diatom bloom periods (MWRA, STFP V,Z, 1987; Parker, 1974). Primary productivity is generally highest during the spring bloom period in March (Parker, 1974). There appears to be a marked offshore trend of decreasing primary productivity and phytoplankton biomass associated with a parallel decline in nutrient concentration (Appendix C).

Parker found that variation in specific productivity rates and variation in chlorophyll content were directly related to observations made on nitrogen-deficient cultures of marine phytoplankton, suggesting that nutrient availability (specifically nitrogen) had a strong influence on the initiation and duration of the major bloom periods. According to Parker (1974), nutrient addition from land drainage into the inner harbor area is transported into Massachusetts Bay and appears to be the most significant variable that contributes to spatial differences in primary productivity. The 1987 survey confirmed that nitrogen is the limiting nutrient in these waters, based on production levels and nitrogen-to-phosphorus ratios.

Significant chlorophyll a concentrations (indicating the presence of phytoplankton) occurred in deep water and the stratified surface layer during the 1987 survey. Nannoplankton (the <10 μ size fraction) accounted generally for more than 70 percent of the total chlorophyll concentration. During the 1987 survey, "surges" of nitrogen and phosphorus which coincided with incursions of colder water occurred twice (MWRA, STFP V Y and Z, 1987). The origins of these surges are unknown.

The mean carbon growth rates during the 1987 survey were similar at all stations, approximately 0.5 g C/day, corresponding to a mean population carbon doubling time of <18 hours. This indicates that the phytoplankton communities at all the sites were in a similar physiological state suggesting that nearshore Sites (P1 and P3;

Fig. 4.2.4.a) were under no more stress than offshore sites (P2; Fig. 4.2.4.a). These phytoplankton communities appear to have similar species composition at all sites but with higher densities and production rates near the harbor.

In summary, the principal components of the phytoplankton communities in the Massachusetts Bay surveys reflect normal occurrence of the summer flora of New England temperature coastal waters with flagellates being abundant throughout the summer and diatom blooms occurring in spring and fall (Marshal and Cohn, 1984; and Marshal, 1984a; Marshall, 1984b, Marshall, 1984; NMFS, MARMAP 1978-1985). Trends of decreasing productivity, chlorophyll a concentration and phytoplankton density with increasing distance from shore occur in Massachusetts Bay. The limiting nutrient in phytoplankton production in the study area is nitrogen.

4.2.4.2.2 Zooplankton. Zooplankton comprise the animal component of the plankton and may be divided into two major groups, the neritic and oceanic zooplankton. The neritic zooplankton exist along the coast and seaward to about 100 meters in depth. The zooplankton occurring in the study area are generally neritic (TRIGOM, 1974).Although no specific data is available on trends in zooplankton densities, it is likely that the relative density of zooplankton reflect the relative densities of their food source, the phytoplankton. Hence, zooplankton densities likely decrease with increasing distance from shore in Massachusetts Bay.

Ichthyoplankton are the component of the zooplankton that consist of fish larvae and eggs. Lux and Kelly (1978) summarized NMFS ichthyoplankton data collected in Massachusetts Bay from 1976 to 1977. Their results show that the abundance of fish eggs and larvae in Massachusetts Bay was low in late winter, increased to a peak in June and declined considerably by August (Appendix C). This appears to be the typical seasonal pattern for ichthyoplankton in Massachusetts and Cape Cod Bays (Anderson and McGrath, 1976).

4.2.4.2.3 Plankton Communities in Boston Harbor. In general, based on a review of several plankton studies in Boston Harbor, both the phytoplankton and zooplankton communities appear to be uniform throughout Boston Harbor. The plankton community composition appears generally similar to that of Massachusetts Bay (MDC,1979; 1984a).

4.2.4.3 Fish

Quantitative information on fish communities in Massachusetts Bay is somewhat limited and not site specific; however, a wide variety of fish investigations have been conducted in the Gulf of Maine and Massachusetts Bay. Most work has been conducted by NMFS and Massachusetts Division of Marine Fisheries (DMF). NMFS is involved in such programs as groundfish surveys, MARMAP, and population dynamics studies of commercially important species (TRIGOM, 1974). Understanding the population dynamics of fish in the Gulf of Maine as well as Massachusetts Bay is important because of the cosmopolitan and migratory nature of fish. The distribution of fish in Massachusetts Bay is highly influenced by the Gulf of Maine. The following is a general description of fish populations in the Gulf of Maine and Massachusetts Bay.

4.2.4.3.1 General. Fish species generally migrate in response to seasonal and local variations in temperature. Seasonal temperature variations therefore have the greatest influence on the seasonal abundance, distribution and species composition of the fish fauna in the study area. Seasonal temperature conditions that influence the fish populations in the study area include the cold water barrier at Cape Cod, which separates the Gulf of Maine from the Mid-Atlantic Bight from June to September by means of a sharp temperature differential. During the rest of the year, a temperature continuity exists between the areas. Temperatures in the Gulf of Maine waters are generally similar throughout the Gulf seasonally while the temperature of Mid-Atlantic Bight waters varies spatially (TRIGOM, 1974).

The Mid-Atlantic Bight contains very few permanent residents and is composed of continuously shifting populations, while the Gulf of Maine contains mostly endemic species with some seasonal change in species composition. In the Mid-Atlantic Bight, a population of southern migratory fishes follows a northern dispersal to Cape Cod (Fig. 4.2.4.c; Table 4.2.4.c; TRIGOM, 1974; Bigelow and Shroeder, 1953). Many of these species including spiny dogfish, American shad, hakes and mackerel enter the Gulf of Maine and Massachusetts Bay and remain there throughout the summer. In winter, they migrate either south or to the warmer continental slope waters in the Gulf of Maine. The Mid-Atlantic Bight populations are "replaced" by a limited seasonal diffusion of a few species that are endemic to the Gulf of Maine, but which "spill over" to the Mid-Atlantic Bight in winter (TRIGOM, 1974).

During winter, many summer migratory species move to the warm slope water off southern New England. These species include red hake, silver hake, scup, butterfish, summer flounder and goosefish, as well as some less common species (Table 4.2.4.c). The winter component of fishes migrating from the north and east consist of Atlantic cod, yellowtail flounder, and longhorn sculpin, (TRIGOM, 1974). Generally, the fishes of the summer component are most abundant on inshore grounds when the water temperature is the same as that in which they were most abundant offshore.

Generally, almost all non-migratory species exhibit some seasonal movement. Fish are generally scarce along nearshore areas in the Gulf of Maine in winter. Only sea raven, or longhorn sculpin occur in shallow waters in winter. In March, winter flounder, ocean pout, sculpin and little skate appear nearshore. Later in the summer, cunners, alewife and lumpfish occur. In the fall the process is reversed (TRIGOM, 1974).

Appendix C presents information on the life histories of several species occurring in Massachusetts Bay.

4.2.4.3.2 Massachusetts Bay. Information on fish in Massachusetts Bay is available from the NMFS biome program, semi-annual trawl surveys of demersal fish, by Massachusetts Division of Marine Fisheries (MDMF) as well as a limited 1987 MWRA survey (Appendix C; Table C.1.k and C.1.l).

MDMF surveys of May and September bottom trawls from 1978 to 1986 show that winter flounder is the most abundant species in all depth intervals sampled in May and remains the most abundant species in September although actual abundance decreased at all depths from May to September. Winter flounder in Massachusetts Bay are known to disperse to deeper water throughout the summer after spawning in Boston Harbor in spring; however, they generally do not migrate a great distance (Howe and Coates, 1975). Atlantic cod and ocean pout are also abundant in May but declined

TABLE 4.2.4.c SEASONAL MIGRATION CHARACTERISTICS OF SOME IMPORTANT FISH SPECIES

Common Name	Species Name
I. Southern summer migrants (north to Cape Cod)	
Summer flounder	*Paralichthys dentatus*
Scup	*Stenotomus chrysops*
Weakfish	*Cynoscion regalis*
Kingfish	*Menticirrhus saxatilis*
Mullets	*Mugil sp*
Black seabass	*Centropristes striata*
Filefishes	*Aluterus sp., Monacanthus sp.*
Pompanos	*Caranx hippos* and other species
Northern puffer	*Sphaeroides maculatus*
II. Northern summer migrants (north into the Gulf of Maine)	
Spiny dogfish	*Squalus acanthias*
Silver hake	*Merluccius bilinearis*
Red hake	*Urophycis chuss*
White hake	*Urophycis tenuis*
American shad	*Alosa sapidissima*
Striped bass	*Morone saxatilis*
Menhaden	*Brevoortia tyrannus*
Bluefish	*Pomatomus saltatrix*
Atlantic mackerel	*Scomber scombrus*
Butterfish	*Peprilus triacanthus*
Bluefin tuna	*Thunnus thynnus*
III. Southern winter dispersal	
Atlantic herring	*Clupea harengus*
Atlantic cod	*Gadus morhua*
Pollock	*Pollachius virens*

Source: TRIGOM, 1974.

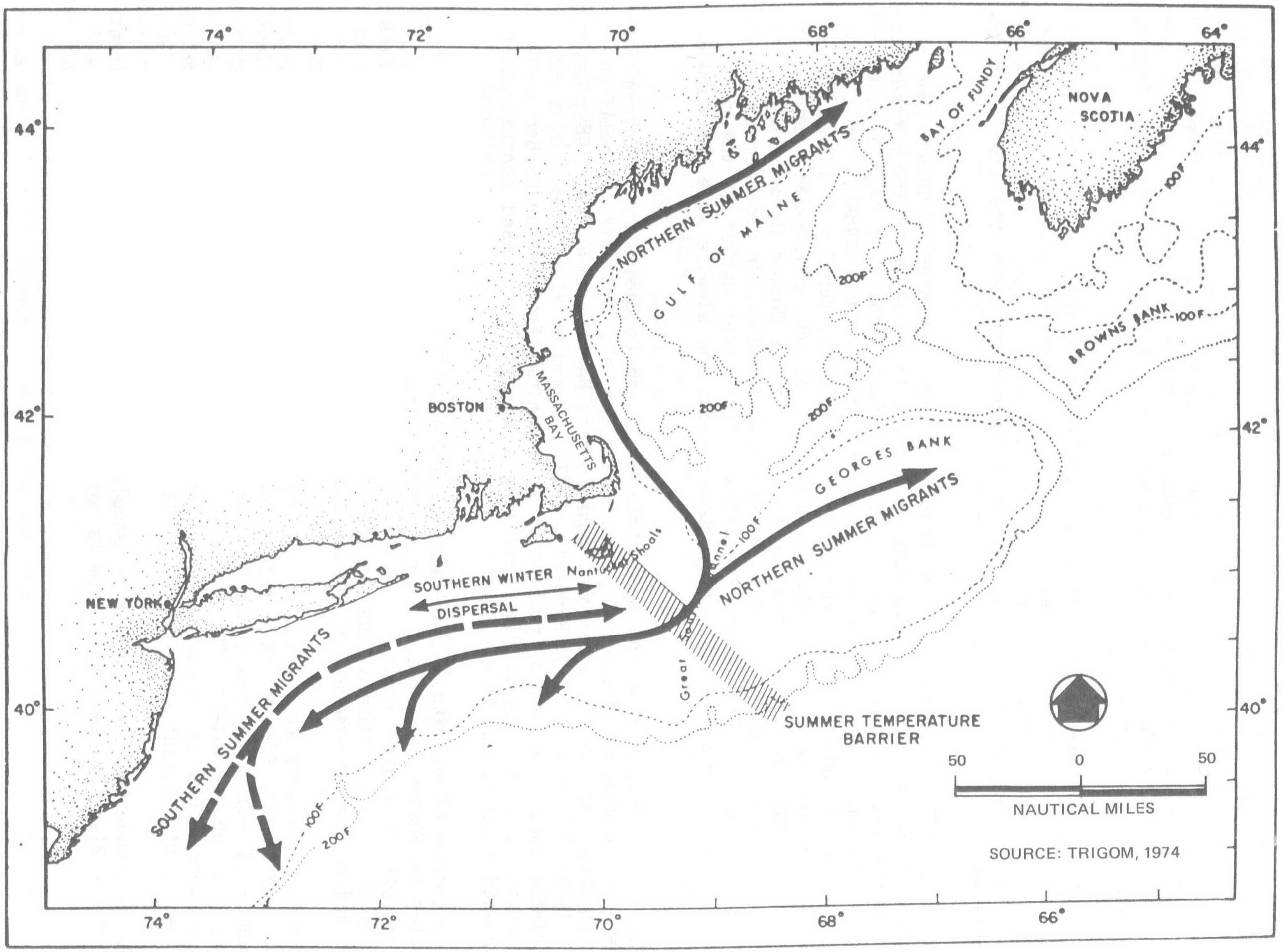


FIGURE4.2.4.c.GENERAL MOVEMENT OF MIGRATORY FISH SPECIES IN THE NORTHWESTERN ATLANTIC OCEAN.

substantially in September. These two species are relatively less abundant in the shallower waters in both May and September. Cod are known to migrate south to spawn in warmer waters during fall and winter. Ocean pout spawn in southern New England waters (including the present study area) in fall (Grosslein and Azarovitz, 1982). A total of 42 species have been collected in these DMF surveys over the sampling period. Total abundance of all species combined tends to decrease from May to September at all depths.

The data on the abundance of shellfish collected in the same DMF trawls from 1978 through 1986 indicate that American lobster (*Homarus americanus*) is the most abundant epifaunal shellfish species in May for all depths. Its numbers tend to increase in deeper offshore water in September as does the rock crab *(Cancer irroratus)*.

4.2.4.3.3 Fish Communities in Boston Harbor. Winter flounder are abundant throughout Boston Harbor. This species appears to dominate in the northern part of the Harbor (west of Deer Island). Demersal fish density is high in the northern part of Boston Harbor but species diversity is low (MDC, 1984). In the southern part of Boston Harbor (in the vicinity of Nut Island), density of fish is lower than the northern harbor but diversity is higher. Pollock, cod, skate, and cunner were also relatively abundant in the southern portion of Boston Harbor (MDC 1984; MDC, 1979; DMF, 1979). Haedrich and Haedrich (1974) found winter flounder dominating the fish population within the upper reaches of the inner harbor at the mouth of the Mystic River. In spring and early summer smelt and alewife were also abundant in this area.

4.2.4.3.4 Demersal Fish and Epibenthic Shellfish Contamination. Several studies have been conducted documenting demersal fish and epibenthic shellfish tissue contamination in Boston Harbor and Massachusetts Bay (Boehm et al., 1984; Capuzzo et al., 1986; MDC, 1984a; 1979; Schwartz, 1987). Boehm et al. (1984) made a comparison of tissue concentrations of pollutants in organisms from Boston Harbor to those in organisms in Massachusetts Bay, revealing a trend of increased contamination with increased proximity to Boston Harbor.

The presence of elevated tissue concentration of PCB's and PAH's in the demersal species in Boston Harbor and vicinity may be the result of the current wastewater discharges in Boston Harbor. PCB's and PAH's from the present discharges may accumulate in the sediments and be transferred to these demersal organisms as they feed and as they otherwise contact the sediment.

Boehm et al. (1984) also evaluated coprostanol, considered a sewage tracer, and its relationship with PCB levels. Coprostanol/PCB ratios have been used to relate the presence of PCB with sewage-ralated material. The ratios range from zero (no sewage) to approximately 200 (Boehm et al., 1984). The highest coprostanol/PCB values were found in Boston Harbor with intermediate values occurring offshore, indicating significant sewage-related PCB transport offshore (Boehm et al., 1984).

MWRA is conducting bioaccumulation studies in support of the Secondary Treatment Facilities Plan; however, this data is not yet available.

4.2.4.4 Marine Mammals

4.2.4.4.1 Whales. Finwhales, humpback whales, minke whales, right whales and sei whales have been known to occur in Massachusetts Bay. All of these species with the exception of the sei whale are listed on the federally endangered species list. Table C.1.p in Appendix C summarizes the ranges of these species. These species primarily occur offshore of the study area (NMFS, 1988; Kenney and Winn, 1987). The highest use areas by whales in the vicinity of the study area is Stellwagen Bank and basin (Kenney and Winn, 1987).

4.2.4.4.2 Seals. Two species of pinipeds, harbor seals *(Phoca vitulina)* and the gray seal *(Halichoerus grypus)* are known to occur in Massachusetts Bay and the Gulf of Maine. The harbor seal is found year-round in inshore waters basking on nearshore half-tide ledges and islands. The gray seal is found among the harbor seals only during the warmer summer months. Gray seals are capable of long periods of pelagic existence. Table C.1.q of Appendix C summarizes the distribution and abundance of these two seals (TRIGOM, 1974).

4.2.4.5 Marine Turtles

Three species of marine turtles are known to occur in Massachusetts Bay, the leatherback turtle (*Demochelys coriacea*), Kemp's Ridley turtle (*Lepidochelys Kempi*) and the loggerhead turtle (*Caretta caretta*). Loggerheads are listed as threatened. Leatherbacks and loggerheads are listed as endangered and threatened respectively by NMFS. Leatherback turtles are highly pelagic. Sitings off Massachusetts are most common from July to September (CeTAP, 1982). Ridley's turtles occur off southern New England in summer. This species uses inshore embayments, estuaries and harbors to feed (NMFS, 1988). Loggerhead turtles are rare north of Cape Cod. Generally, Massachusetts is the northern range limit for loggerheads, therefore these waters are marginal habitat (Payne and Ross, 1986).

4.2.4.6 Seabirds

Manomet Bird Observatory (MBO) has conducted standardized bird surveys east of the present study area in Stellwagen Basin from 1980 to 1985. The species observed in these surveys are typical of the Gulf of Maine and are generally the same species that would occur in the present study area. Dominant taxa include alcids, gulls and shearwaters. Of the species occurring in the study area, Leach's storm-petrel is listed as threatened by the state of Massachusetts. Table C.1.r of Appendix C summarizes the feeding behavior of the dominant species. Some coastal species including seaducks, grebes, loons, petrals and terns may also occur in the study area.

4.2.5 HARBOR RESOURCES

Harbor resources discussed in this section include the natural, commercial, and recreational resources of Boston Harbor and adjacent Massachusetts Bay that could potentially impacted by the construction and operation of the effluent outfall and dispersion structure. Harbor resources and impacts are described in detail in Appendix D, with emphasis on the marine transportation aspects of this and related projects which could impact existing harbor resources. MWRA also presents a description of some harbor resources (MWRA, STFP V,L, 1987). The affected harbor resources environment is summarized below. Potentially affected harbor resources are navigation, commercial shipping, commercial fishing, recreation, and marine archaeology.

4.2.5.1 Navigation

Navigation channels and anchorages provide commercial and recreational boating routes from Massachusetts Bay to the marinas and commercial port facilities of Boston Harbor. These channels and anchorages support shipping, commercial and recreational fishing, and pleasure boating and will be used by project-related marine traffic. Two major channels serve Boston Harbor, passing through President Roads and Nantasket Roads (Fig. 4.2.5.a). The President Roads Channel serves port and pier facilities in Boston, Charlestown, East Boston, South Boston, Everett, Chelsea, and Revere (Boston Shipping Assn., 1986). The channel passing through Nantasket Roads serves the industrial waterfront of Quincy including the former General Dynamics Shipyard now owned by MWRA. A single designated anchorage area for large vessels, located west of Deer Island, is used by 95 percent of commercial shipping traffic which needs to anchor due to delays in loading or unloading (USACE, 1984). Channels and anchorages are periodically maintained by the U.S. Army Corps of Engineers. Improvement dredging will likely occur within the inner harbor on the Mystic and Chelsea Rivers and the Reserved Channel in South Boston during the project construction period, as will dredging for the Third Harbor Tunnel/Central Artery highway project (Appendix D). Navigation resources are shown in Fig. 4.2.5.a.

4.2.5.2 Commercial Shipping

Commercial shipping contributes significantly to local and regional economies surrounding Boston Harbor (Appendix D). The inner Boston Harbor waterfront supports roughly two dozen public and private port facilities. Nearly 7,000 commercial vessel round trips occur yearly. Most of the commercial vessel traffic enters and leaves the harbor via the President Roads channel traveling to and from port facilities on the Boston, Chelsea River, and Mystic River waterfronts with the remaining traffic traveling through Nantasket Roads to the Quincy waterfront on the Weymouth Fore River. In 1985, 6,266 vessels traveled through President Roads and 633 through Nantasket Roads (USACE, 1986).

Commercial shipping traffic is expected to remain stable or increase slightly during the next decade (Habel, 1987). In addition to commercial shipping activity, sightseeing and whale watching cruises and passenger ferry services operate from piers at Logan Airport, Hull, Hingham, the Boston Harbor Islands State Parks (seasonal), and downtown Boston wharves (Fig. 4.2.5.b). Commuter ferries carried an average of 931 passengers per day in 1985 (MWRA, WTFP 7, 1987). Most ferry vessels operating in Boston Harbor have the capacity for approximately 150 passengers.

4.2.5.3 Commercial Fishing

Commercial fishing in the Boston Harbor vicinity consists largely of lobster fishing, shellfish (clam and mussel) harvesting, and finfishing by draggers and gillnetters. Shellfish and lobster harvest is allowed and takes place inside and outside the harbor, while commercial finfishing is prohibited within the harbor, but

LEGEND

Navigation Channels

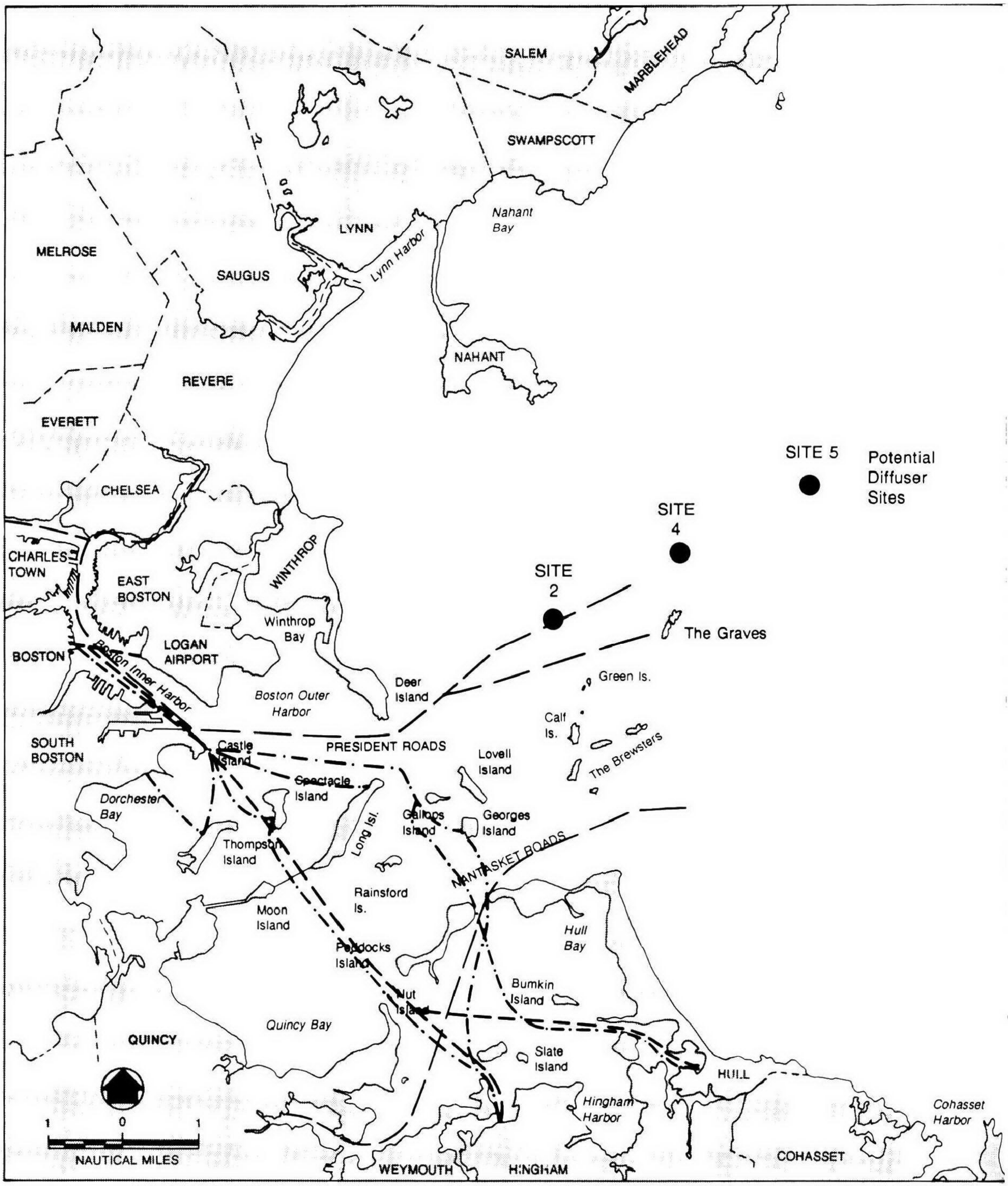
Anchorage #2

Third Harbor Tunnel Dredging 1991 – 1992

U.S. Army Corps of Engineers Improvement Dredging 1988 – 1995

Sources: NOAA Nautical Charts, USACOE, 1987
USACOE Project Maps, 1986
Federal Highway Admin., 1985
MWRA STFP VL, 1987

FIGURE 4.2.5.a. COMMERCIAL NAVIGATIONAL RESOURCES



LEGEND

Commercial Vessels

Boston Harbor Island State Park Ferries (Projected and Existing)

Commuter Service and Logan Shuttle

Source: Boston Harbor Islands State Park 1986 Master Plan, Mass Dept. of Environmental Management Massport, 1987 B, Boston Shipping Association, 1986

FIGURE 4.2.5.b. TYPICAL COMMERCIAL AND PASSENGER SHIP ROUTES

does occur in Massachusetts Bay. Boston commercial fishing landings for 1986, which include fish harvested outside the study area, included 4 million pounds of lobster and 17.5 million pounds of finfish (MDMF 1987; MWRA, STFP V,L, 1987). More than 5,000 acres of shellfish beds exist in Boston Harbor, but at present, unacceptable levels of coliform bacteria have caused more than half of the existing shellfish bed acreage to be closed. Harvest of the remaining shellfish beds is limited to licensed Master Diggers whose harvest is processed at the Newburyport depuration plant before being consumed (MWRA, STFP V, 1987; MDC, 1984). Lobster fishing is generally concentrated inside the harbor in summer and outside the harbor in fall and winter (MDC, 1984a).

Herring *(Clupea herangus herangus)* winter flounder *(Pseudopleuronectes americanus)*, yellowtail flounder *(Limanda ferruginea)* and cod *(Gadhus morhua)* are major finfish commercially harvested in the project area. Virtually the entire study area east of a line from Deer Island to Hull is utilized by commercial fishermen (MDMF, 1988).

Site 2 is in a restricted area inshore of the spawning closure and the trawl closure line (Fig. 4.2.5.c) and so is intensively fished during January but closed to trawling for the rest of the year. Sites 4 and 5 are fished less intensively than Site 2, but are open to fishing more of the year.

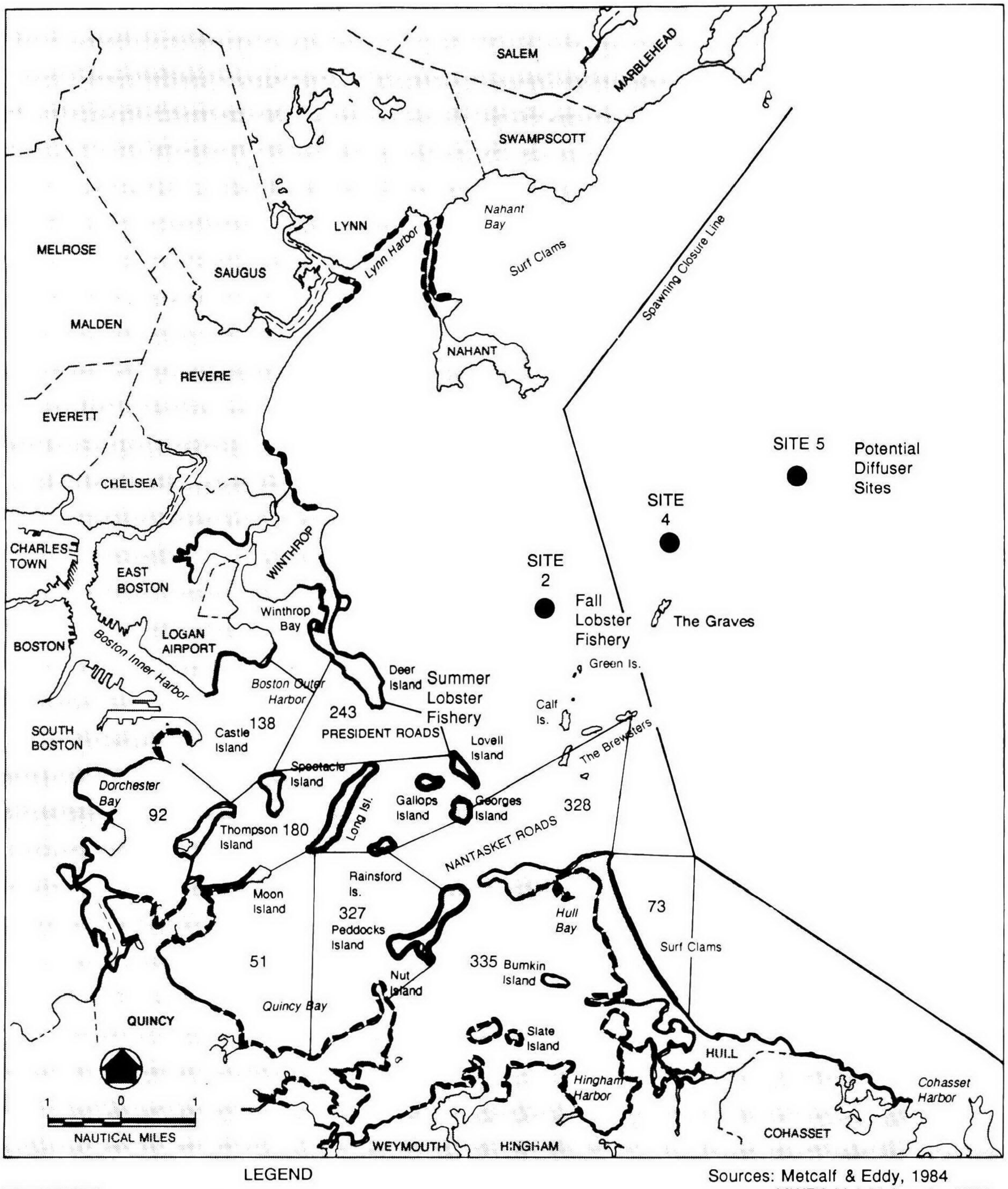
4.2.5.4 Recreation

Recreation areas and facilities are located along the shoreline of Boston Harbor and the harbor islands and on the coast along Massachusetts Bay north and south of the harbor. Recreational resources include parks, beaches (Fig. 4.2.5.d), boating facilities, fishing facilities, and sightseeing and whale watching vessel services. More than 100 recreational beaches and parks and 150 facilities for recreational boating are present in Boston Harbor and Massachusetts Bay from Lynn to Scituate (MWRA, STFP V,L, 1987). Boston Harbor Islands State Park encompasses 9 major islands, each with various recreational facilities available and serviced by seasonal passenger ferries (Appendix D).

Recreational fishing takes place in the harbor and throughout the Massachusetts Bay area. Most anglers utilize their own boats, lease boats, or use the available party boats and charters based in the area. The recreational fishing industry in the Boston area once thrived but has been depressed in recent years because of the negative publicity on harbor pollution and contaminated or cancerous fish.

Recreational fishing activity generally occurs from spring through fall with peaks during the summer vacation months. The Massachusetts Division of Marine Fisheries (MDMF, 1988) has indicated that this activity occurs at all candidate outfall sites. However, the most popular areas are located inshore of Site 2 and the "B" buoy located about one mile south of Site 5. Other popular areas include the Harbor Islands, Graves Light, Boston Light, and the Three and One-Half Fathom Ledge.

The most popular target species include winter flounder, cod, mackerel, and bluefish.



LEGEND

98	Approximate Number of Lobster Buoys 7/27/79
━━━━	Shellfish Beds Closed to All Diggers (Closure Varies w/Conditions)
━ ━ ━	Shellfish Beds Restricted to Master Diggers

Sources: Metcalf & Eddy, 1984
MWRA Vol. V App. L, 1987
MWRA Vol. V App. B, 1987
MDMF, 1988

FIGURE 4.2.5.c. COMMERCIAL FISHING RESOURCES

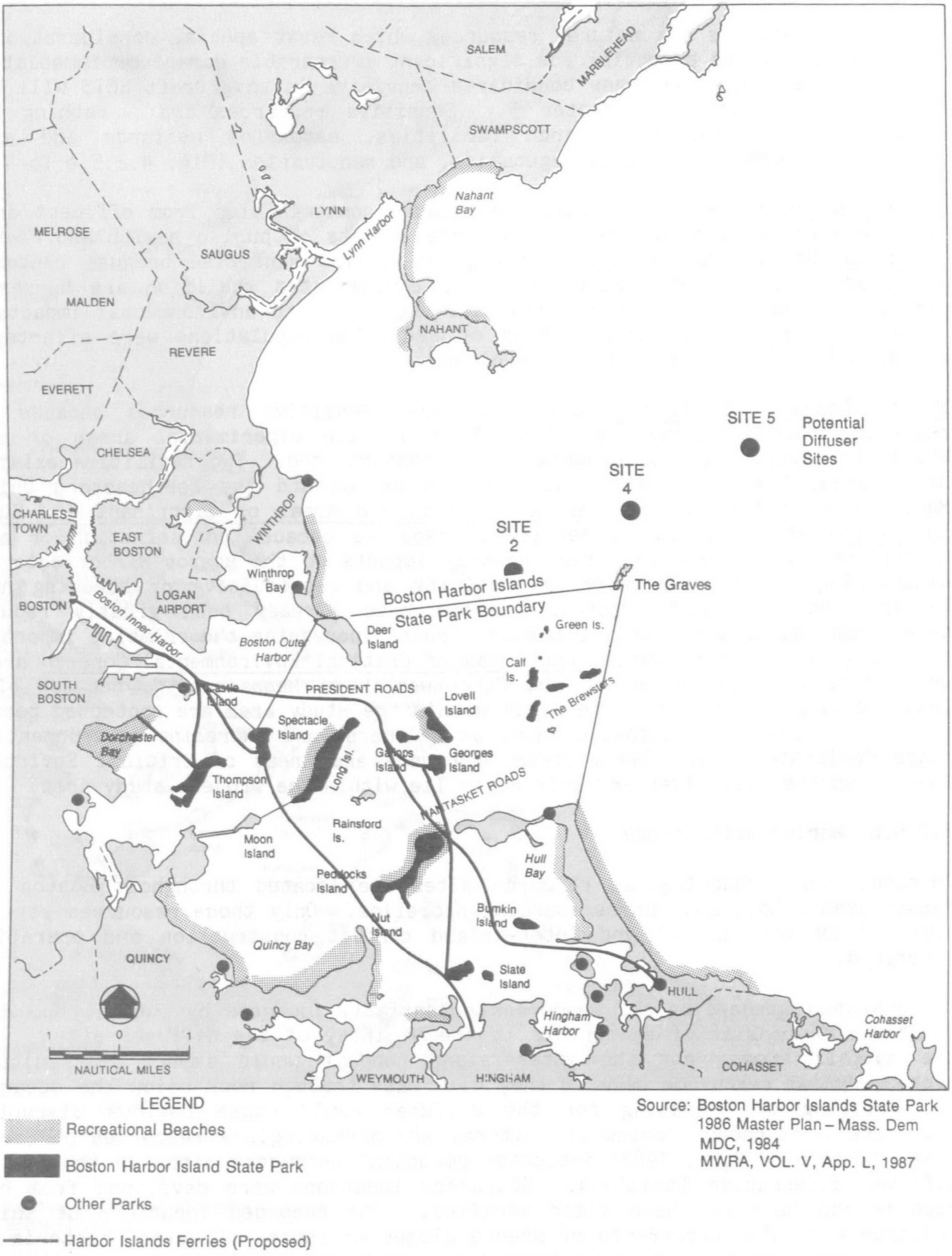


FIGURE 4.2.5.d. BEACHES, SHORELINE PARKS, AND ISLAND PARKS

4.2.5.5 Sensitive Resources

Sensitive resources are natural resources which merit special consideration due to their fragility and potential for significant irreparable damage or immediate danger to public health. Resources considered sensitive in this Draft SEIS will be given particular attention in Chapter 5. Sensitive resources are: bathing beaches, shellfish beds, marine research facilities, estuarine wetlands and areas of significant submerged aquatic vegetation, and sanctuaries (Fig. 4.2.5.e to 4.2.5.f).

Bathing Beaches are deemed sensitive because contamination from effluent or spills from vessels could have immediate adverse effects on public health and recreation. Shellfish Beds, like bathing beaches, are deemed sensitive because contamination could adversely affect public health if contaminated shellfish are harvested and consumed. Contamination could also cause economic and environmental impacts if the vigor and reproductive capabilities of shellfish populations were affected or if additional shellfish beds had to be closed.

Marine Research Facilities are considered sensitive resources because ongoing research could be adversely affected if in-site experimental areas or seawater supply to laboratories or aquaria became contaminated. Two facilities exist in the study area, the New England Aquarium in Boston and the Northeastern University Marine Lab in Nahant. Estuarine Wetlands and Areas of Signficant and Submerged Vegetation are included as sensitive resources because contamination or physical disruption could cause long term adverse impacts on the Boston Harbor ecosystem by diminishing areas of primary productivity and reproductive or breeding habitat. Wetland and submerged vegetation areas have already been greatly reduced by development along the shore of Boston Harbor, increasing the relative importance of remaining areas. Sanctuaries and Areas of Critical Environmental Concern are areas which have been protected by the Commonwealth of Massachusetts because of their unique ecological values. The areas within the study area are protected because of their ecological and aesthetic value as saltmarsh and shoreline environments. The state designated South Essex Ocean Sanctuary and Areas of Critical Environmental Concern on the Back River and Weir River lie within the project study area.

4.2.5.6 Marine Archaeology

Cultural and archaeological resource sites are located throughout Boston Harbor, Massachusetts Bay, and the surrounding shoreline. Only those resources potentially affected by the outfall and inter-island conduit construction and operation are described.

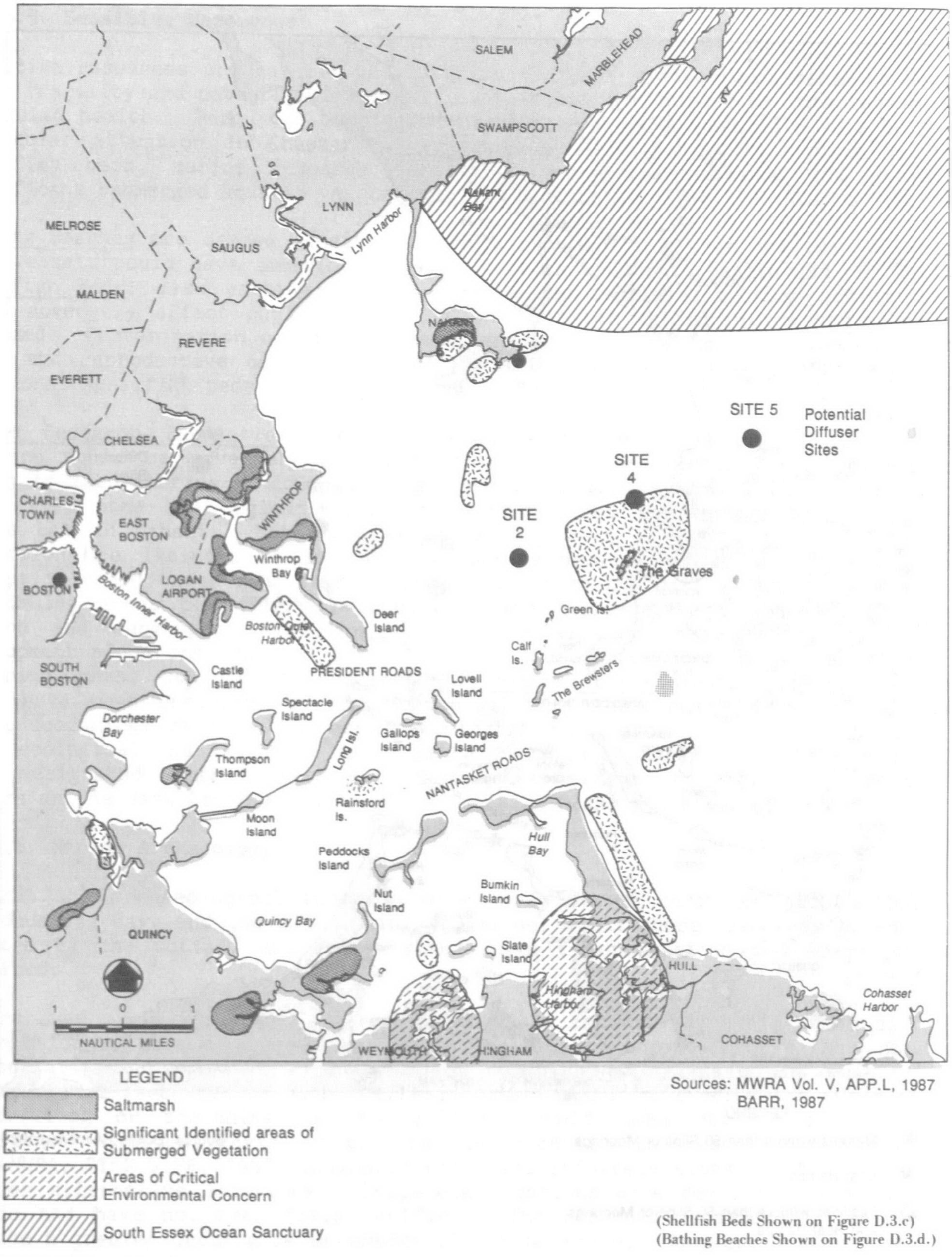
Cultural and archaeological resources potentially impacted by outfall and diffuser construction consist of shipwrecks in the vicinity of the diffuser sites. Neither the outfall tunnel nor the inter-island conduit would impact any cultural or archaeological resources because they will pass through rock below the ocean floor, but drilling or trenching for the diffuser could cause obvious disruption of wrecksites. A recent review of cultural and archaelogical resources performed for MWRA (MWRA, STFP V,FF, 1987) indicated potential shipwreck sites in the vicinity of diffuser alternative locations. Shipwreck locations were developed from historic records and have not been field verified. The recorded locations of shipwrecks indicate a greater occurrence of wrecks closer to shore. However, historic records of shipwrecks are thought to be incomplete and locations reported are not thought to

LEGEND

- ● Marinas w/more than 50 Slips or Moorings
- ★ Boat Ramps
- ✪ Facilities w/more than 50 Slips or Moorings and Boat Ramps

Source: Boating Almanac 1986

FIGURE 4.2.5.e. MAJOR BOATING PUBLIC ACCESS POINTS

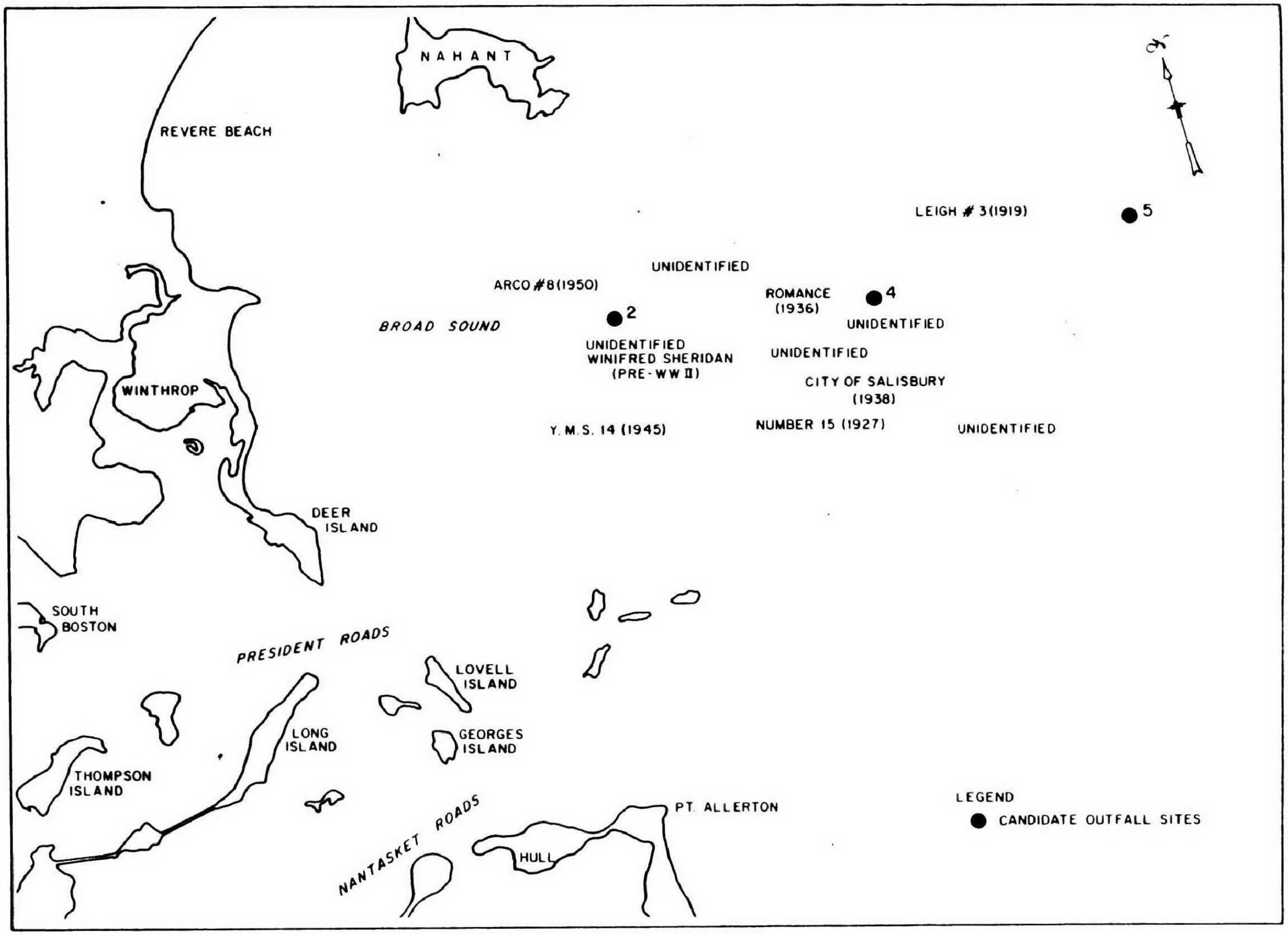


(Shellfish Beds Shown on Figure D.3.c)
(Bathing Beaches Shown on Figure D.3.d.)

FIGURE 4.2.5.f. SENSITIVE HARBOR RESOURCES

be precise. About one third of the known shipwrecks identified in the diffuser area date from 1919 to 1950. Wrecks predating World War I are possible but are not recorded. The general locations of recorded wrecks are shown by Fig. 4.2.5.g.

Historical and archaeological resources on land (Deer Island and Nut Island) have been evaluated by earlier studies (USEPA, 1984; USEPA, 1985; MWRA, STFP IV, 1987). No potential marine archaeological impacts will occur from construction of the inter-island conduit or the effluent outfall tunnel because both will be deep rock tunnels originating onshore.



SOURCE: MWRA VOL. V APP. FF 1987

FIGURE 4.2.5.g. SHIPWRECKS WITHIN 1.5 MILES OF CANDIDATE OUTFALL SITES (SHIP NAMES INDICATE APPROXIMATE LOCATIONS)

4.3 INTER-ISLAND CONDUIT AREA

4.3.1 INTRODUCTION

Wastewater from the Nut Island collection system will be conveyed to Deer Island via an inter-island conduit system. The deep rock tunnel alternative was selected for detailed evaluation since it would incur fewer impacts on the environment and harbor resources and be less costly than the other potential alternatives (Chapter 3). This inter-island conduit system involves the construction of access shafts on Nut and Deer Islands connected by a 25,000 foot long, 11 foot diameter deep rock tunnel between Nut Island and Deer Island.

4.3.2 SUMMARY OF CONDITIONS

Only the subsurface geology between Nut and Deer Islands and the island shaft locations would be affected by construction of a deep rock tunnel.

The dominant bedrock in Boston Harbor is the Cambridge Formation. This rock is somewhat metamorphosed, and extremely folded and faulted. The Cambridge Formation is generally thinly bedded, laminated to occasionally nonbedded, fine grained, well indurated and moderately hard to hard. Within the Cambridge Formation, there are documented areas of kaolinized bedrock which is assumed to be randomly distributed along the inter-island conduit route (MWRA, STFP IV 1987).

Along the inter-island conduit route, the bedrock, which is predominantly argillite with intrusion by igneous dikes or sills, has a very irregular surface configuration. Some areas of bedrock are exposed as harbor islands while other areas occur 150 to 175 feet below mean sea level. The presence of igneous bedrock along the inter-island conduit route increases the likelihood that tillite or conglomerate would also be encountered. In the vicinity of the conduit route, argillite bedding occurs at angles varying from 45 degrees to vertical. These formations show evidence of complex folding and shearing. Several major irregularities are anticipated along the conduit route.

Bedrock formations in the vicinities of the access shafts on Nut and Deer Islands are similar. The argillite bedrock generally dips at an angle of 45 to 50 degrees from horizontal and has closely spaced parallel-to-subparallel jointing. Fractures in the bedding have often been healed by calcite. Exposed joint surfaces show little indication of weathering. At Nut Island, the top of the bedrock is at elevation 43 feet while at Deer Island, the bedrock is located at elevation 33 feet.

4.4 DISPOSAL AREAS

4.4.1 IDENTIFICATION OF AVAILABLE DISPOSAL AREAS

Excavated materials from the construction of the inter-island conduit and effluent tunnel will, for the most part, be utilized as construction materials for project-related construction or for such other projects as the Third Harbor Tunnel/Central Artery highway project (MWRA, STFP III, 1987; MWRA, STFP V, 1987). If any excavated materials remain unutilized, upland disposal is likely. Since the materials consist of crushed rock, they are presumed to be relatively uncontaminated "clean fill". Upland disposal should not be constrained, and disposal should not affect selection of conduit or outfall alternatives. No specific upland disposal sites have been identified or evaluated for these materials. However, disposal operations will follow all state requirements for disposal on upland areas.

4.4.2 SUMMARY OF EXISTING CONDITIONS AT THE FOUL AREA DISPOSAL SITE

Dredged materials will result from the construction of the diffuser, and are likely to be disposed of at sea at the nearest federally designated dredged material disposal site. The federally designated disposal site nearest the project is the Foul Area Disposal Site located approximately 22 miles east of Boston, centered at latitude 42° 25" N and longitude 70° 35" west (USACE, 1984). Disposal is administered by the U.S. Army Corps of Engineers (USACE) and subject to EPA approval. To gain USACOE acceptance for disposal, the quality of the dredged material (as sampled and tested) must be compatible with the ocean dumping criteria stipulated in the Marine Research, Protection, and Sanctuaries Act (Appendix G).

The Foul Area Disposal Site is topographically within the Stellwagen Basin in a 300 foot-deep depression separated from Stellwagen Bank on the east by a 200 foot high slope (USACOE, 1984). The site has historically been used for the disposal of dredged materials and industrial wastes and has received approximately 3 million cubic yards of dredged material per decade (USACOE, 1988). Sediments at the site are largely sandy silts, reflecting the nature of past deposition. Mean bottom currents at the site are generally less than 5 centimeters per second with a maximum bottom current of about 35 centimeters per second (SAIC, 1984).

Recent sampling for USACOE indicates that the western portion of the site where disposal occurs is dominated by spionid, cirratulid, and capitellid polychaete and oligochaete worms which typically inhabit clayey silts (SAIC, 1984). Continued disturbance due to disposal activities keeps the community in a pioneering state. A 1985 sampling of the area indicates that the dominant fish species include dogfish (*Squalus ananthias)* in the late spring/summer season and witch flounder (*Glyptocephalus cynoglossus*) and American plaice (*Hippoglossoides platessoides*) during the rest of the year. Less dominant species include red hake (*Urophycis chuss*), white hake (*Urophycis tenuis*) and deepwater redfish (*Sebastes mentella*) (SAIC 1987). Most fisherman avoid the Foul Area because of the debris from previous disposal operations.

Humpback, finback and right whales and leatherback and loggerhead turtles, currently on the endangered species list, use the nearby Stellwagen Bank area (NMFS, 1988). Kenny and Winn (1988) indicated a high habitat use in the region based on a three year study performed by the University of Rhode Island (CETAP, 1982).

CHAPTER 5

CONSEQUENCES OF ALTERNATIVES

5.1 OPERATION OF EFFLUENT DISCHARGE AT ALTERNATIVE LOCATIONS

5.1.1 WATER QUALITY

5.1.1.1 Constituents

The water quality impact analyses furnish the basis for the evaluation of compliance with water quality standards and criteria (Section 4.2.2.1) and the assessment of impacts to water column and benthic ecosystems. For these analyses, the parameters and constituents which must be evaluated are:

- Dissolved Oxygen (DO), which is consumed by the biochemical oxygen demand (BOD) of the effluent, sediment oxygen demand (SOD), and resuspension oxygen demand (RDOD);

- Suspended Solids and Sedimentation, resulting from the discharge of solids with the effluent;

- pH, which is affected primarily by the alkalinity of the effluent;

- Nutrients, including nitrogen, phosphorus and silica, which support primary productivity and the development of objectionable algal blooms; and

- Toxic Chemicals, including volatile organic compounds (VOCs), acid/base neutrals, metals, pesticides and other chemicals. A list of toxic chemicals to be considered has been developed by MWRA based on measurements of influent quality, the applicable water quality standards and criteria and specific toxicity concerns (MWRA, STFP V,A, 1987).

These water quality parameters are measured in terms of water column concentrations. Sediment deposition rates, in turn, are directly dependent on suspended solids concentrations. These concentrations are the result of a balance between loadings and removal or fate processes. The loadings of interest are from the proposed MWRA discharge; loadings from other sources, however, are also considered to evaluate cumulative impacts. The fate processes include transport processes, which are the same for all the constituents, and physico-bio-chemical processes which are constituent specific. These elements are briefly described below and are covered in further detail in Appendix A.

5.1.1.2 Loadings

The discharge rates or loadings of the constituents identified above are provided in Table 5.1.1.a for primary and secondary effluent (MWRA, STFP III and V,A, 1987).

The carbonaceous BOD loadings for primary and secondary effluent are based on the MWRA estimates (MWRA, STFP III, 1987). Separate values are provided for low and

TABLE 5.1.1.a. CONSTITUENTS LOADINGS

Constituents Conventional Pollutants	(g/sec)	Primary Effluent Low Groundwater	Primary Effluent High Groundwater	Secondary Effluent Low Groundwater	Secondary Effluent High Groundwater
Carbonaceous BOD		2,915	3,145	374	858
Nitrogenous BOD		1,785	1,785	1,785	1,785
DO Deficit		139	278	139	278
Total Suspended Solids		1,150		363	
Nitrogen		390	390	390	390
Flows(1)	mgd	377	657	390	670
	m^3/s	16.5	28.8	17.1	29.3

Toxic Chemicals	(mg/sec)	Primary Effluent Mean	Primary Effluent Standard Deviation	Secondary Effluent Mean	Secondary Effluent Standard Deviation	Secondary Effluent High(2)
benzene		86.8	16.0	4.3	0.8	26.0
bromomethane		327.6	116.8	16.4	5.8	81.9
chloroform		117.1	54.0	11.7	5.4	58.5
ethylbenzene		175.8	79.4	8.8	4.0	52.7
methylene chloride		632.3	454.6	31.6	22.7	279.4
styrene		197.2	47.7	19.7	4.8	59.2
tetrachloroethylene		324.2	189.9	32.4	19.0	97.3
trichloroethylene		183.3	97.4	11.5	6.1	68.7
bis(2-ethylhexyl)phthalate		411.3	121.1	41.1	12.1	205.6
butylbenzyl phthalate		334.7	149.3	16.7	7.5	100.4
di-n-octyl phthalate		345.7	129.7	34.6	13.0	103.7
fluorene		86.4	27.2	8.6	2.7	25.9
arsenic		30.0	9.3	20.0	6.2	24.0
cadmium		37.6	14.4	22.2	8.5	26.6
chromium		279.1	108.7	111.6	43.5	186.0
copper		1365.4	409.1	378.1	113.3	630.2
lead		197.2	86.2	157.0	68.6	109.6
mercury		20.4	25.7	6.5	8.2	7.8
nickel		353.1	157.9	282.5	126.3	290.8
selenium		251.9	237.9	139.9	132.1	167.9
silver		66.0	16.4	9.4	2.3	18.9
zinc		2731.0	3111.5	1092.4	1244.6	1365.5
aldrin		3.5	1.5	0.3	0.1	1.0
4,4'-DDT		0.85	0.29	0.09	0.03	0.252
dieldrin		0.37	0.15	0.04	0.02	0.11
heptachlor		4.0	0.03	0.44	0.003	1.32
polychlorinated biphenyls (PCBs)		16.7	4.3	1.3	0.3	4.7

(1) Average day, year 1999 for primary, 2020 for secondary.
(2) Reduced removal during storms.
Source: MWRA STFP III and V,A 1987.

high groundwater conditions, reflecting the fact that increased infiltration during high groundwater produces additional flows and loads. The nitrogenous BOD loadings were calculated based on the nitrogen loadings, which are practically the same for primary and secondary effluent.

The nitrogen loading was computed based on the measured influent Total Kjeldahl Nitrogen (TKN) concentration of 23 mg/l (MWRA Memo FB20C attachment to MWRA, STFP III, 1987), which was assumed to be essentially unchanged during treatment. The average day, low groundwater flowrate of 390 mgd (17 m^3/sec) was used to calculate the loading, recognizing that high groundwater conditions provide additional flow without additional significant nitrogen load. The NBOD loading was calculated as the nitrogen loading multiplied by 4.57, which is the theoretical ratio of NBOD to TKN.

The dissolved oxygen deficit (DOD) is the amount by which dissolved oxygen (DO) is reduced due to the discharge. The DO in the effluent was assumed to be zero, leading to a DOD loading equal to the ambient DO concentration multiplied by the discharge flow rate. Average day flows were used, since the development of DO deficits occurs on a time scale of one to two weeks and short duration events would not significantly affect DO levels.

The toxics loadings are highly variable and the corresponding water quality criteria are based on exceedance frequencies (Section 4.2.2.1). To allow determination of these frequencies, both the mean and standard deviation of the toxics loadings are provided based on measured influent concentrations and estimated removal efficiencies. Except for PCBs, these loadings are the same as those used by MWRA in their analyses (MWRA, STFP, V,A, 1987). Lower removal efficiencies were, however, assumed to prevail during periods of very high flows. Further discussion of this factor is provided in Appendix H of this Draft SEIS.

The PCB loading used by MWRA corresponded to the 1 µg/l concentration of Aroclor 1242, which was the only PCB mixture detected in the 1984 surveys (MDC, 1984). In 1986-87, influent surveys conducted by MWRA could not detect any PCBs. The detection limit for Aroclor 1242 was 0.5 µg/l and this value was therefore used conservatively here to compute a loading. This reduced PCB level is consistent with observed trends towards decreasing PCB levels in wastewaters and in the environment.

5.1.1.3 Fate Processes

The fate processes include transport processes, which affect all the constituents comparably, and physico-bio-chemical processes which are constituent specific.

Transport Processes. These processes are advection (the transport of dissolved or suspended matter due to the movement of the carrier fluid), and diffusion (the transport from high to low concentration areas due to turbulence). These processes assume very different characters in the immediate vicinity of the outfall structure (discharge nearfield) and farther away from it (farfield) and different models are used to analyze these two regions.

In the discharge nearfield, the effluent undergoes rapid dilution with ambient water because of turbulent entrainment. This dilution is enhanced by discharge through the multiport diffuser, which distributes the effluent over a number of individual jets eventually merging into a single line plume. In the nearfield, the main driving forces are buoyancy and, to a lesser degree, the discharge momentum of the effluent. Because of buoyancy, the effluent plume rises through the water column while entraining ambient water (Figure 4.2.1.a). When the water column is stratified, the density of the plume may reach that of the ambient because of previous entrainment of deep, dense ambient waters. In this case, the plume reaches a maximum height of rise. For unstratified conditions, the plume rises all the way to the water surface and typically achieves greater dilution. The dynamics of the nearfield plume are controlled by the diffuser characteristics (primarily its length), the ambient current speed and direction relative to the diffuser axis, and the ambient density stratification profile. The time that the effluent spends in the nearfield is relatively short (on the order of a few minutes) and, therefore, the effects of the constituent-specific physical, chemical or biochemical reactions is negligible.

The multiport diffuser is made up of a line of individual or multiport risers (Chapter 3). In order to achieve maximum dilution for a given diffuser length, the port spacing must be sufficiently small to insure that all the ambient crossflow is intercepted and optimum dilution of the effluent is achieved by orienting the diffuser perpendicularly to the ambient current direction. Hydraulically, the diffuser must be designed to insure seawater purging, uniform flow distribution among ports and sufficient velocities in the conduit to avoid settling (Fischer et al., 1979).

In the farfield, the diluted effluent is carried by ambient currents, undergoing additional mixing by large scale turbulent diffusion. This mixing is largely controlled by the large scale circulation patterns in Massachusetts Bay. The effluent becomes mixed vertically over the water depth. During stratified conditions, the effluent may remain trapped under the pycnocline and, in these critical conditions, become mixed in the lower layer only. This represents the most critical condition in terms of constituent concentrations and settling, since the water depth is effectively reduced. On the other hand, the surface waters remain relatively unaffected, with associated benefits such as reduced shoreline impacts. The constituent-specific physical, chemical or biochemical fate processes play an important role in the farfield, where residence times are longer. These processes are reviewed below.

Dissolved Oxygen Exertion. Dissolved oxygen (DO) is consumed by carbonaceous and nitrogenous biochemical oxygen demand (CBOD and NBOD), sediment oxygen demand (SOD), and resuspension oxygen demand (RDOD). The latter occurs during storms or other resuspension events, when organic sediments are put back in suspension and exert additional DO demand. DO is replenished by surface reaeration (or diffusion through the interface for effluent trapped in the lower layer), and photosynthetic activity. These processes and their kinetics are further described in Appendix A. Photosynthesis is only active during the day and, for conservativeness, its effect were not taken into account in this analysis.

Suspended Solids Deposition. Suspended solids (SS) remain in suspension because of turbulence and their deposition is controlled by their fall velocity. The fall velocity is a function of the particle sizes, ambient turbulence and suspended solids concentration, which controls flocculation (Farley, 1984). For a given range of suspended solids concentrations and ambient turbulence levels, experiments have been conducted to determine the distribution of particles fall velocities (Cardoni et al., 1986). For this SEIS, three fall velocities were used: 0.1, 0.01 and 0.001 cm/sec. Solids with a fall velocity lower than 0.001 cm/sec effectively do not settle. The fraction of solids in each fall velocity range is given in Table 5.1.1.b based on EPA, 1982b; Cardoni et al., 1986; and MWRA, STFP V,A, 1987.

TABLE 5.1.1.b. DISTRIBUTION OF DISCHARGED SOLIDS FALL VELOCITIES

Fall Velocity (cm/sec)	Primary	Secondary
0.1	5%	0%
0.01	20%	16%
0.001	35%	34%
Does not settle	40%	50%

Nutrients Cycling. The most important nutrient is nitrogen, since it tends to be the limiting growth factor in estuarine and coastal areas (Appendix C). Nitrogen is supplied by the effluent primarily in the form of ammonia and, following discharge, undergoes a number of bio-chemical reactions and transformations within the nitrogen cycle. During the summer, nitrogen is recycled very rapidly and it can be assumed that nitrogen is a conservative substance.

Chemical Decay Processes. Organic chemicals discharged in the effluent will be subject to the following removal processes in the water column: vaporization, hydrolysis, photolysis, biodegradation and adsorption onto suspended solids followed by settling. Each of these processes approximately follows a first order decay (decay rate proportional to the constituent concentration), with a rate constant dependent on the chemical and other ambient. For each organic chemical and each process, MWRA estimated a rate constant, from which combined rate constants were calculated. Based on these, three classes were identified, characterized by half lives (time required for one half of the concentration to decay) of 20 days, 60 days and no decay, in to which the organic chemicals were placed (MWRA, STFP V,A, 1987). These estimates of half lives were reviewed and found to provide an adequate characterization of the decay processes. This classification was therefore used for the Draft SEIS analyses.

Inorganic chemicals, primarily metals, can exist many different forms, depending on ambient factors such as pH and ligand concentrations, with different bioavailability and toxicity. The primary physico-chemical fate process undergone by these chemicals is adsorption to suspended solids followed by settling. The degree of adsorption and settling, however, is difficult to predict and, therefore, these chemicals were treated as conservative (no decay) for water column concentration predictions. This is a conservative approach because a significant portion of the metals were also assumed to be deposited in the sediments (Appendix B and Section 5.2).

5.1.1.5 Nearfield Dilution Modeling

The EPA nearfield dilution model ULINE was used for these analyses (Muellenhoff et al., 1985). Based on diffuser characteristics, effluent flowrate and density, ambient current, and stratification, this model calculates the nearfield dilution and maximum height of rise of the effluent plume. Recent studies have shown that this model consistently underpredicts nearfield dilution (Appendix A Section A.3.5.1); it was nevertheless used here because other available model sometimes overpredict dilution and might thus not provide a conservative assessment of impacts.

For each alternate diffuser site, a range of effluent flow, ambient current and stratification conditions were considered. A probability of occurrence was attributed to each of these parameters, to allow subsequent evaluation of compliance with toxicity criteria, which involve a frequency of exceedance limit. The effluent flowrates were the same for all the sites, based on MWRA estimates (MWRA, STFP V,A, 1987). For each site, the current speeds used in the simulations were the 10, 50 and 90 percentile speeds (Table 4.2.1.a) measured at the lower current meters (since the plume first experiences these currents and may stabilize below the upper current meter in the summer). The density profiles used in the simulations were based on site-specific temperature and salinity measurements. These profiles and their probabilities are the same as those used by MWRA (MWRA, STFP V,A, 1987). Further details on the nearfield modeling conditions are provided in Appendix A (Section A.3.3.2).

The discharge depth used at each site was the depth below mean low water minus 1.5 m to account for riser height. The proposed diffusers have a length of 2000 m and were assumed to be oriented at 45 degrees to the current, (MWRA, STFP V,A, 1987). This intermediate value between 90°, which gives the highest dilution, and 0°, which gives the lowest, was used by MWRA because current directions at the discharge sites are variable. The current scatter plots at the proposed diffuser sites, however, exhibit a strong biomodality (approximately east-west), suggesting that the diffusers could be oriented perpendicular to the ambient current for a preponderence of the time. Another consideration in the selection of a diffuser orientation is to have the ports at the same elevation, to insure a uniform flow distribution among all the ports. This would suggest that a preferred orientation is along the depth contours, which tend to be north-south in the diffuser site areas. An average orientation close to 90 degrees therefore appears desirable and achievable. This orientation was therefore also considered in the analyses. A critical design parameter for the diffuser is its length and sensitivity to this parameter was investigated by also running the analyses for a 3000 m long diffuser.

For each diffuser site and design, between 120 and 135 sets of ambient conditions were considered, as described above. The results are summarized in terms of 10, 50 and 90 percentile nearfield dilutions (Table 5.1.1.c), which are minimum dilutions obtained 10, 50 and 90 percent of the time.

TABLE 5.1.1.c. NEARFIELD DILUTIONS

Diffuser Configuration					
Length(m)	Orientation(1)	Percentile(2)	SITE 2	SITE 4	SITE 5
2000	45°	10	57	75	92
		50	98	128	150
		90	163	259	272
2000	90°	61	79	105	
		50	114	150	190
		90	222	369	388
3000	45°	10	72	91	122
		50	120	159	196
		90	232	385	404

(1) Angle between diffuser and ambient current.
(2) Percent of the time that the dilution is less than the value indicated.

For the 2000 m long diffuser oriented at 45 degrees to the currents (base case), nearfield dilutions increase from Site 2 to Site 5, as expected. The increase of 50 percentile (median) dilution is 31 percent from Site 2 to 4 and 17 percent from Site 4 to 5. The 10 percentile dilutions increase slightly more.

Orienting the diffuser at 90 degrees to the currents increases dilutions by an average of about 23 percent, with larger increases for the larger dilutions (90 percentile). This increase can be put in perspective by noting that the Site 4 diffuser at 90 degrees to the current provides essentially the same dilutions as the Site 5 diffuser at 45 degrees.

The 3000 m long diffuser at 45 degrees to the currents provides an average increase of dilution of 33 percent compared to the base case. This option should be considered as it can potentially be achieved at minimal extra cost by increasing the port spacing and keeping the same number of ports.

5.1.1.5 Farfield Modeling

Farfield modeling simulates the transport and physio-bio-chemical processes which take place over large distances and time scales (hours to weeks) after the nearfield dilution. The results of the farfield modeling are i) constituent background build-ups, ii) depletion of dissolved oxygen and iii) rates of effluent solids deposition due to discharge at the alternative diffuser sites.

Background concentration build-up develops in the discharge area as a result of the returning ebb and flood of the tide, which bring previously discharged effluent back in to the diffuser area. The magnitude of the background build-up is determined by a balance of the input from the effluent discharge and removal rates of individual constituents. The removal mechanisms are: i) transport by net drift (Section 4.2.1.4), ii) horizontal dispersion and iii) natural decay phenomena (Section 5.1.1.4). Perfectly symmetrical tidal currents do not provide any net transport removal since their average velocity (net drift) is zero. The net drift is the result of tidal asymmetries, winds, fresh water discharges and large scale weather patterns and, as such, is variable in space and time (Section 4.2.1.4). Periods of low net drifts result in temporarily higher background build-ups and the duration of low net drift periods is therefore an important factor. The background build-up represents the ambient water which is used for initial dilution of the effluent in the nearfield.

Models and Methodologies. The hydrodynamic model TEA and companion water quality transport model ELA were selected for the farfield modeling of this study. These two-dimensional (vertically-averaged) finite element models account for the location, magnitude and configuration of alternative effluent discharges, as well as the effects of spacial and temporal variations in tidal and residual circulation, turbulent diffusion and effluent constituent decay and sedimentation. These models permit detailed resolution of complex coastal geometries as well as refined grid resolution in areas of special interest. Further description of these models is provided in Appendix A (Section A.3.6.2).

The finite element grid used for farfield modeling during unstratified conditions is the same as that used by MWRA (Figure 5.1.1.a). The model grid is highly resolved in Boston Harbor and in the vicinity of the alternative discharge sites where concentration gradients are likely to be large. Lower resolution is used in portions of Massachusetts Bay removed from the alternative discharge sites. This grid is more resolved than in any previous numerical models of Boston Harbor and/or Massachusetts Bay.

TEA and ELA were also used to simulate discharge under vertically stratified conditions, during which the effluent plume would be trapped below the pycnocline. For this purpose, the grid was modified by decreasing nodal depths to include only those below a 15 meter-deep pycnocline, which corresponds to observed summer stratified conditions. As a result, most of the shallow nodes within Boston Harbor and numerous nodes along the land boundaries of the original grid were eliminated (Figure 5.1.1.b).

The TEA model of Boston Harbor and Massachusetts Bay used to simulate circulation in non-stratified conditions was recalibrated during preparation of this Draft SEIS to more accurately simulate the semi-diurnal tidal circulation observed at the current meters during the Spring of 1987. The tidal forcing specified at the ocean boundary of TEA was recalculated based on a harmonic analysis of the tide gauge data and the bottom friction coefficient was readjusted. A similar calibration was performed for stratified conditions.

Net drifts are produced in the model by specifying a slope (tilt) at the ocean boundary. Results of the net drift analysis of the 1987 current meter data indicate that net drifts can be either towards the south or north in the vicinity of the

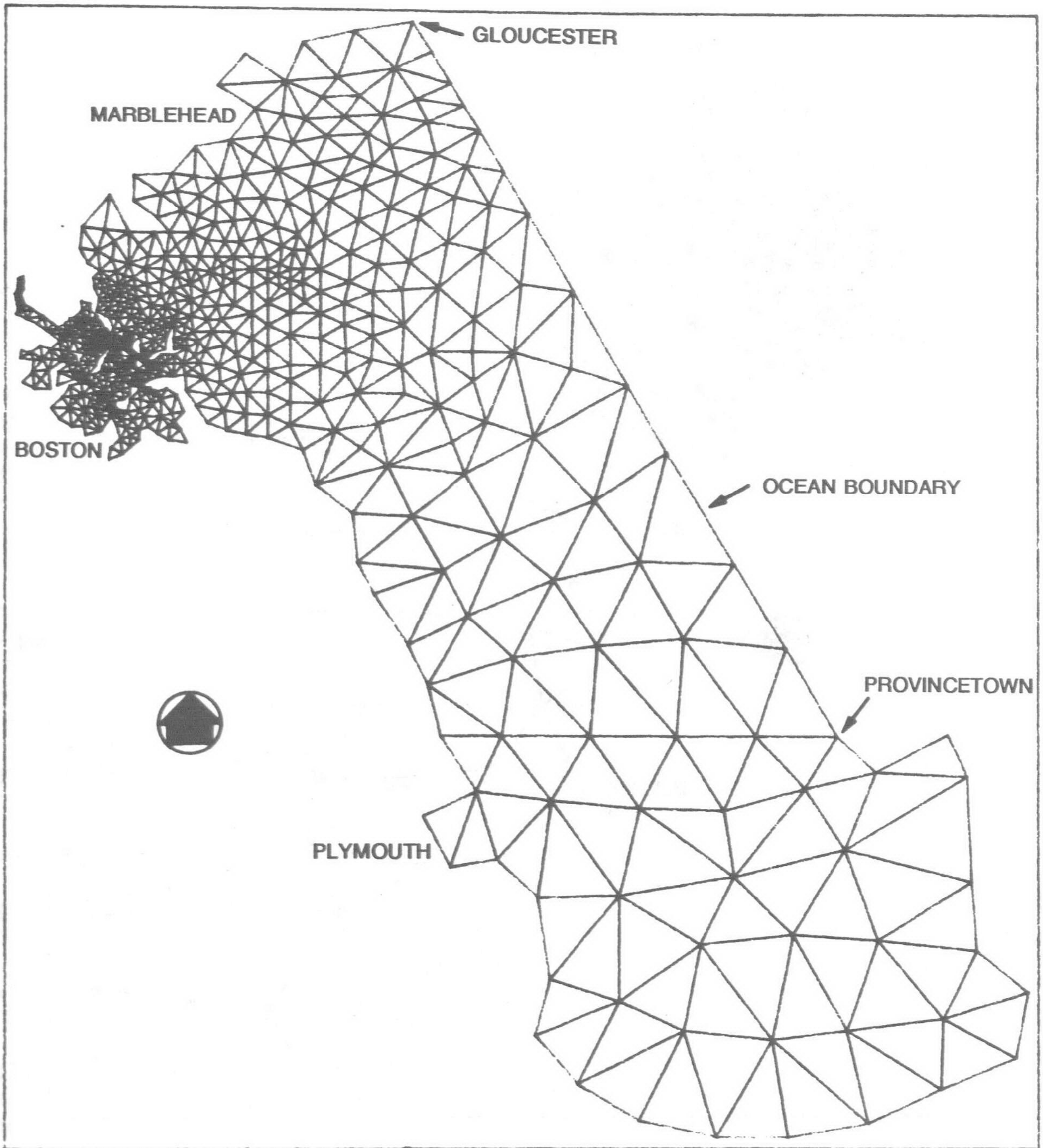


FIGURE 5.1.1.a MODEL GRID FOR UNSTRATIFIED CONDITIONS

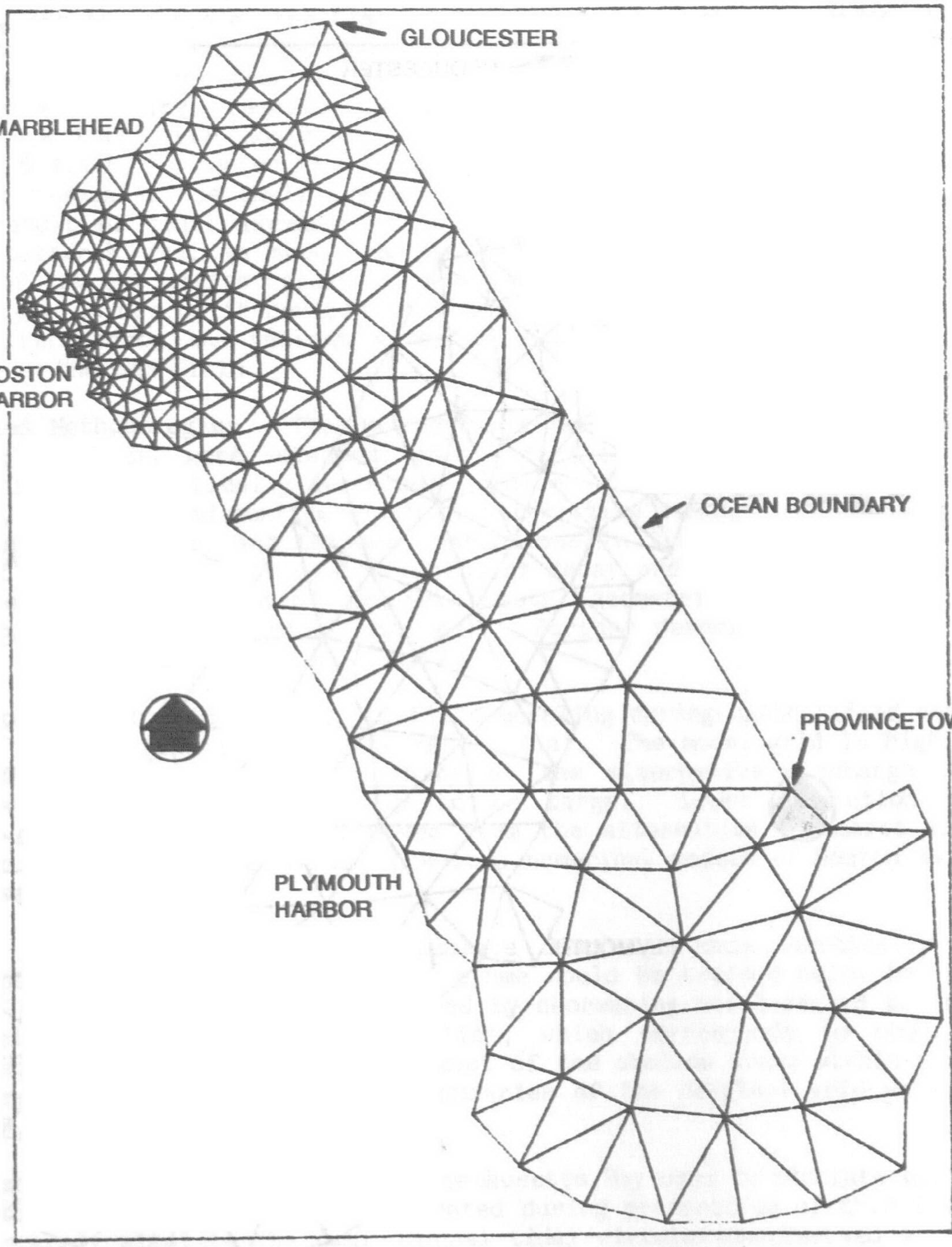


FIGURE 5.1.1.b MODEL GRID FOR STRATIFIED CONDITIONS

alternative discharge sites (Section 4.2.1.4). Therefore, TEA was run with both steady north-to-south and south-to-north boundary tilts. Tilts of 10 cm between Gloucester and Provincetown were found to provide net drifts similar to those measured. The net drift analysis also indicated that periods of low net drift occurred and, accordingly, TEA was also run with no boundary tilt.

The water quality model, ELA, was used to simulate both stratified and non-stratified conditions with discharge of conservative and first-order decaying constituents (20 and 60-day half lives) at the alternative sites. A base constituent mass loading of 200 mg/sec was simulated at each diffuser site. Because of linearity, concentrations are proportional to the loading and these base simulations can be used for any constituent. Results can be converted to individual constituents by multiplying the computed concentrations by the ratio of the actual loading to the simulated loading of 200 mg/sec.

The modeling approach was to compute "average" concentrations corresponding to average net drift conditions and "worst case" concentrations corresponding to zero net drift for a period of time. The "average" simulations were continued until steady state (tidally repeating concentrations) was reached. The net drift analyses showed that relatively stagnant periods of low drift can persist in Western Massachusetts Bay for up to approximately 10 days (Section 4.2.1.4). Accordingly, worst-case ELA simulations were conducted for that duration.

Contour plots of concentration for all the ELA runs are given in Appendix A.e. Plots of the results for a conservative tracer under average net drift, vertically unstratified conditions for Sites 2 and 5 are shown in Figure 5.1.1.c and 5.1.1.d respectively. It is seen that the constituent concentrations are higher at Site 2 than at Site 5.

Background build-ups were determined using concentrations computed with the discharge stopped for one tide cycle before the display time. Background build-ups with the north-south and south-north boundary tilts were found to be closely equal and only north-south tilts were considered for the majority of the simulations.

Background build-up results are given in Table 5.1.1.d. It is seen that sensitivity to constituent decay rate is generally small, being greatest at Site 2 and least at Site 5. Differences between build-up during average and worst-case stagnant conditions is greatest at Site 5 and least at Site 2 because net drift currents at Site 2 are lower, and thus closer to non-net-drift conditions, than at Site 5.

Dissolved Oxygen. For dissolved oxygen simulations, ELA was modified to include the processes of carbonaceous and nitrogenous BOD decay, reaeration and sediment oxygen demand. Predicted contour plots of dissolved oxygen deficit for primary treated effluent discharged at Sites 2 and 5, under average net drift, stratified conditions, are shown in Figures 5.1.1.e and 5.1.1.f, respectively. DO deficits are the amounts by which DO is lowered below the ambient by the discharge. Contour plots for all DO deficit simulations are given in Appendix A.g. Maximum DO deficits averaged over an area of approximately 1.5 km^2 representative of the mixing zone are listed in Table 5.1.1.e.

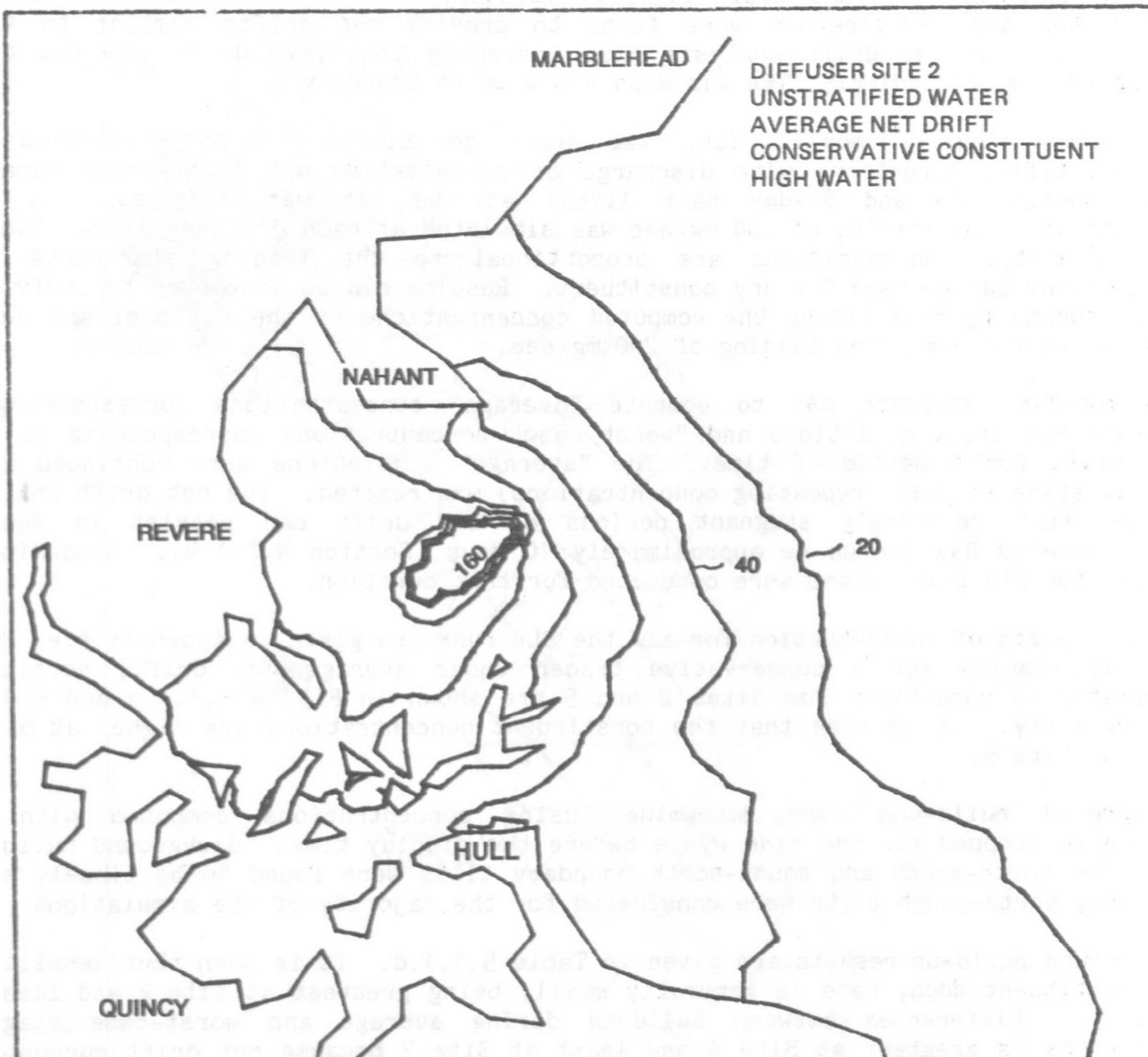


FIGURE 5.1.1.c CALCULATED FARFIELD CONCENTRATIONS (mg/l) FOR BASE LOADING (200mg/sec)

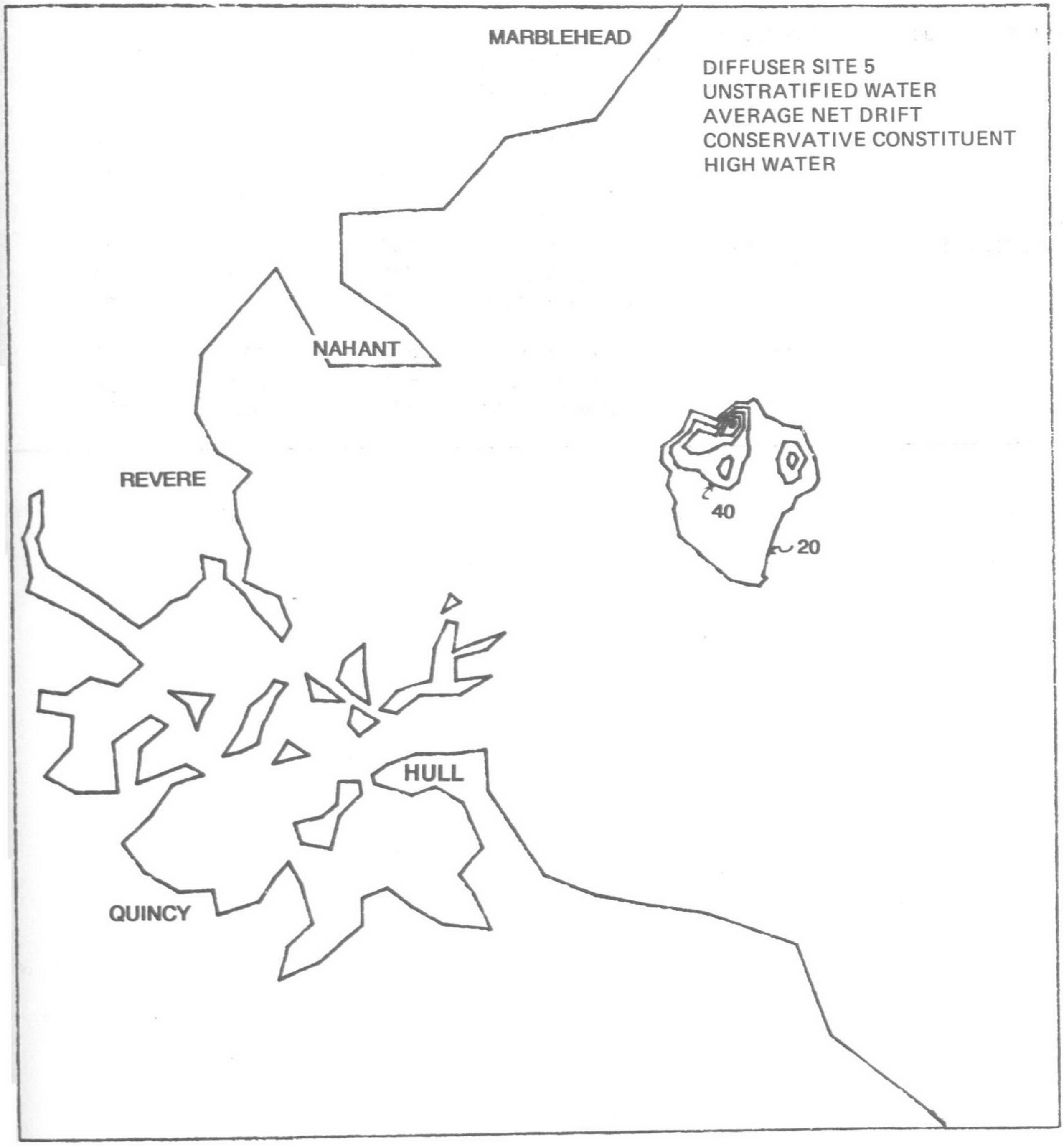


FIGURE 5.1.1d CALCULATED FARFIELD CONCENTRATIONS (mg/l) FOR BASE LOADING (200mg/sec)

TABLE 5.1.1.d BACKGROUND BUILDUP (ng/l) FOR BASE LOADING (200 mg/sec)

Stratification	Net Drift	Half Life	Site 2	Site 4	Site 5
Unstratified	Average	20 days	125	75	38
		60 days	144	81	40
		Conservative	158	86	41
	Worst	20 days	127	81	68
		60 days	150	101	73
		Conservative	166	108	75
Stratified	Average	20 days	443	178	78
		60 days	507	196	81
		Conservative	550	208	83
	Worst	20 days	451	205	123
		60 days	524	230	132
		Conservative	576	248	137

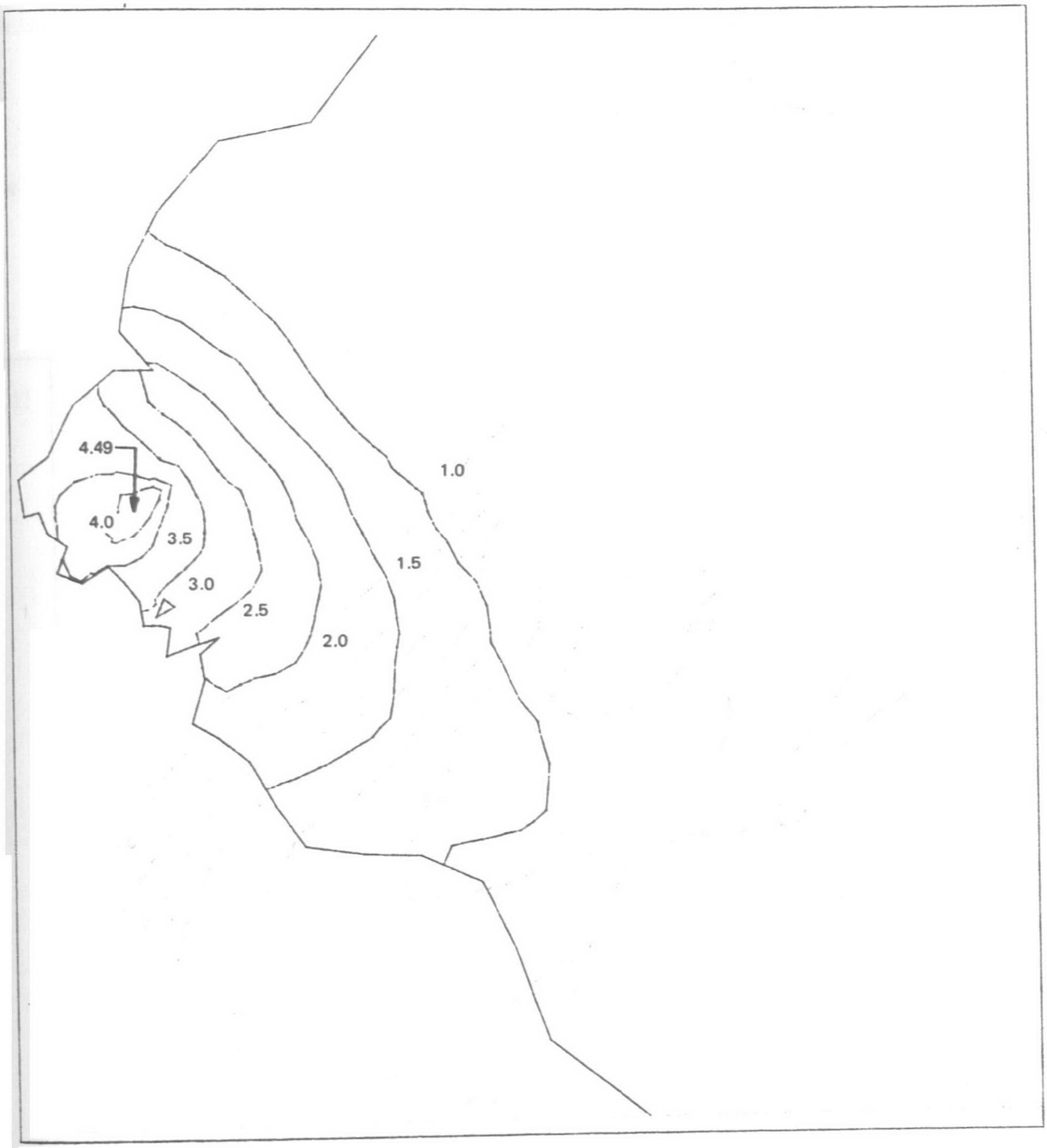


FIGURE 5.1.1.e DISSOLVED OXYGEN DEFICIT (mg/l) FOR PRIMARY DISCHARGE AT SITE 2 UNDER STRATIFIED CONDITIONS, AVERAGE NET DRIFT.

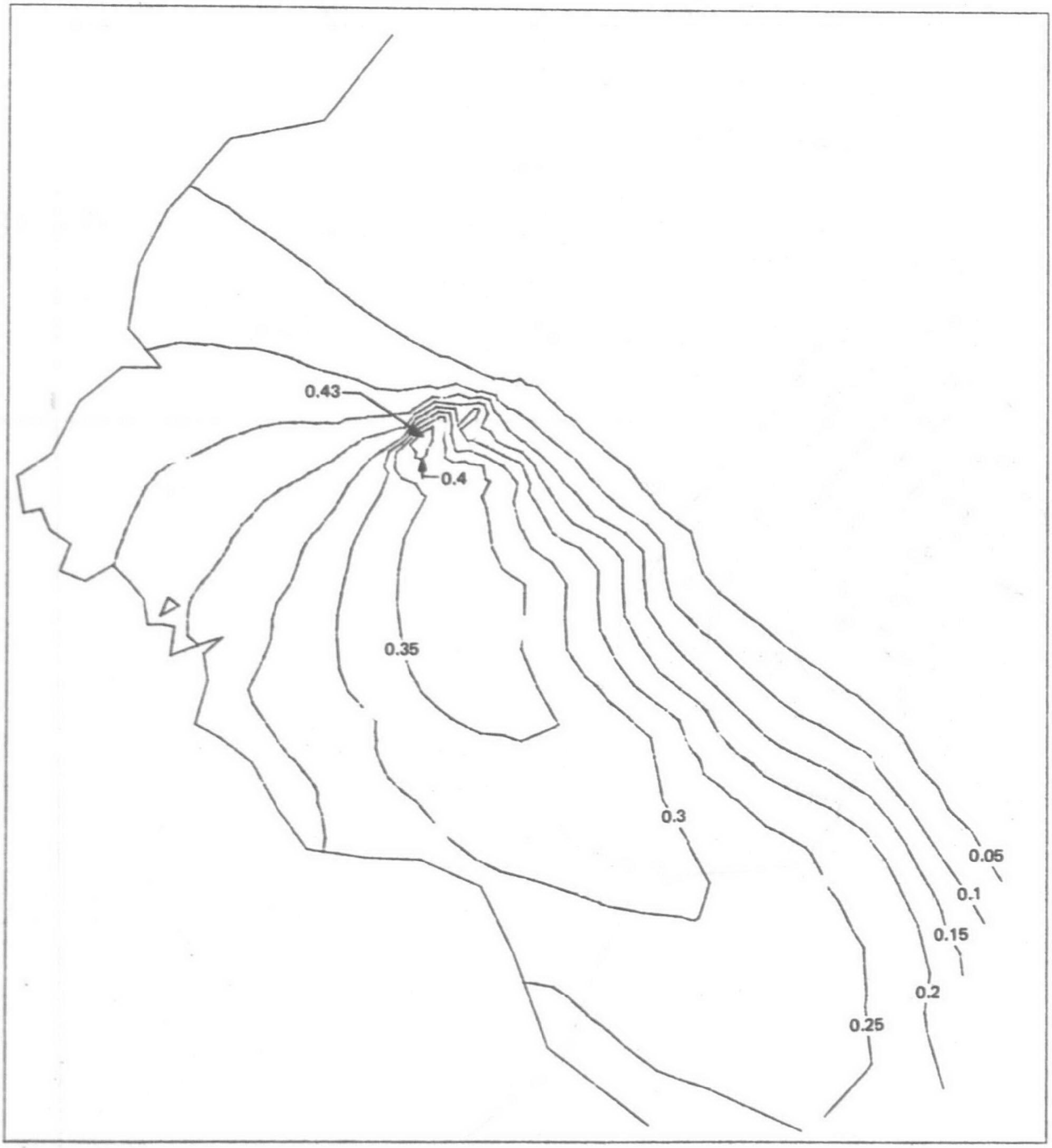


FIGURE 5.1.1.f DISSOLVED OXYGEN DEFICIT (mg/l) FOR PRIMARY DISCHARGE AT SITE 5 UNDER STRATIFIED CONDITIONS, AVERAGE NET DRIFT.

TABLE 5.1.1.e MAXIMUM DISSOLVED OXYGEN DEFICITS (mg/l)[(1)]

Treatment	Stratification	Net Drift	Site 2	Site 4	Site 5
Primary	Unstratified	Average	0.91	0.63	0.21
		Worst	0.92	0.80	0.58
	Stratified	Average	4.15	1.56	0.39
		Worst	4.22	1.91	1.03
Secondary	Unstratified	Average	0.53	0.38	0.14
		Worst	0.54	0.48	0.35
	Stratified	Average	1.76	0.69	0.19
		Worst	1.81	0.87	0.46

(1) Averaged over area of approximately 1.5 km^2, representative of the mixing zone.

Sedimentation. Sediment deposition rates were determined for primary and secondary treated effluent discharges at the alternative sites, under both stratified and unstratified average net drift conditions. Simulations were carried out for fall velocities of 0.1, 0.01 and 0.001 cm/sec until steady-state results were achieved and total sediment accumulation rates were determined by summing the accumulation rates for each fall velocity prorated by the appropriate percentage (Table 5.1.1.b).

Contour plots of the resultant total sediment accumulation rates for primary and secondary discharges at Site 5 under stratified conditions are given in Figures 5.1.1.g and 5.1.1.h. At Sites 2 and 4, the deposition was found to be more concentrated spacially, with higher deposition rates over smaller areas. These predicted sedimentation rates were used in Appendix B to determine sediment concentrations of effluent constituents. The sedimentation rates were also used in Appendix C to determine benthic enrichment.

5.1.1.6 SHORELINE IMPACT ANALYSES

Shoreline concentrations of discharged constituents were determined as part of the farfield modeling. However, the farfield analyses considered average and zero net drift conditions, and the highest shoreline concentrations can be expected as a result of sustained net drifts towards shore, most likely due to critical wind events. A different model was therefore used for the shoreline impact analyses.

The worst shoreline impacts will occur when the plume surfaces and is driven to the shore by ambient current. However, it is conceivable that upwelling of lower layer waters at the shoreline, due to a combination of events, could bring a submerged plume to the shoreline. Therefore, the protecting influence of stratification was neglected and the same analyses were conducted for stratified and non-stratified conditions.

The quasi-analytical MIT Transient Plume Model (TPM) was used for the shoreline impact analyses (Adams et al., 1975). This model simulates a discharge as a succession of puffs (or short duration releases of effluent) which are individually transported by the current and superimposed for continuous discharge simulations. An advantage of this approach is that it allows realistic three-dimensional diffusion of the effluent plume. The currents used to drive the model are assumed to be spacially uniform, which is an obvious limitation, but also permits measured currents to be used, representing actual events.

Analyses were conducted with the Transient Plume Model using MWRA current meter data for spring and summer 1987 (MWRA, STFP V,G, 1987). Simulations of discharges at each of the three alternative diffuser sites used current records from the nearest current meter station. Maximum shoreline concentrations at Swampscott, Nahant, Deer Island and Hull are listed in Table 5.1.1.f in percent of the discharge concentration.

5.1.1.7 Criteria Compliance Evaluation

5.1.1.7.1 **Dissolved Oxygen.** The dissolved oxygen criterion of the applicable Massachusetts Surface Water Quality Standards is a minimum value of 6 mg/l anywhere in the water column after hydraulic mixing and consideration of natural background conditions (314 CMR 4.02) (Table 4.2.2.1.b).

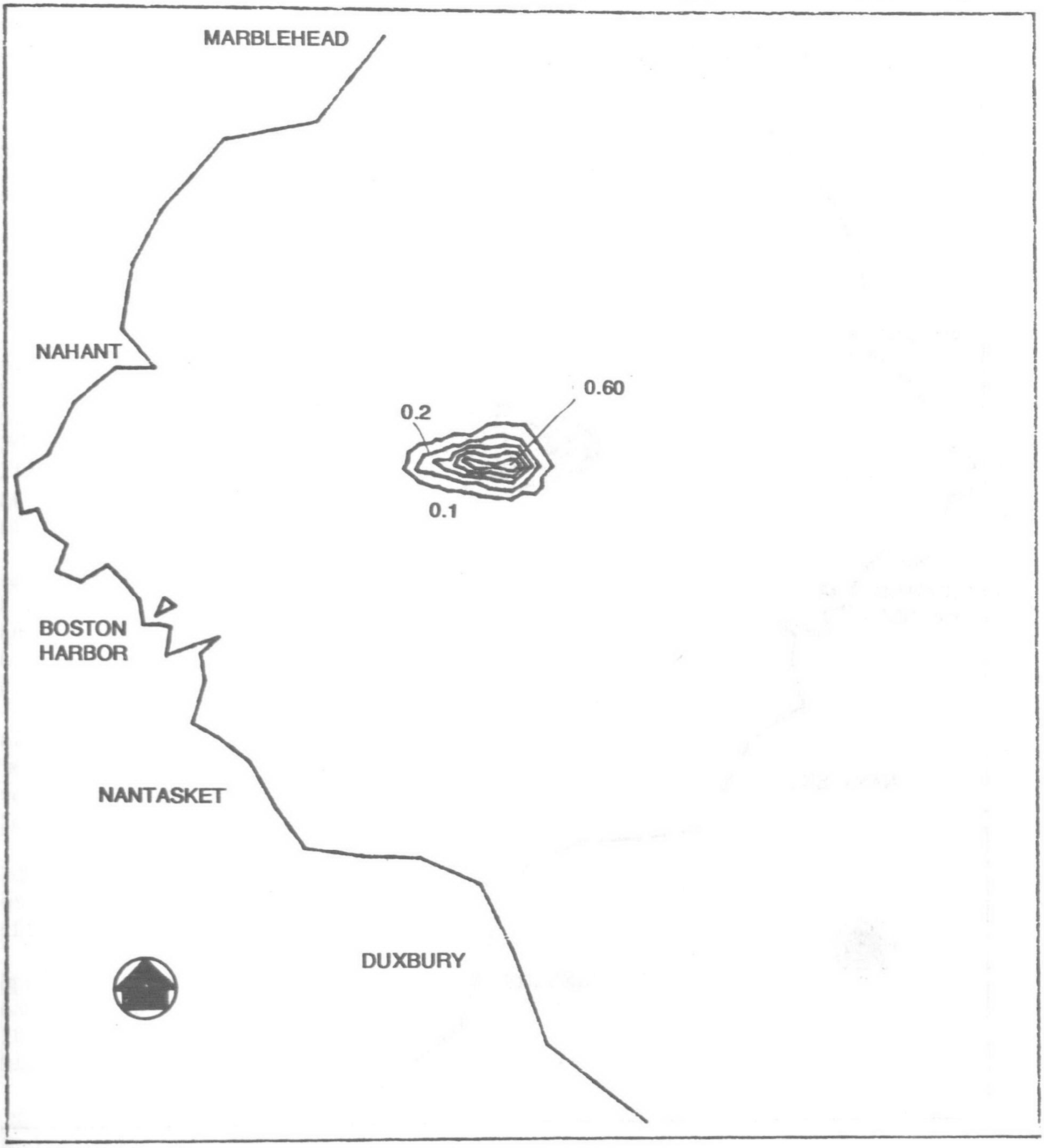


FIGURE 5.1.1.g ELA PREDICTED SEDIMENTATION RATES SITE 5, SECONDARY TREATMENT, STRATIFIED CONDITIONS ($g/m^2/day$)

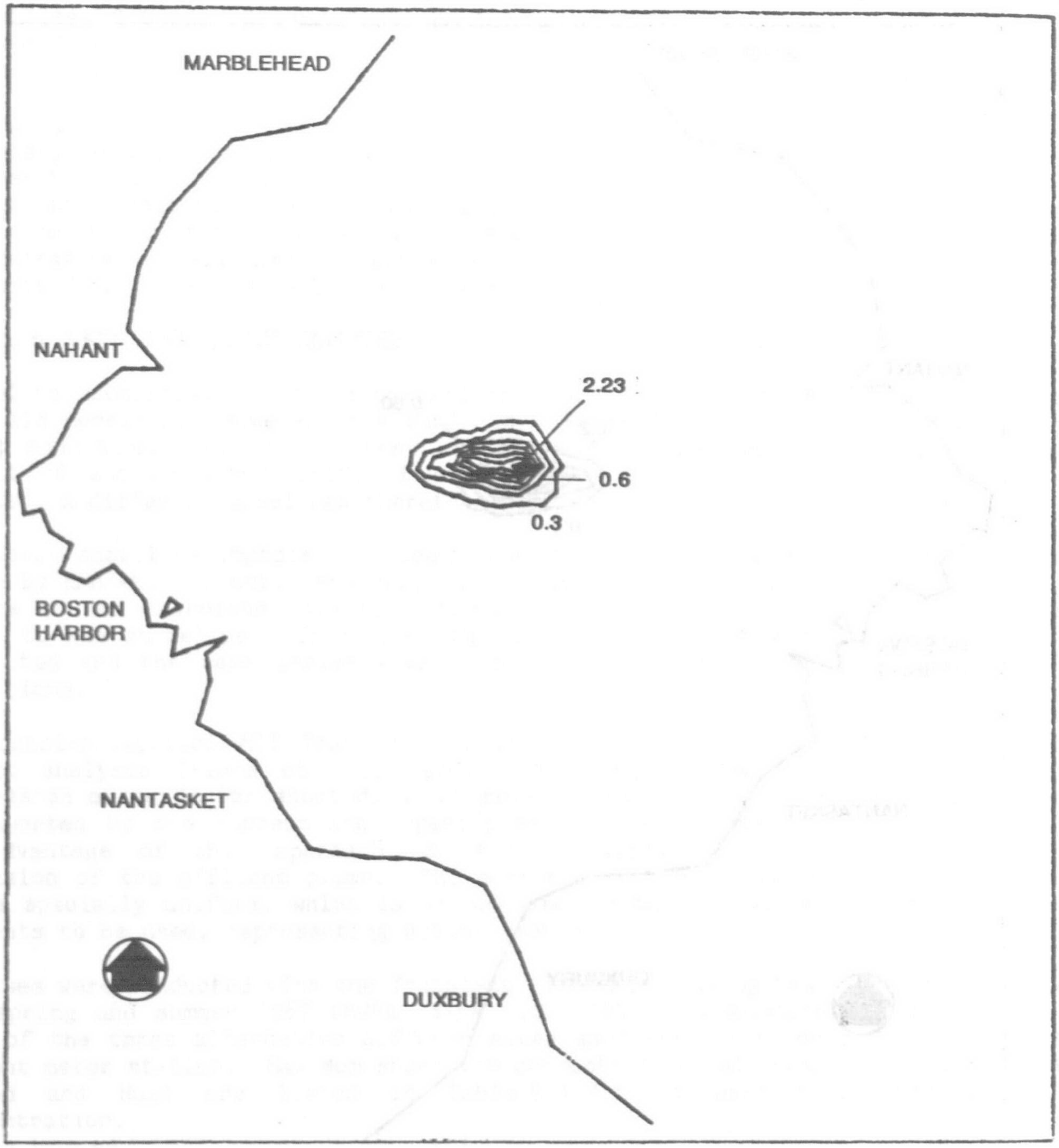


FIGURE 5.1.1.h ELA PREDICTED SEDIMENTATION RATES, SITE 5, PRIMARY TREATMENT, STRATIFIED CONDITIONS (g/m^2/day)

TABLE 5.1.1.f MAXIMUM SHORELINE CONCENTRATIONS (IN PERCENT OF THE DISCHARGE CONCENTRATION) PREDICTED WITH SPRING AND SUMMER 1987 CURRENT DATA

Area	Site 2	Site 4	Site 5
Swampscott	0.65	0.58	0.57
Nahant	1.01	0.55	0.58
Deer Island	1.27	0.19	0.24
Hull	0.56	0.32	0.41

Dissolved oxygen deficits have been predicted in the farfield analyses (Section 5.1.1.6). Contrary to individual constituents discharged in the effluent, dissolved oxygen deficits develop over a time scale of several days as a result of the BOD exertion. Therefore, the largest DO deficits are obtained in the farfield modeling and those were listed in Table 5.1.1.e for the different sites and operating conditions. Actual DO levels will be equal to the ambient value minus the DO deficit.

The ambient DO is almost always above 8 mg/l (Section 4.2.2.2) both in the upper and lower water column. During the fall, however, the ambient DO can drop to 6.5 mg/l or less in the lower layer (Section 4.2.2.2). At that time, however, the pycnocline is very deep and weak and would not be able to trap the effluent plume in the lower layer. The thickness of the lower layer would be about 3 m at Site 2 to 13 m at Site 5, with strong tidal variations, and these depths are not sufficient to contain the effluent plume. Therefore, DO values in the lower layer would not be reduced by BOD exertion from the effluent. The low ambient DO values, however, would be reduced by resuspension of sediment deposited during the summer and this aspect is considered separately below.

Outside of resuspension events, therefore, and in areas affected by the effluent, a low estimate of the ambient DO concentration is 8 mg/l and minimum DO levels due to the effluent are listed in Table 5.1.1.g.

Resuspension Oxygen Demand. Further dissolved oxygen exertion can occur as a result of sediment resuspension during storms or other events. The dissolved oxygen demand resulting from a resuspension event, RDOD, can be estimated based on the sediment deposition rates (EPA, 1982b) and is fully discussed in Appendix A (Section A.3.8).

For spring and summer conditions, 8 mg/l represents a low estimate of the ambient DO; and the minimum DO concentration, during a resuspension event, is equal to the ambient DO minus the farfield DO deficit (Table 5.1.1.f) minus the resuspension DOD demand. During the fall, lower layer ambient DO concentrations drop to about 6.5 mg/l. However, the effluent does not remain trapped in the lower layer and the minimum DO concentration, during a resuspension event, is therefore equal to the ambient DO minus the resuspension DO demand only. The corresponding minimum DOs are listed in Table 5.1.1.h.

TABLE 5.1.1.g MINIMUM DISSOLVED OXYGEN CONCENTRATIONS IN THE WATER COLUMN(1)

Treatment	Stratification	Net Drift	Site 2	Site 4	Site 5
Primary	Unstratified	Average	7.1	7.4	7.8
		Worst	7.1	7.2	7.4
	Stratified	Average	3.9	6.4	7.6
		Worst	3.8	6.1	7.0
Secondary	Unstratified	Average	7.5	7.6	7.9
		Worst	7.5	7.5	7.7
	Stratified	Average	6.2	7.3	7.8
		Worst	6.2	7.1	7.5

(1) Equal to ambient DO (8 mg/l) minus maximum DO deficient (Table 5.1.1.e).

TABLE 5.1.1.h MINIMUM WATER COLUMN DISSOLVED OXYGEN CONCENTRATIONS DURING RESUSPENSION EVENT (mg/l)

Treatment	Stratification	Net Drift	Site 2	Site 4	Site 5
Primary	Unstratified(1)	Average	6.5	6.7	7.2
		Worst	6.5	6.5	6.8
	Stratified(1)	Average	2.3	5.3	6.8
		Worst	2.2	5.0	6.2
	Fall(2)		5.0	5.4	5.7
Secondary	Unstratified(1)	Average	7.3	7.5	7.8
		Worst	7.4	7.4	7.6
	Stratified(1)	Average	5.9	7.1	7.7
		Worst	5.9	7.0	7.4
	Fall(2)		6.2	6.3	6.4

(1) Equal to ambient DO (8 mg/l) minus maximum farfield DO Deficit (Table 5.1.1.e) minus resuspension oxygen demand.
(2) Equal to ambient DO (6.5 mg/l) minus resuspension oxygen demand.

The smallest minimum DO concentration is generally obtained for primary effluent, in stratified, worst net drift conditions, after a resuspension event. These values can be obtained only once per year, at the end of the summer and assume the following combination of events: no resuspension event during 90 days in the summer, followed by a 10 day period of zero net drift, followed by a resuspension event. Given the limited expected duration of primary discharge, it is likely that such an event will never be experienced.

For secondary discharge, the results show that the 6 mg/l standard would not be violated at any site, except by 0.1 mg/l at Site 2 during stratified conditions.

For primary discharge, the standard would be violated at Site 2 during resuspension events for both stratified and non-stratified conditions. At Site 4, the standard would be violated during resuspension events occurring while the water column is stratified. The violations during resuspension events would be over a depth of approximately 10 m from the bottom. Unfortunately, data are not available to indicate how frequently resuspension events can occur at the various sites during stratified summer conditions. The large storms leading to resuspension occur most often in the winter when DO levels are usually higher.

5.1.1.7 2 pH

Changes in pH in the ambient water will arise due to the pH of the effluent and its alkalinity. Using a range of ambient water temperatures, carbon dioxide content and pH, with an effluent alkalinity of 0.5 to 1.0 meq/l and pH of 6.5 to 7.0, MWRA estimated a range of pH values of 7.6 to 8.3 at the edge of the mixing zone for secondary effluent discharge. These estimates are based on a minimum nearfield dilution of 10:1 and are therefore applicable to all sites (MWRA, STFP V,A, 1987).

For primary effluent discharge, changes in ambient water pH were estimated experimentally by MDC by diluting a mixture of Deer Island and Nut Island effluents with Massachusetts Bay water in ratios of 20:1, 40:1, 500:1, and 1600:1 (MDC, 1984). The initial pH of the seawater was 8.1 and the measurements indicated that no significant change occurred for the duration of the tests (19.5 hours). The minimum pH of any mixture was 7.8.

The Massachusetts Water Quality Standards require the pH to be in the range of 6.5 to 8.5, with a maximum change of 0.2. The analyses and tests described above indicated that pH values for primary and secondary discharges will be within the required range at all the alternative diffuser sites. Additional testing is proposed by MWRA to show that the change will not exceed 0.2. (MWRA, STFP V,A, 1987).

5.1.1.7 3 Mixing Zone Criteria. The EPA water quality criteria (4.2.2.1) apply at the edge of the mixing zone, which is defined as the end of the zone of initial dilution, when the plume either reaches the surface or its final intermediate height of rise.

Concentrations at the edge of the mixing zone are made up of the following components: i) nearfield concentration, ii) background build-up concentration, iii) concentration due to other discharges into Massachusetts Bay and iv) ambient concentration. Because the dilutions are large, these concentrations are additive.

Nearfield Concentrations are equal to the effluent concentrations divided by the nearfield dilution; the effluent concentration being equal to the constituent loading divided by the flowrate. The nearfield dilution depends on the flowrate, among other parameters, but it can be assumed that the loadings are independent of the flowrate, even though at first, high flows during storms carry higher loads. The probability of any nearfield concentration occurring is then equal to the product of the probabilities of the flowrate, current speed, stratification profile and constituent loading.

Background Build-up Concentrations were calculated in the farfield modeling for stratified and non-stratified water columns under average and worst net drift conditions. Based on a review of the net drift persistence plots (Appendix A.c), a probability of occurrence of 90 percent was attributed to the average background build-ups and 10 percent to the worst case build-ups.

Concentrations from Other Sources were calculated by MWRA, accounting for discharges from Lynn/Saugus, Swampscott, South Essex Sewerage District (SESD) and the inner harbor combined sewer overflows (CSOs). Since these discharges are far from the alternative diffuser sites, their contribution is the result of long term processes ~~and, therefore,~~ average net drift conditions can be used. These concentrations were obtained through the TEA/ELA farfield models with loading estimates for each constituent of interest (Appendix A, Table A.3.12). Values were not available for some constituents, such as pesticides, and therefore, their loadings were taken equal to zero.

Ambient Concentrations represent concentrations present in Massachusetts Bay due to previous discharges and other inputs. These are assumed to be uniform over the Bay and were estimated from measurements far from known sources (Section 4.2.2.3). Measurements were not available for all constituents and zero ambient concentrations were assumed in case of lack of data.

The EPA Water Quality Criteria for aquatic life toxicity involve concentrations not to be exceeded with a frequency greater than a specified value. For acute toxicity, the limiting concentrations are the Criteria Maximum Concentrations (CMC) which must not be exceeded with a frequency of more than 1 day in 3 years. For chronic toxicity, the limiting concentrations are the Criteria Continuous Concentrations (CCC), which must not be exceeded for more than 4 consecutive days every 3 years. The CMC and CCC concentrations are listed in Table 4.2.2.c. In order to evaluate compliance with the aquatic life toxicity criteria, a joint probability analysis was conducted (Appendix A, Section A.3.8.7).

The EPA Water Quality Criteria human toxicity and carcinogenicity are based on long term, (lifetime) exposure and fish consumption and, therefore, their compliance was addressed by comparing the average expected edge of mixing zone concentrations (statistical expected values) to the criteria concentrations.

All chemicals on EPA's Priority Pollutant and Hazardous Substances lists were orginally included in this analysis. MWRA conducted a screening analysis which identified the constituents of concern. Many constituents were present at levels below the Water Quality Criteria in the effluent and thus also at all sites. The constituents which did exceed either aquatic life or public health criteria at the edge of the mixing zone are summarized in Table 5.1.1.i in terms of the ratios of calculated concentrations to criteria concentrations. This table shows that some of the exceedances are by a small amount and others by several orders of magnitude. Exceedances by ambient waters for the arsenic and PCBs carcinogenicity criteria occur at all sites. For PCBs, but not for arsenic, the criterion would be exceeded because of the discharge, even in the absence of any ambient concentration.

For secondary treatment, Table 5.1.1.i shows that Site 5 does not exceed any aquatic life criterion and exceeds 5 human health criteria at the 10^{-6} risk factor. At the 10^{-5} risk factor, Site 5 exceeds only two human health criteria (arsenic and PCBs), which are already exceeded by the ambient. Site 4 exceeds one more criterion than Site 5 (CCC Mercury).

For primary treatment, a larger number of criteria exceedances at the 10^{-6} risk level occurs: 12 for Sites 2 and 4 and 11 for Site 5. For the 10^{-5} risk level, 11 criteria are exceeded at Site 2, 10 at Site 4 and 8 at Site 5.

5.1.2 SEDIMENT QUALITY

A simulation of the composition of bottom sediment in Massachusetts Bay was conducted to assess changes that will take place following initiation of primary and secondary effluent discharges at the alternative diffuser locations. The wastewater discharge will cause increased sediment accumulation due to deposition of effluent solids. The chemical constituents contained in the effluent solids will result in a change in the concentration of these chemicals in the bottom sediments. In general, greater deposition of effluent solids results in greater increase in bottom sediment chemical content. A summary of the methods used to assess these increases and the resulting concentration changes is presented in this section. A full description of the simulation process and results is provided in Appendix B, Marine Geology and Sediment Deposition. The marine biological impacts associated with the change in bottom sediment chemical content are presented in Section 5.1.3.2, Sediment Toxicity.

5.1.2.1 SEDIMENT CHEMISTRY SIMULATION METHODS

Effluent suspended solids deposition was evaluated at the alternative discharge sites for both primary and secondary treatment using the models TEA-NL and ELA (Appendix A). The deposition contours from this analysis are important to the simulation of bottom sediment chemical concentrations. An effluent solids chemical concentration was estimated for each constituent of concern (Appendix B). In addition, the concentration of chemicals associated with the background water column sediments and the background sediments were estimated. These values were used in the simulation to account for settling of background solids and distribution mixing of settled solids with existing bottom sediments. The effluent solids deposition pattern and background bottom sediment chemical content varies for each discharge site based on predicted effluent solids deposition and measured values in sediments. The background water column solids deposition is assumed the same at all sites. The simulation of sediment chemistry impacts therefore varies for each of the discharge sites. The three discharge sites under consideration were evaluated for the following conditions:

TABLE 5.1.1.i SUMMARY OF PREDICTED WATER QUALITY CRITERIA EXCEEDANCES

Criterion Constituent	Ambient	CONCENTRATION/CRITERION RATIOS[1] Primary Site 2	Primary Site 4	Primary Site 5	Secondary Site 2	Secondary Site 4	Secondary Site 5
CMC							
copper		2.1	1.26				
CCC							
heptachlor		3.49	2.11	1.51	1.01		
4,4'-DDT		3.55	1.99	1.34			
mercury		4.96	3.14	2.18	1.90	1.26	
PCBs		2.37	1.46	1.09			
Carcinogenicity							
(10^{-5} risk factor)							
aldrin		13.30	6.02	3.26	1.41		
4,4'-DDT		11.40	5.04	2.65	1.21		
heptachlor		3.66	1.73				
dieldrin		1.57					
arsenic	2.85	3.51	3.17	3.04	3.32	3.09	2.99
PCBs	9.24	72.75	38.00	24.80	14.69	1.70	10.57
(10^{-6} risk factor)							
aldrin		133.1	60.23	32.11	14.08	6.35	3.43
4,4'-DDT		114.1	50.38	26.46	12.08	5.33	2.79
heptachlor		36.64	17.30	9.81	4.30	2.03	1.15
dieldrin		15.68	6.02	3.26	1.66		
fluorene		7.50	3.56	2.04			
arsenic	28.45	35.07	31.75	30.37	33.25	30.95	30.84
PCBs	92.40	727.50	379.78	247.96	146.86	117.00	105.70

(1) Concentration ÷ Criterion (e.g. at Site 2, for primary, the predicted concentration is 2.1 times the CMC criterion).

- Nonstratified conditions for five years duration, primary and secondary effluent;

- Nonstratified conditions for one year duration, primary and secondary effluent;

- Stratified conditions for six months duration, primary and secondary effluent; and

- Stratified conditions for six months duration, no bioturbation mixing (rocky bottom), primary and secondary effluent at Site 5 only.

Under stratified conditions, sediment concentrations will be higher but over a smaller area because the effluent is trapped at a lower depth and settles at greater concentrations near the diffuser. Stratified conditions were evaluated for six months duration, since this condition would not be maintained over the full year. Nonstratified conditions were evaluated for six months, one year and five years duration to evaluate the change in impacts with time.

The case of no bioturbation mixing under stratified conditions was evaluated to assess the potential worst-case impacts at a site where there is minimal existing bottom sediment accumulation due to seasonal resuspension (such as hard rock surfaces), but where periods of sediment accumulation occur between resuspension events. This is a worst-case condition because there is no dilution of effluent solid chemicals with background solids. This condition would occur only within the portion of the predicted deposition area with no previously accumulated sediments. This is presumed to be a relatively small area and thus does not represent the general case.

The chemicals which are a potential problem under primary effluent conditions were evaluated for secondary effluent conditions (bis(2-ethylhexyl)phthalate, DDT, PCB, Zn). The background bottom sediment concentrations used in the secondary effluent simulations are the results of the primary effluent simulations under nonstratified conditions after five years duration. This is based on the assumption that secondary treatment will begin approximately five years after the primary discharge. The modified background bottom sediment concentration for secondary treatment is the weighted average of five years primary effluent simulation concentration over the entire deposition area.

5.1.2.2 SUMMARY OF SEDIMENT SIMULATION RESULTS

For nearly all compounds, the highest simulated pollutant sediment concentrations occur at Site 2 and the lowest concentrations at Site 5 (Tables 5.1.2.a, b, c and d). For several metals, the highest background bottom sediment concentrations occur at Site 4, and therefore, in some cases, high simulated concentrations also occur at Site 4.

The worst case simulation is the case of primary effluent with no bioturbation for six months duration. In this case, it is assumed that effluent and background water column solids are deposited on a rocky bottom with no dilution with existing bottom sediments. This case could occur at any location where sediment resuspension has exposed a rocky bottom substrate. ROV Studies (MWRA, STFP V,0, 1987) indicate that

TABLE 5.1.2.a. COMPARISON OF SIMULATED MAXIMUM SEDIMENT POLLUTANT CONCENTRATIONS, PRIMARY EFFLUENT, 5 YEARS DURATION, NONSTRATIFIED CONDITIONS

Background Concentration (ug/g)	Maximum Simulated Concentration (ug/g)					
Chemical	Site 2	Site 4	Site 5	Site 2	Site 4	Site 5
PCBs	0.01	0.02	0.01	1.38	1.03	0.77
Metals						
Arsenic	2.87	5.53	4.62	3.79	5.78	4.97
Copper	12.56	17.88	6.71	130.63	104.02	72.30
Mercury	0.15	0.17	0.11	1.82	1.41	1.04
Nickel	4.66	9.24	4.88	29.67	28.72	21.00
Selenium	2.00	2.00	2.00	11.12	8.65	6.92
Silver	2.44	0.10	0.10	7.88	4.40	3.28
Zinc	26.12	47.54	25.03	283.20	233.63	166.69
Pesticides						
Aldrin	0.04	0.04	0.04	0.30	0.23	0.18
4,4-DDT(2)	0.04	0.04	0.04	0.14	0.11	0.09
Dieldrin(2)	0.04	0.04	0.04	0.04	0.04	0.04
Heptachlor	0.04	0.04	0.04	0.13	0.10	0.09
Acid Base Neutrals						
Bis(2-ethylhexyl)phthalate	NA(1)	NA	NA	20.21	14.89	11.02
Butylbenzyl phthalate	NA	NA	NA	14.19	10.46	7.74
Di-n-octylphthalate	NA	NA	NA	22.71	16.74	12.39

1. NA = No data available - zero background concentration assumed.
2. Analyzed for public health impacts only.

TABLE 5.1.2.b. COMPARISON OF SIMULATED MAXIMUM SEDIMENT POLLUTANT CONCENTRATIONS, PRIMARY EFFLUENT, 6 MONTHS DURATION, STRATIFIED CONDITIONS

	Background Concentration (ug/g)			Maximum Simulated Concentration (ug/g)			
Chemical	Site 2	Site 4	Site 5	Site 2	Site 4	Site 5	Site 5(3)
PCBs	0.01	0.02	0.01	0.41	0.22	0.15	5.57
Metals							
Arsenic	2.87	5.53	4.62	3.10	5.58	4.68	6.82
Copper	12.56	17.88	6.71	47.24	35.51	18.84	490.85
Mercury	0.15	0.17	0.11	0.64	0.42	0.28	6.94
Nickel	4.66	9.24	4.88	10.98	12.71	7.56	112.02
Selenium	2.00	2.00	2.00	4.65	3.36	2.92	38.50
Silver	2.44	0.10	0.10	4.04	0.98	0.69	23.69
Zinc	26.12	47.54	25.03	101.39	85.56	51.19	1068.84
Pesticides							
Aldrin	0.04	0.04	0.04	0.12	0.08	0.07	1.08
4,4-DDT(2)	0.04	0.04	0.04	0.07	0.05	0.05	0.43
Dieldrin(2)	0.04	0.04	0.04	0.04	0.04	0.04	0.03
Heptachlor	0.04	0.04	0.04	0.07	0.05	0.05	0.39
Acid Base Neutrals							
Bis(2-ethylhexyl)phthalate	NA(1)	NA	NA	5.95	3.05	2.05	81.78
Butylbenzyl phthalate	NA	NA	NA	4.18	2.14	1.44	57.45
Di-n-octylphthalate	NA	NA	NA	6.69	3.43	2.30	91.91

1. NA = No data available - zero background concentration assumed.
2. Analyzed for public health impacts only.
3. No bioturbation mixing analyzed on Site 5 only.

TABLE 5.1.2.c. COMPARISON OF SIMULATED MAXIMUM SEDIMENT POLLUTANT CONCENTRATIONS, SECONDARY EFFLUENT, 5 YEARS DURATION, NONSTRATIFIED CONDITIONS

Background Concentration (ug/g)	Maximum Simulated Concentration (ug/g)					
Chemical	Site 2	Site 4	Site 5	Site 2	Site 4	Site 5
PCBs	0.10	0.10	0.11	0.33	0.27	0.21
Zinc	42.50	61.84	43.06	85.53	91.10	62.98
4,4-DDT	0.045	0.045	0.046	0.06	0.06	0.05
Bis(2-ethylhexyl)phthalate	1.08	1.06	1.21	4.28	3.34	2.54

TABLE 5.1.2.d. SUMMARY OF SITE-TO-SITE COMPARISON OF SEDIMENT POLLUTANT CONCENTRATIONS

	Primary				Secondary			
	Site 2	Site 4	Site 5	5HB[a]	Site 2	Site 4	Site 5	5HB
PCB[b] Background	0.01	0.02	0.01	0.01	0.1	0.1	0.1	0
0.5 Years Stratified Km^2 >0.1 ug/g	3.5	2.4	1.3	50.1	16.9	9.8	7.5	>7.5
5 Years Unstratified Km^2 >0.1 ug/g	17.7	13.6	10.4		6.2	5.2	4.5	
Bis phthalate Background	NA	NA	NA		1.1	1.1	1.2	0
0.5 years stratified Km^2 >7.2 ug/g	0	0	0	35.6	0	0	0	5.7
5 years unstratified Km^2 >7.2 ug/g	2.8	2.4	1.6		0	0	0	
DDT Background	0.04	0.04	0.04		0.05	0.05	0.05	0
0.5 years stratified Km^2 >0.07 ug/g	0	0	0	50.1	0	0	0	7.5
5 years unstratified Km^2 >0.1 ug/g	1.4	0.9	0		0	0	0	
ZN Background	26.1	47.5	25.0		42.5	61.8	43.1	0
0.5 years stratified Km^2 >709 ug/g	0	0	0	3.4	0	0	0	0
5 years unstratified Km^2 >709 ug/g	0	0	0		0	0	0	

(a) Hard Bottom area; only hard rock surfaces within the area would be at the concentration.

(b) For PCB at Site 5, for secondary effluent, the predicted depositions in Table B.3.e (Appendix B) are somewhat higher than for Site 4. This is an artifact of the prediction method because a much smaller area was used at Site 5 to estimate weighted average after 5 years of primary. Since the rates are actually smaller at site 5 than at site 4, rates have been used in this calculation.

rocky substrate is more prevalent in the immediate vicinity of Site 5 than Site 4, and minimal at Site 2. Therefore, the analysis was done only for Site 5 (Table 5.1.2.d). These concentrations would only occur in the limited portion of the depositional area where horizontal hard rock surfaces occur.

The results presented herein are most useful in comparing relative impacts between sites. Figure 5.1.2.a presents a comparison of the PCB simulations for primary effluent, 5 years duration, with similar trends occurring for the other compounds analyzed. The projected PCB levels represent a range associated with PCB contamination elsewhere in New England. These concentrations would be 10 (soft bottom) to 100 (rock surface) times higher than concentrations presently characteristic of Sites 2, 4, and 5. The maximum values fall within the range of 0.3-78 ug/g reported for the New Bedford Outer Harbor (Boehm et al., 1984 and Hillman et al., 1987). They also overlap the upper end of the range of PCB concentrations of the more contaminated sediments in Boston Inner Harbor (0.1-0.4 ug/g; Boehm et al., 1984). While the projected soft-bottom sediment values are less than those projected for hard bottoms, they still overlap the ranges of potential concern cited above within the immediate vicinity of the outfall, even at Site 5.

The existing background concentration at the alternative outfall sites is approximately 0.01 ug/g. This level is representative of areas where little to no PCB effects are reported. Areas where potentially adverse bioaccumulation is occurring include Quincy Bay and New Bedford Harbor. Maximum sediment levels in Quincy Bay are about 1.0 ug/g and levels generally range from 0.5 to 0.9 ug/g (EPA, 1987). High levels of PCBs in the tissues of bottom dwelling organisms have been found in the same areas in the Bay. Similarly, sediment PCB levels in New Bedford Harbor range from 0.3 to 78 ug/g are reported for areas closed to fishing due to high PCB levels in fish and shellfish tissue (Boehm, 1984).

The level of of 0.1 ug/g chosen for this analysis represents a conservative estimate of sediment PCBs which could result in bioaccumulation. This level has no established regulatory or accepted scientific basis, but is used to differentiate sediment PCB impacts between sites for this analysis.

PCB concentrations are predicted to build up during discharge of primary effluent. With the cessation of primary discharge and the initation of secondary treatment the amount of both PCBs and solids discharged will be greatly reduced (Table 5.1.2.d). Also, constant addition of relatively uncontaminated background sediment will dilute the PCB concentration built up during the primary discharge. Finally, over the 5 years of primary discharge, sediment resuspension and resettlement are predicted to redistribute the sediment PCBs. The result of these processes is that after 5 years of secondary discharge, the area of sediment with a PCB concentration greater than the comparison level of 0.01 ug/g will be largely confined to the mixing zone and similar for all sites. Consequently, long term build up of PCB in the sediment is similar and of minimal impact for all sites.

These projections indicate that the build-up of potential sediment contaminants is greatest at Site 2 and generally intermediate at Site 4. The resulting concentrations are not expected to produce significant adverse impacts at any of the sites (Section 5.1.3). However, sediment pollutant concentrations are predicted to build-up during primary discharge and then decrease during secondary discharge.

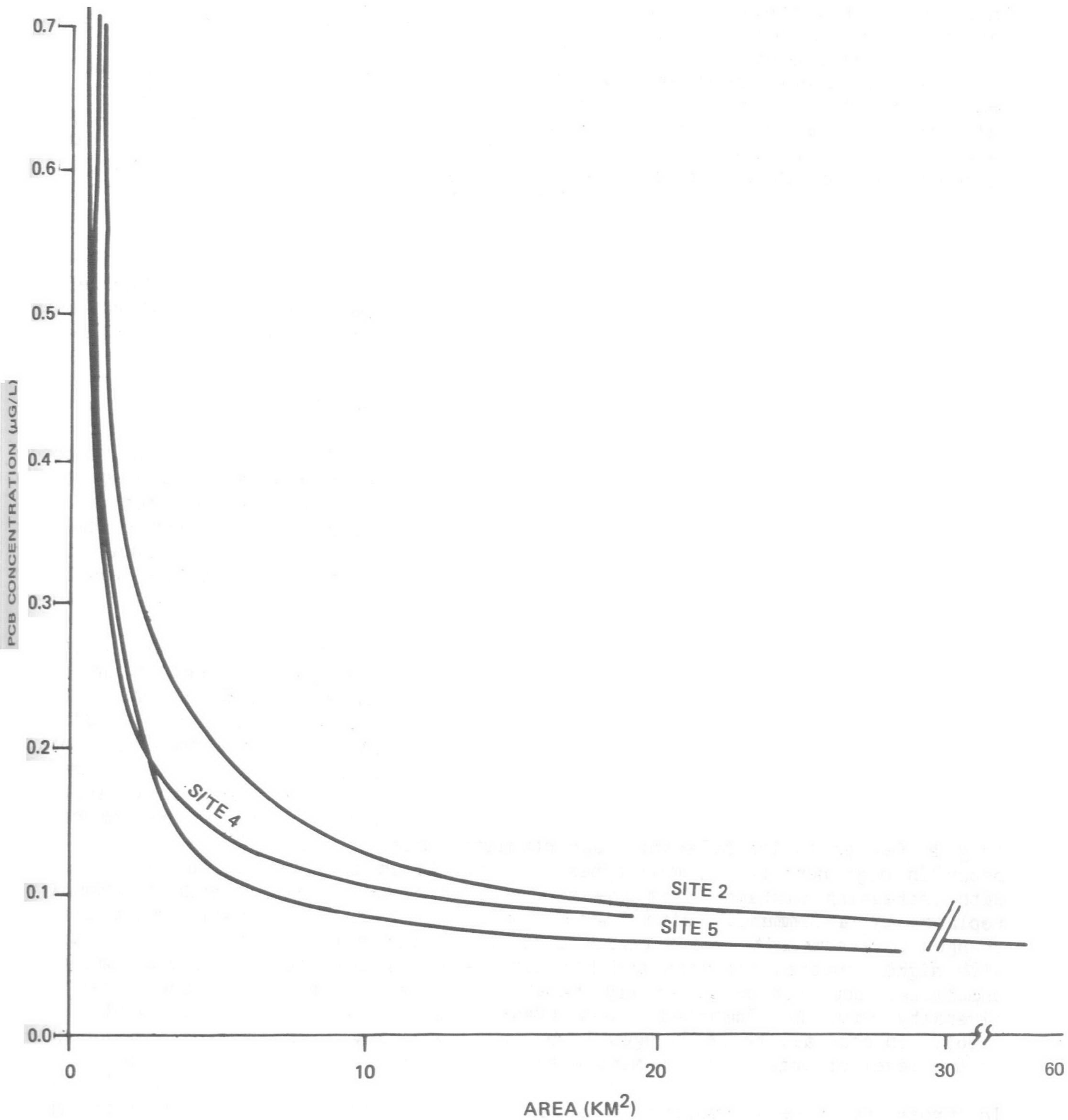


FIGURE 5.1.2.a. SEDIMENT PCB CONCENTRATIONS VS. AREA; PRIMARY EFFLUENT, NONSTRATIFIED CONDITIONS, 5 YEAR DURATION

This reduction is predicted based on dilution with cleaner background sedimentation, natural redistribution of in-place sediments and less deposition of PCB in secondary effluent. Assessment of present pollutant concentrations (MWRA, STFP V,S, 1987) indicate that there is an area of relatively high sediment concentrations in the area between Sites 2 and 4. Neither the source of this material nor the mechanisms which produce the concentrations are known. However, no matter what the cause, the data indicate that there could be less reduction during secondary discharge in concentrations built up during primary discharge in this area. This would make any discharge in the area between Sites 2 and 4 less desirable.

5.1.3 MARINE ECOSYSTEMS

This section presents an analysis of the operation impacts of the effluent outfall. Operation impacts are discussed for the three alternative outfall locations (Sites 2, 4 and 5). Operational impacts both outside the mixing zone and inside the mixing zone are considered.

5.1.3.1 Operation Consequences Outside the Mixing Zone

Impacts outside the mixing zone due to the discharge of both primary and secondary effluent are evaluated in terms of predicted changes in sediment and water quality and resultant impact on the biota. The parameters that are examined in detail include organic enrichment, sediment toxicity and accumulation of toxic compounds, while for the water column the parameters analyzed in detail include nutrient enrichment, exceedance of U.S. EPA (1986a) water quality criteria for aquatic life and periodic low dissolved oxygen concentrations.

5.1.3.1.1 Sediment Organic Enrichment. Historically, organic enrichment from wastewater discharges has been observed to have the greatest impact on benthic communities (Swartz et al., 1986; Pearson and Rosenberg, 1978; Mearns and Word, 1982; Bascom et al., 1978; Maughan, 1986; Pearson, 1982; Oviatt et al., 1987; Poore and Kudenov, 1978). Pearson and Rosenberg (1978) found macrobenthic infaunal communities to respond in a consistent pattern to changes in the level of sediment organic enrichment. In general, benthic communities in the immediate vicinity of a source of major organic enrichment contain either no macrofauna or are dominated by only a few pollution-tolerant, opportunistic species (such as capitellids) that occur in high numbers. These types of communities are considered to be *degraded*. With increasing distance from the source of enrichment this degraded community is replaced by a community with higher species richness and biomass that gradually changes to a community characteristic of unpolluted environment. These communities with higher species richness and biomass are considered to be *changed* communities. *Unpolluted* communities generally have lower species densities and often higher diversity than the impacted areas (Pearson and Rosenberg, 1978; Swartz et al., 1986). In general, these changes in benthic community structure reflect the changes in the level of organic enrichment with increasing distance from the source.

In order to assess impacts (changes in community structure) due to organic enrichment from the future MWRA wastewater, discharge rates of organic sediment enrichment have been predicted at the alternative outfall locations. These rates have been predicted from modeled sediment deposition rates (Section 5.1.1) assuming organic carbon comprises 40 percent of the effluent particulates (Metcalf & Eddy, 1979). The rate of organic enrichment above *in situ* production in which benthic community *degradation* would occur (1.5 g C/m^2/day) and the rate below which no change in community structure would occur (0.1 g C/m^2/day) were estimated from literature values. Between these two values, it is expected that species densities will increase over unaffected areas; however, the relative abundance of species will remain fairly constant. These types of communities are considered *changed* communities.

The rates used in this analysis were estimated from both field and experimental studies. Deposition rates causing no benthic change have been estimated between 0 and 0.13 g C/m^2/day while areas of *degraded* benthos have organic deposition rates estimated from 1.5 g C/m^2/day to approximately 5.0 g C/m^2/day (Maughan, 1986). These rates were estimated from studies in the New York Bight (O'Conner et al., 1983; Gunnerson et al., 1982) and southern California (Herring and Abati, 1979; Mearns and Word, 1982) as well as mesocosm experiments (Maughan, 1986). Enrichment rates above 1.5 g C/m^2/day generally result in benthic communities characterized by densities 3 to 4 times background densities, numerical domination by a few species, domination by species with a different feeding type and potential mass mortality produced by anoxia (Maughan, 1986).

A maximum sedimentation value of 25 g/m^2 (as defined by the sediment deposition rate divided by the sediment decay rate of 0.01 /day) was used by MWRA (STFP V,H, 1987) to present an "area of impact." This has also been used by U.S. EPA (1982b) to evaluate other discharges. Assuming effluent solids are 40% organic carbon, the maximum sedimentation value would be: (25 g/m^2 * 0.40) = 10 g C/m^2. This interprets to a deposition rate of: 10 C/m^2 * 0.1 /d = 0.1 g C/m^2/day. This is consistent with literature values discussed above.

In order to compare alternative outfall sites, the areal extent of predicted *degraded* benthic communities and *changed* benthic communities have been determined. Table 5.1.3.a presents a comparison of predicted organic enrichment between Sites for both primary and secondary treatment under stratified and nonstratified conditions.

Nonstratified conditions. No areas of *degraded* benthic conditions (organic loading greater than 1.5 g C/m^2/day) are predicted for any site under secondary treatment during nonstratified conditions. Under primary treatment, during nonstratified conditions, *degraded* areas (less than 1 km^2) are expected to occur at Sites 2 and 4. *Changed* benthic conditions are predicted to occur at all sites under both types of treatment during nonstratified conditions with the area of impact being greatest at Site 2 and lowest at Site 5 (Figures 5.1.3.a and 5.1.3.b). Under primary treatment with nonstratified conditions, the area of *changed* conditions is approximately 40 percent less at Site 5 than Site 2. Under secondary treatment (nonstratified), this area is approximately 80 percent less at Site 5 than Site 2.

Stratified Conditions. Organic enrichment has also been predicted for the stratified summer conditions, from approximately late-June to mid-September. During these months, impacts to the benthos due to organic enrichment will be most severe. This is because the solids are deposited over a smaller area since they have a shorter distance to fall before currents disperse them. *Degraded* communities are predicted to occur under primary treatment at all three sites over small areas during this period (Figure 5.1.3.c to 5.1.3.d). The area of predicted degradation at Site 5 is only 2 percent of that predicted for Site 2 under primary treatment.

TABLE 5.1.3.a SUMMARY OF AREAL EXTENT OF PREDICTED SEDIMENT ORGANIC ENRICHMENT

	Primary Treatment		Secondary Treatment	
	AREA DEGRADED (Km^2) (>1.5gC/m^2/d)	AREA CHANGED (Km^2) (0.1-1.5gC/m^2/d)	AREA DEGRADED (Km^2) (>1.5gC/m^2/day)	AREA CHANGED (Km^2) (0.1-1.5gC/m^2/day)
Non-Stratified Conditions				
SITE 2	0.8	16.9	0	3.0
SITE 4	0.02	13.7	0	1.9
SITE 5	0	10.4	0	0.6
Stratified Conditions				
SITE 2	2.2	32.7	0	4.9
SITE 4	1.2	18.9	0	3.2
SITE 5	0.05	12.2	0	3.1

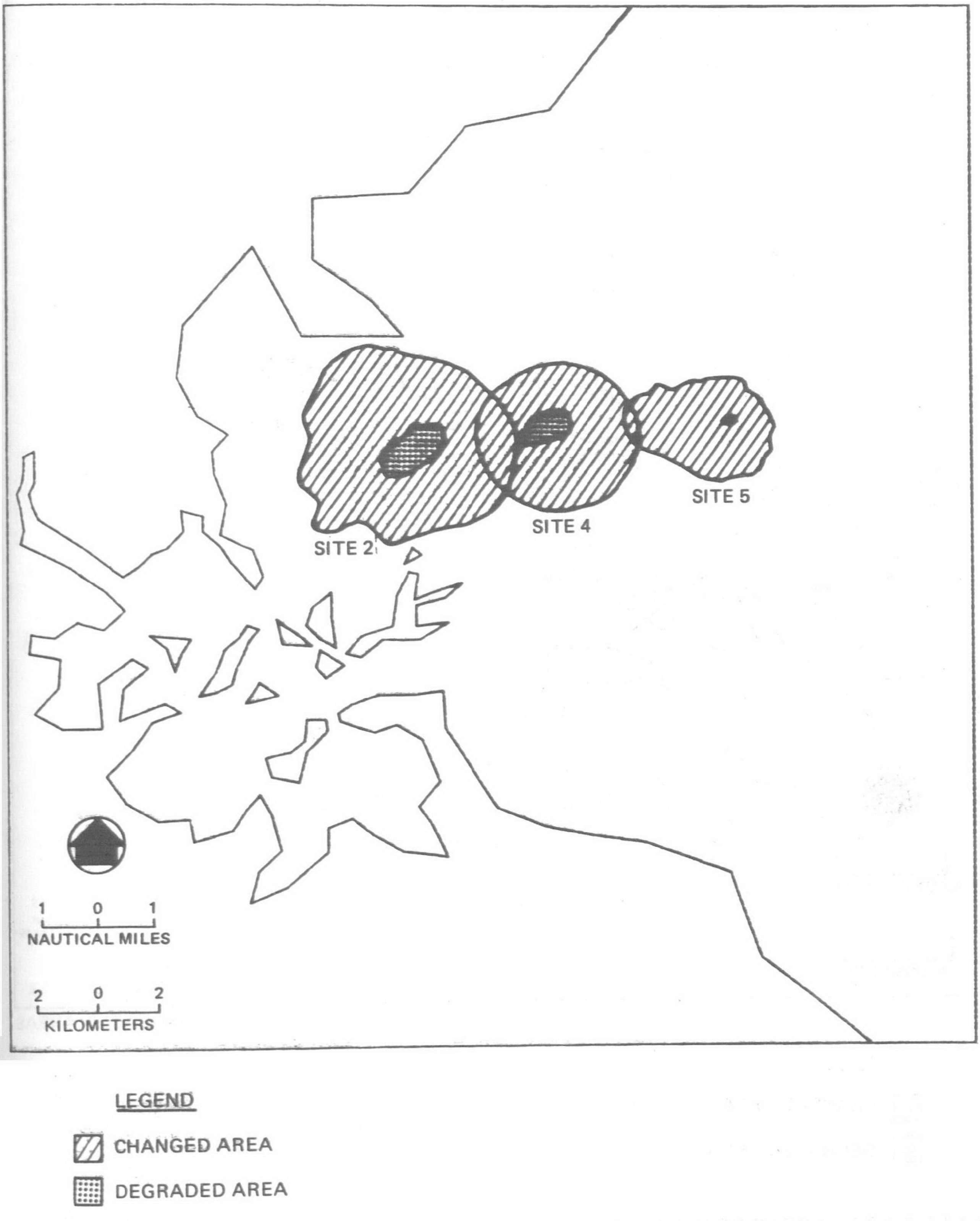


FIGURE 5.1.3.a. AREAS OF PREDICTED CHANGED AND DEGRADED BENTHIC COMMUNITIES DUE TO ORGANIC ENRICHMENT UNDER STRATIFIED CONDITIONS WITH PRIMARY TREATMENT FOR ALL SITES

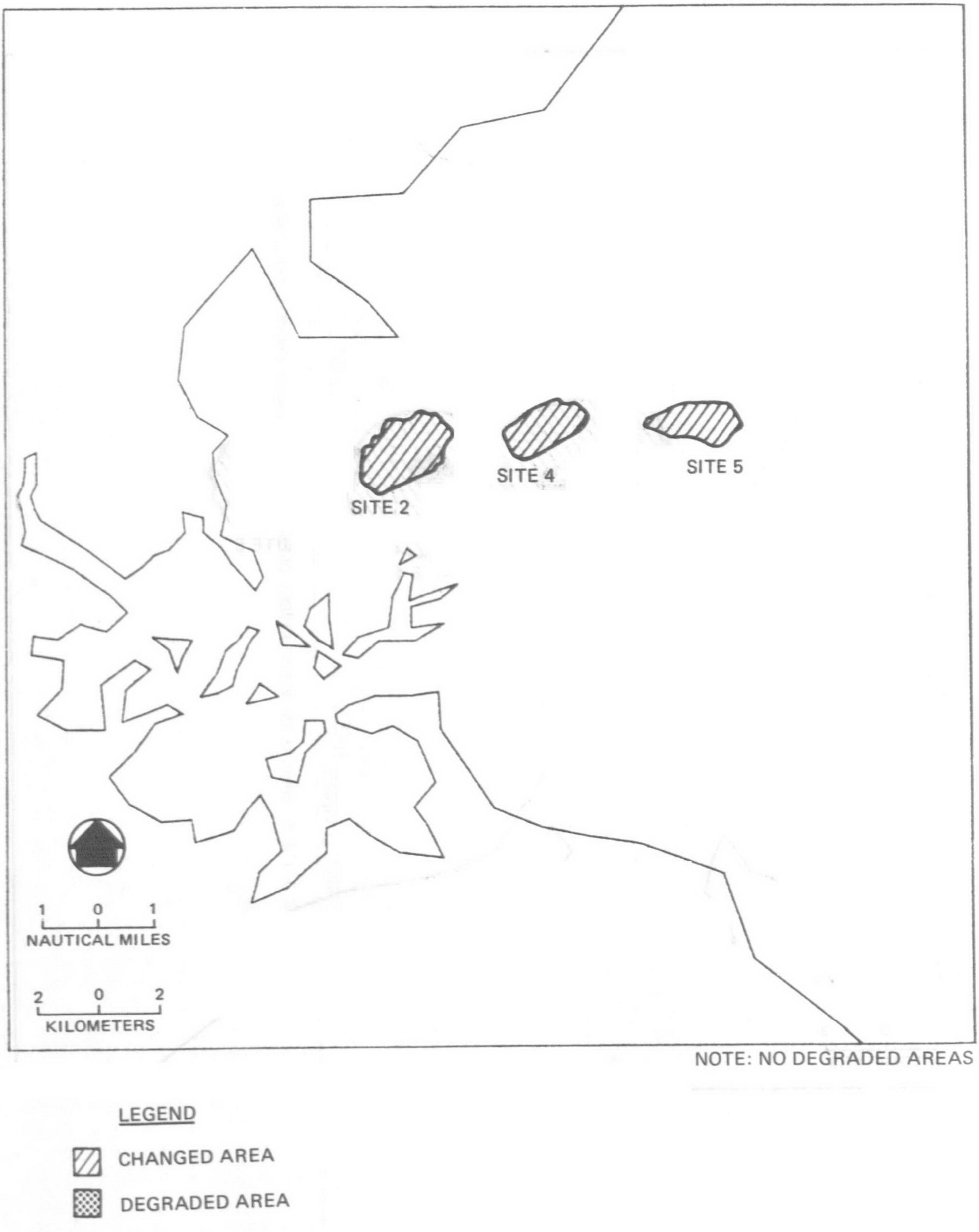


FIGURE 5.1.3.b. AREAS OF PREDICTED CHANGED AND DEGRADED BENTHIC COMMUNITIES DUE TO ORGANIC ENRICHMENT UNDER STRATIFIED CONDITIONS WITH SECONDARY TREATMENT FOR ALL SITES

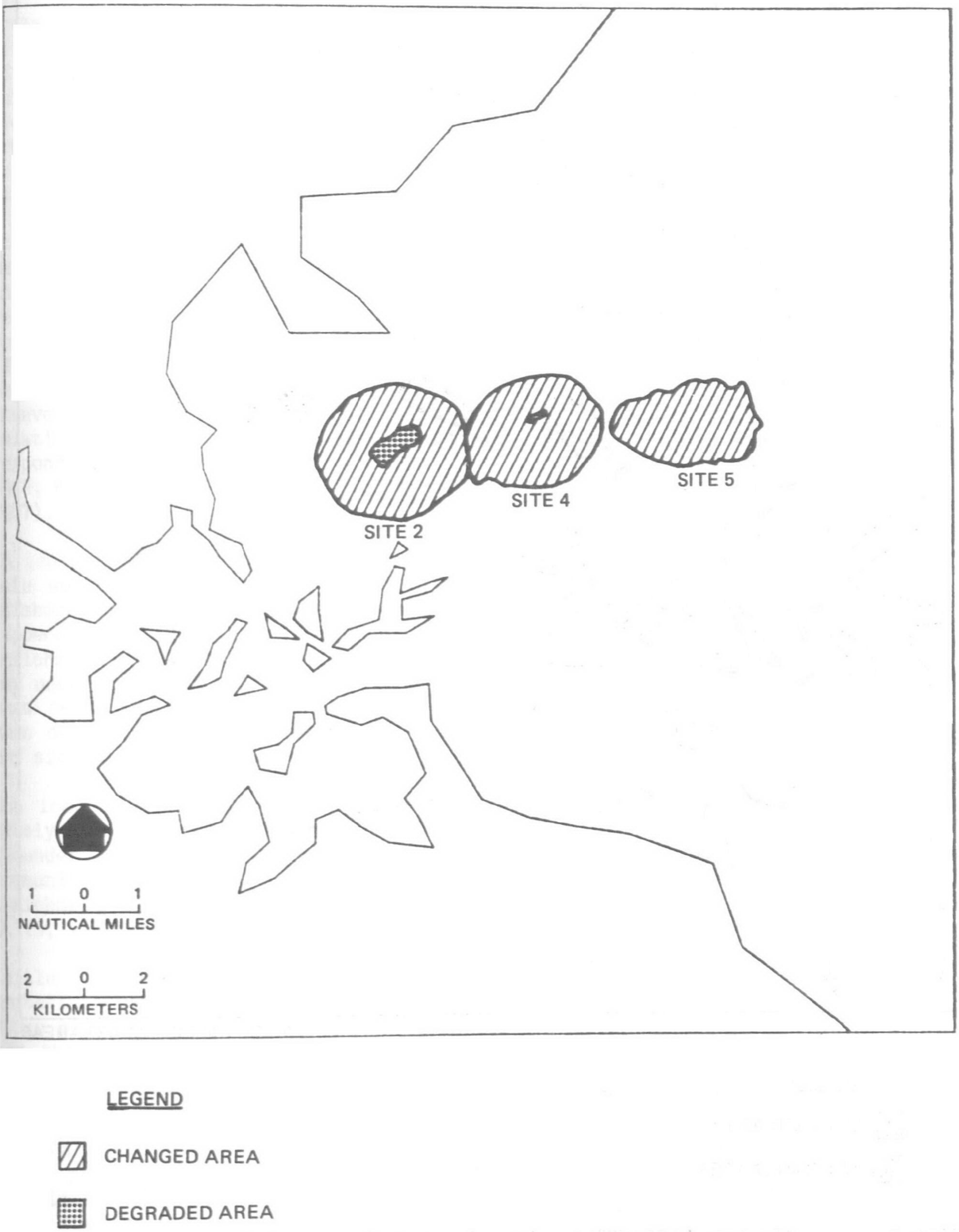
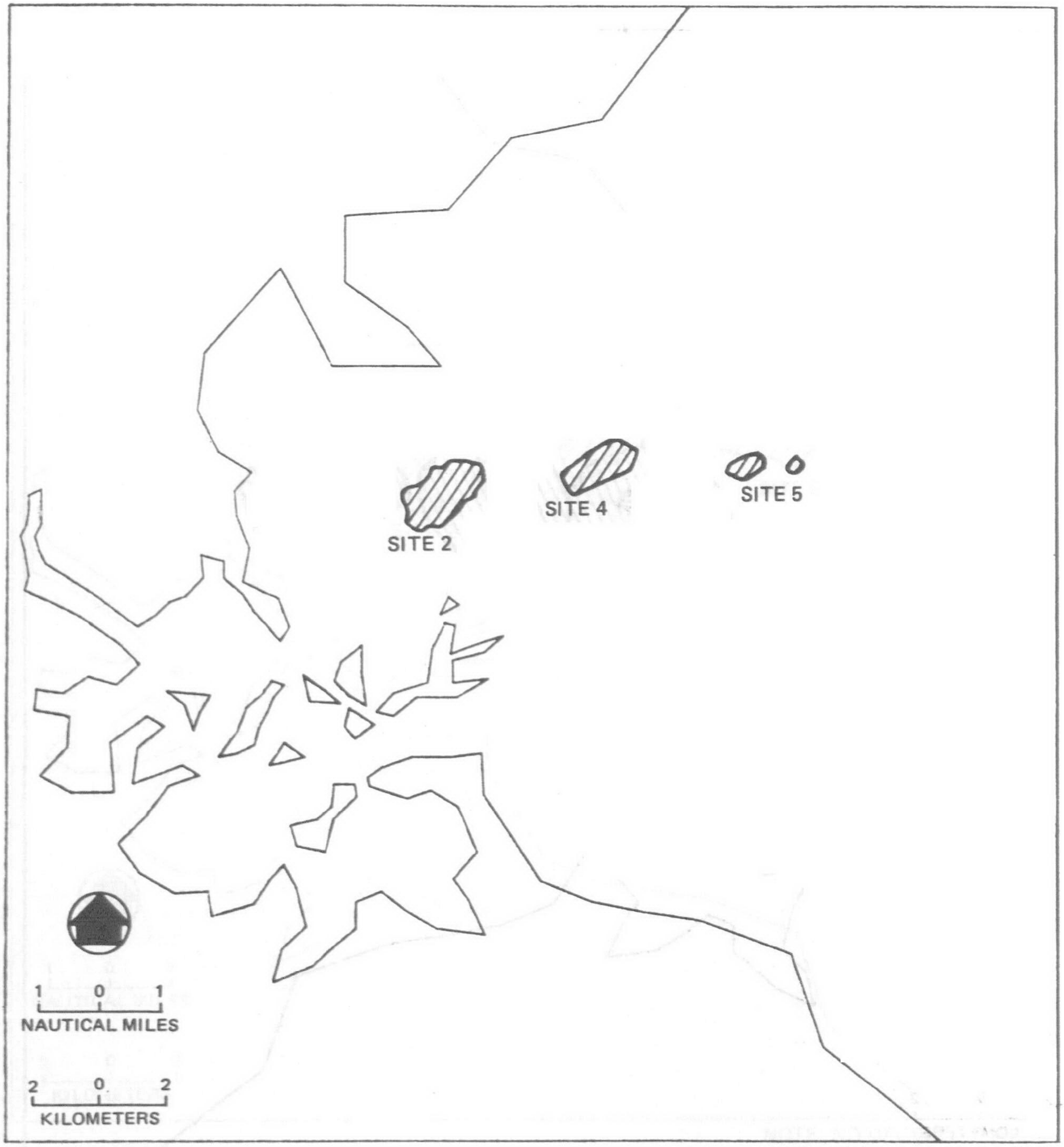


FIGURE 5.1.3.c. AREAS OF PREDICTED CHANGED AND DEGRADED BENTHIC COMMUNITIES DUE TO ORGANIC ENRICHMENT UNDER NON-STRATIFIED CONDITIONS WITH PRIMARY TREATMENT FOR ALL SITES



NOTE: NO DEGRADED AREAS

LEGEND

CHANGED AREA

DEGRADED AREA

FIGURE 5.1.3.d. AREAS OF PREDICTED CHANGED AND DEGRADED BENTHIC COMMUNITIES DUE TO ORGANIC ENRICHMENT UNDER NON-STRATIFIED CONDITIONS WITH SECONDARY TREATMENT FOR ALL SITES

Areas of *changed* benthic communities are expected to occur at all sites under both primary and secondary treatment during periods of stratification. The greatest area of *changed* communities with stratified conditions is expected to occur at Site 2 while the lowest area of *change* is expected at Site 5 under both primary and secondary treatment. Under primary treatment, the area of change at Site 5 is predicted to be approximately 37 percent of that at Site 2. Under secondary treatment, areas of *change* at Site 5 is predicted to be 60 percent of that area at Site 2.

The surface deposit feeding polychaetes, spionids, are the most abundant infaunal taxa throughout the study area (Appendix C). This taxon has been reported to increase in numbers with organic enrichment (Bottom, 1979; Dauer and Conner, 1980; Pearson and Rosenberg 1978; Oviatt et al, 1987). Two taxa common at Site 2, *Tharyx* spp. and Oligachaeta are also known to respond positively to organic enrichment (Thompson, 1982; Pearson and Rosenberg, 1978; Swartz et al., 1986). Under *changed* conditions, these species will increase in densities along with most other taxa; however, under *degraded* conditions these taxa will likely dominate. At Site 4, the relatively common pollution-sensitive amphipods will likely decrease in numbers in response to maximum organic enrichment with the exception of *Corophium* spp. (Pearce, 1972; Bottom, 1979; Steimle et al., 1982; Pearson and Rosenberg, 1978; Oviatt et al; 1987).

In general it would appear that within the *changed* or *degraded* area the nearshore site would undergo less of a shift in infaunal species composition than the more offshore sites since there is already some evidence of stress nearshore (Appendix C). Several infaunal taxa that are known to respond positively to organic enrichment are already abundant at Site 2. The relatively unstressed offshore sites may undergo a greater shift in infaunal species composition and relative abundance than nearshore; however, the area impacted will be considerably smaller offshore than nearshore (Figure C.1.3.a to C.1.3.d). No species changes are anticipated at any site areas of enrichment less than 0.1 g $C/m^2/d$.

The increased abundance and biomass of the benthic infaunal community will also likely result in an increase in abundance in demersal species such as winter flounder that feed on these organisms or organic matter directly. Pelagic fish communities will not necessarily be as directly affected by sediment organic enrichment since these species are highly mobile and have broad ranges (Section C.1.5, Appendix C).

Little information is available on impacts to epibenthic organisms; however, epibenthic organisms living in these areas will potentially be subjected to the same types of impacts as infaunal benthic communities. Therefore, the degree of impact and the relative differences of impacts between sites will be similar to that described above for infaunal communities. Based on the characteristics of the epibenthic species present, a qualitative assessment of likely impacts is presented.

There are two basic types of epibenthos. One group consists of sessile organisms which predominantly feed in the water column (such as sponges, anemones and hydroids). The other group contains organisms which are motile and feed mostly on or in the sediments (such as crabs, lobsters and crangon shrimp). These two groups have different susceptibility to organic enrichment and are discussed separately.

The sessile group is highly dependent on particulate matter in the water column. If the particulates are at suitable density and have a usable nutritional value, the organisms would respond with increased consumption and thus possible increased growth and reproduction. There is evidence that benthic animals can assimilate sewage solids (Maughan, 1986), so epibenthic populations could be expected to increase in areas of moderate deposition. However, if deposition is too high, dominance by tolerant species and high sediment oxygen demand could inhibit the epibenthic populations. There is no quantitative documentation of the deposition rate that would produce these adverse affects, however the rates used above for *degraded* infauna could also be expected to adversely affect the epifauna.

The motile epifauna are expected to respond differently to organic sediment deposition. They do not rely directly on particulate matter as food so a simple response to enrichment is not anticipated. They could be expected to increase somewhat in density as overall system secondary production increased due to their general scavenging and carnivorous feeding behavior.

5.1.3.1.2 **Sediment Toxicity.** Toxic substances associated with effluent particulates can accumulate in bottom sediments and may have adverse effects on the associated biota. Toxic substances may not only cause mortality but at sublethal concentrations may limit the reproductive potential of sensitive populations, thereby causing a shift in community composition (Wolfe et al., 1982).

Very little quantitative information is available on concentrations of toxics in the sediments and the associated effects on the benthos and higher trophic levels. There is also no established criteria to evaluate sediment chronic and acute toxicity. Even at a given concentration, toxicity of a given constituent may vary between different sediment types due to differences in bioavailability of the constituent (Windom et al., 1982). Realizing these limitations, an attempt has been made to predict and quantify impacts associated with toxics accumulation in the sediments in order to compare relative impacts among sites.

An approach has been developed to predict concentrations of various effluent toxics in the sediments (Appendix B). The list of constituents was developed from a list of detectable influent constituents of concern (MWRA, STFP V,A, 1987). This original list was reduced by eliminating all constituents that were not predicted to occur in effluent suspended solids and all constituents whose predicted concentration in effluent (MWRA, STFP V,A, 1987) was known from literature to be non-toxic in sediments. Also eliminated from this list were volatiles with low associations with sediment particulates. Table 5.1.3.b summarizes this elimination procedure and presents a list of the remaining constituents.

The sediment concentrations and the areal extent of these remaining constituents were then predicted for the remaining 15 constituents for each site for durations of six months, one year, and five years under both stratified and non-stratified conditions (Appendix B). The sediment concentrations of these constituents for each site were compared to available literature concentrations where possible to determine potential impacts to benthic organisms. Studies found to be useful for these comparisons include Swartz et al., 1986; Perez et al., 1983; Reed et al., 1984; Peddicord, 1980; Rubenstein et al., 1984; Calabrese, et al. 1982; and Oviatt et al., 1982. Values for selenium, aldrin, butylbenzyl phthalate, di-n-octyl phthalate and heptachlor were not found in the available sources. Table 5.1.3.c summarizes the available sediment toxics concentrations information.

TABLE 5.1.3.b SUMMARY OF EVALUATION OF CONSTITUENTS OF CONCERN

Influent Constituent of Concern	Eliminated Because Not Projected in Effluent Suspended Solids	Eliminated Because of Low Association With Particulates	Eliminated Because Effluent Concentration Not Toxic	Remaining Sediment Constituents of Concern
VOLATILES				
benzene	X			
bromomethane	X			
chloroform	X			
ethylbenzene		X		
methylene chloride	X			
styrene		X		
tetrachloroethylene		X		
trichloroethylene	X			
ACID, BASE NEUTRALS				ACID, BASE NEUTRALS
bis (2-ethylhexyl)phthalate				bis (2-ethylhexyl)phthalate
butylbenzyl phthalate				butylbenzyl phthalate
di-n-octyl phthalate				di-n-octyl phthalate
flourene			X	
METALS				METALS
arsenic				arsenic
cadmium			X	
chromium			X	
copper				copper
lead			X	
mercury				mercury
nickel			X	nickel
selenium				selenium
silver				silver
zinc				zinc
PESTICIDES				PESTICIDES
aldrin				aldrin
4,4-DDT				4,4 DDT
dieldrin				dieldrin
heptachlor				heptachlor
OTHER CHEMICALS				OTHER CHEMICALS
PCBs				PCBs

TABLE 5.1.3.c SUMMARY OF SEDIMENT TOXICS INFORMATION

Constituent	Maximum Concentration (ppm) Predicted in Sediment (a) Site 2	Site 4	Site 5	Concentration (ppm) below which toxic effects do not occur	Literature source	Comments
bis (2-ethylhexyl)phthalate	20.2	14.9	11.0	7.2	Perez et al., 1983; Swartz et al., 1986.	
butylbenzyl phthalate	14.2	10.4	7.7	NA		
di-n-octyl phthalate	22.7	16.7	12.4	NA		
flourene	*	*	*	129	Oviatt et al., 1982	Toxic concentration given is for total PAHs
arsenic	3.8	5.8	5.0	128	Peddicord, 1980	Not accumulated by juvenile crab, *Cancer magister*
cadmium	*	*	*	22	Swartz et al., 1986	
chromium	*	*	*	720	Swartz et al., 1986	
copper	130.6	104.0	72.3	547	Swartz et al., 1986	
lead	*	*	*	252	Swartz et al., 1986	
mercury	1.8	1.4	1.01	1.47;6	Peddicord, 1980; Calabrese et al, 1982	Not accumulated by shrimp, (*Crangon migromaculata*); no effect on lobster (*Homarus americanus*)
nickel	29.7	28.7	21.8	85	Swartz et al., 1986	
selenium	11.0	8.6	6.9	NA		
silver	7.9	4.4	3.3	6-10	Calabrese et al, 1982	
zinc	283.2	233.6	166.7	>709	Swartz et al., 1986	
aldrin	0.3	0.2	0.2	NA		
4,4-DDT	0.13	0.1	0.1	>0.07	Swartz et al., 1986 U.S. EPA, 1986	Toxic concentration for 4,4-DDE was given in Swartz et al.; 4,4-DDT is 108 times more toxic than 4,4-DDE in water column. Therefore DDE concentration was divided by 108.
dieldrin	0.04	0.04	0.04			
heptachlor	0.1	0.1	0.08	NA		
PCB	1.4	1.03	0.8	>20 5.2	Reed et al., 1982 Rubenstein et al., 1984	

NA = Not available
*Concentration of effluent particulates is less than concentration known to cause effects; therefore, concentration in sediments not predicted.
a. Under primary treatment for 5 years, nonstratified.

As shown in Appendix B, maximum concentrations of all constituents at each alternative outfall site occurred over the five-year interim primary discharge period. Maximum predicted sediment concentrations of all constituents were consistently highest at Site 2 and lowest at Site 5 with the exception of arsenic which was highest at Site 4. The high arsenic concentration at Site 4 is due to the high background concentration in the existing sediment (MWRA, STFP V,S, 1987).

Of the constituents for which toxic information exists, only two (DDT and bis(ethyl-hexyl phthalate) are predicted to occur in concentrations that will directly effect the benthic species (Table 5.1.3.c). The maximum areal extent of impacts due to sediment toxicity ranges from 2.8 km^2 at Site 2 to 1.6 km^2 at Site 5 during primary treatment (Table 5.1.3.d). These areas are within the mixing zone area. No sediment toxicity impacts are predicted under secondary treatment.

A possible sublethal effect of sediment toxicants includes the potential for organisms to concentrate toxicants in their tissues (bioaccumulation). The concentrated toxicant may then be transferred through the food web and be biomagnified. It is difficult to predict the effects of biomagnification on carnivores at the top of the food chain including sea birds and marine mammals because the rate of accumulation and body turnover time is poorly understood and varies among toxicants (U.S. EPA, 1980a).

Perez et al. (1983) found bis(ethyl-hexyl) pthalate to accumulate in mollusc and polychaete tissue in a controlled mesocosm experiment. Kay (1984) reviewed the available literature on biomagnification of heavy metals, organic compounds (including PCB and DDT) and PAH's. In general, he found PCB's to have the potential for biomagnification in the food web while information on heavy metal biomagnification was frequently contradictory.

> ***Although top predatory fishes sometimes contained higher levels of specific contaminants than other members of the food web, the relationship between contaminant levels in the tissues and an organism's position in the food web was not clear. The apparent inconsistency in the data may reflect a number of factors including the mobility of the top predators, age and size differences, inadequate understanding of the feeding habits of different species (particularly with respect to the changing of feeding habits at different stages of the life cycle), in precision in the assignment of trophic levels, and inadequate sampling and analytical procedures.*** (Kay, 1984).

Compounds which likely do not biomagnify include DDT and most PAHs (Kay, 1984).

Although it may not be possible to quantify impacts at each alternative outfall site for each constituent in terms of toxicity and biomagnification, it may be assumed that these affects, if any, would be greatest where toxic sediment concentration is predicted to be the highest (Site 2) and least where the concentration is predicted to be the lowest (Site 5).

5.1.3.1.3 Nutrient Enrichment. Wastewater discharges have been shown to cause nutrient enrichment in marine waters (Mearns et al., 1982; Malone, 1982; Oviatt et al., 1986). Moderate increases in nutrients may result in stimulation of the entire marine community by increasing phytoplankton growth, respiration, secondary production and eventually density of predators such as fish. However, above certain

TABLE 5.1.3.d AREAL EXTENT (KM^2) SEDIMENT TOXICITY AT ALTERNATE OUTFALL SITES UNDER PRIMARY AND SECONDARY TREATMENT

	Primary Treatment			Secondary Treatment		
	Site 2	Site 4	Site 5	Site 2	Site 4	Site 5
Bis(ethyl-hexyl) phthalate						
After 6 months stratified	0	0	0	0	0	0
After 5 years non-stratified	2.8	2.4	1.6	0	0	0
DDT						
After 6 months stratified	0	0	0	0	0	0
After 5 years non-stratified	1.4	0.9	0	0	0	0

nutrient levels the stimulation cannot be assimilated by the marine systems. Above this critical level, significant shifts in species composition or even excessive oxygen demand and anoxia may occur (Mearns et al., 1982).

For the purpose of this analysis of nutrient enrichment, increases in nitrogen concentrations have been predicted for each alternative outfall location (Appendix A). Nitrogen was used in the analysis because it appears to be the limiting nutrient in the study area (Section C.1.1.3 of Appendix C). Also, increases in concentrations of other nutrients would be proportional to those of nitrogen. Nitrogen additions greater than 0.5 mg/l are expected to cause excessive oxygen demand leading to *degraded* conditions in the summer months, while additions of less than 0.14 mg/l are expected to have no impact. The estimates were derived from long-term marine system nutrient addition studies with multiple dose levels (Oviatt et. al, 1986). These values have been calculated based on estimated steady-state concentrations. Between these two values, increased production is expected but with no excessive oxygen demand resulting in *changed* conditions. Generally consistent with these levels, forty-eight hour nutrient spike experiments conducted by MWRA with water samples collected within the study area (MWRA, STFP V,Z, 1987) indicated that nitrogen addition of up to 0.35 mg/l stimulated carbon production rates, chlorophyll biomass yield and species growth rates, but did not cause algal blooms within the experimental time period.

In this analysis, the enrichment effects were assumed to be similar for primary and secondary treatment. This is because neither treatment process will remove significant amounts of nitrogen, therefore the influent nitrogen concentrations were used. The form of nitrogen will initially be different for these two levels of treatment with more amonia present in the secondary effluent. However, nitrogen has been treated as a conservative substance for this analysis; therefore, for the steady-state projections most, of the nitrogen is in the system long enough to be initially consumed and then remineralized. Consequently, its original form is the major concern.

The areas within which *degraded* and *changed* water column conditions may occur were predicted for each site under average conditions (Table 5.1.3.e). The area in which *degraded* conditions are predicted as a result of increased nutrients in the water column is greatest at Site 2. The area in which these conditions are predicted to exist is 75 percent smaller at Site 4 than Site 2 during average conditions. High oxygen demand resulting in *degraded* conditions, is not expected to occur at all at Site 5. The area of increased primary production (changed conditions) is also greatest at Site 2 (Table 5.1.3.e). The area affected by increased production resulting from a discharge at Site 2 would include most of Boston Harbor.

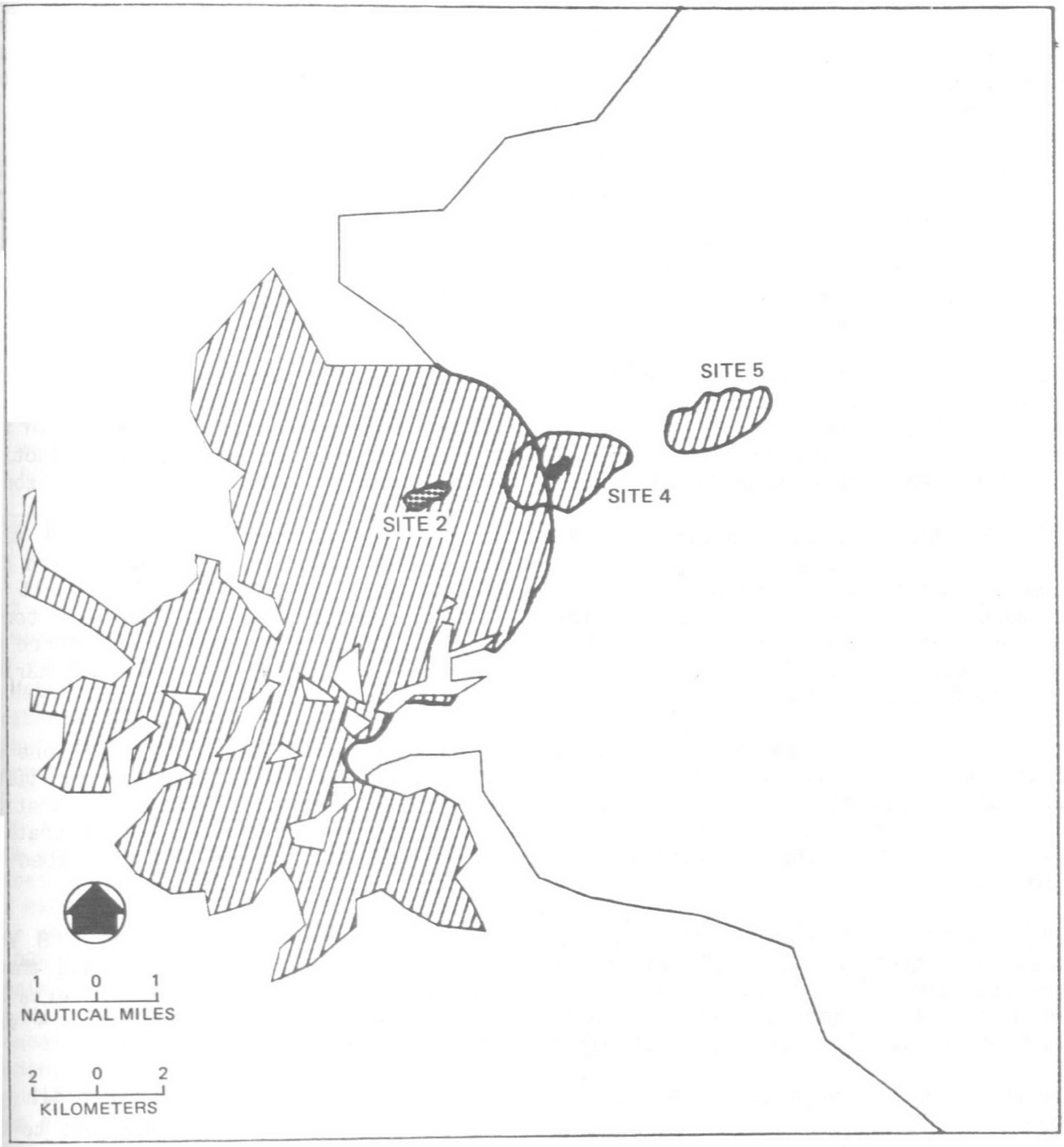
Nutrient enrichment predictions were also made for worst-case conditions with no net drift for a period of ten days (Figure 5.1.3.e). These conditions are expected to occur approximately ten percent of the time. The area of *degraded* conditions is 96 percent smaller at Site 2 than Site 4 during no net drift conditions. No degradation due to water column nutrient enrichment is predicted at Site 5.

Since ambient nutrient concentrations are generally higher in the vicinity of site 2 than site 5 (MWRA, STFP V,Z, 1987), it is likely that nutrient enrichment would have a greater impact at site 2 than site 4 even over equal areas, since the higher ambient nutrient concentrations occur at site 2; therefore the water column at site 2 would require less additional nutrient loading to reach potential algal bloom conditions.

TABLE 5.1.3.e. SUMMARY OF AREAL EXTENT OF PREDICTED AVERAGE AND WORST-CASE NUTRIENT ENRICHMENT IN THE WATER COLUMN (VALUES ARE THE SAME FOR BOTH PRIMARY AND SECONDARY TREATMENT)

	Average Conditions		Worst-Case Conditions	
	Area (Km^2) of Increased Primary Production**	Area (Km^2) of degraded conditions*	Increased Primary Production**	Area (Km^2) of degraded conditions*
SITE 2	130.0	0.5	159.0	0.5
SITE 4	6.6	0.1	6.8	0.2
SITE 5	0.4	0	4.25	0

* Nitrogen addition > 0.57 mg/l
** Nitrogen addition 0.14 to 0.57 mg/l



LEGEND

DEGRADED AREA

AREA OF INCREASED PRODUCTIVITY

FIGURE 5.1.3.e AREAS OF PREDICTED CHANGED AND DEGRADED WATER COLUMN CONDITIONS DUE TO NUTRIENT ENRICHMENT UNDER CONDITIONS OF NO NET DRIFT (PREDICTIONS ARE THE SAME FOR BOTH PRIMARY AND SECONDARY TREATMENT

Under both average and no net drift conditions, discharge from site 2 would entrain and trap nitrogen in Boston Harbor. This, along with the other sources of nutrients in the Harbor (such as CSOs and urban runoff) could add to the already stressed Harbor ecosystem. This in turn could have implications on all Harbor uses and reduce the benefits of the Boston Harbor clean-up. In contrast, discharges at Sites 4 and 5 are not expected to impact the Harbor.

In general, areas of increased primary production with no associated excessive oxygen demand have little negative impact (Oviatt et al., 1986; Oviatt et al., 1987). Increased phytoplankton growth will likely result in increased zooplankton densities and eventual increase in production up the food web. Local fish populations such as sculpin, sand lance and Atlantic herring may increase in abundance and provide increased food source for their predators such as marine mammals and sea birds in the area of the increased production.

In summary, areas of excessive production leading to depressed oxygen levels and degraded conditions are predicted at Sites 2 and 4 under both primary and secondary treatment. The areas in which these conditions are expected to occur are within the area of the mixing zone (approximately 1.5 km^2) and therefore increased production is not expected to have significant impact on the ecosystem outside the mixing zone.

5.1.3.1.4 Water Column Toxicity. Toxic constituents (priority pollutants) will occur in the water column as a result of the wastewater discharge. Depending on the concentrations of these constituents, chronic or acute mortality could result in more sensitive species such as amphipods. Also, zooplankton may uptake toxic constituents directly from the water column, consequently a concentrated source of toxicants may be available to higher trophic levels including seabirds and marine mammals (U.S. EPA, 1980a).

Toxicity in the water column is assessed by comparing predicted concentrations of priority pollutants to U.S. EPA (1986a) water quality criteria for aquatic life. Specifically, criteria used in this analysis are the Criteria Maximum Concentration (CMC) for evaluation of acute effects and the Criteria Continuous Concentration (CCC) for evaluating chronic effects on marine organisms. These are described in Section 5.1.1.

Under primary treatment conditions, heptachlor, 4,4'-DDT, mercury and PCB are expected to exceed U.S. EPA CCC criteria at the edge of the mixing zone at all three alternative outfall locations, while copper is expected to exceed CMC criteria at Sites 2 and 4. Under secondary treatment, only mercury at Sites 2 and 4 and heptachlor at Site 2 exceed CCC criteria at the edge of the mixing zone.

Heptachlor is an organochlorine pesticide which is very persistent in the environment. At all sites under primary treatment, heptachlor is expected to be less than 2.5 times greater than the criteria (Table 5.1.3.f). Under secondary treatment, heptachlor will exceed criteria by only one percent only at Site 2. The CCC criterion for heptachlor is 0.0036 µg/l for a 24-hour average concentration. The likelihood of an organism being exposed to chronic affects from heptachlor is minimal because of the small areal extent in which this exceedance would occur. It is unlikley that an organism would remain in that small area long enough for chronic effects to occur. Also, a chronic value of 1.58 µg/l has been reported for sheepshead minnow (U.S. EPA, 1985c). This value is two orders of magnitude higher than the conservative criteria.

TABLE 5.1.3.f SUMMARY OF PREDICTED AQUATIC LIFE WATER QUALITY CRITERIA EXCEEDANCES

	CONCENTRATION/CRITERION RATIOS[1]					
	Primary			Secondary		
Constituent	Site 2	Site 4	Site 5	Site 2	Site 4	Site 5
CMC						
copper	2.10	1.26				
CCC						
heptachlor	3.49	2.11	1.51	1.01		
4, 4'-DDT	3.55	1.99	1.34			
mercury	4.96	3.14	2.18	1.90	1.26	
PCBs	2.37	1.46	1.09			

(1) Concentration ÷ Criterion

DDT is another organochlorine pesticide that is very persistent in the environment. The CCC value for DDT is 0.0010 µg/l as a 24-hour average. This value is expected to be exceeded at all three alternative outfall sites under primary treatment only. The predicted CCC exceedence for DDT is 1.34 times greater than the criteria at Site 5 and over 2 times greater at Sites 2 and 4. As discussed previously with heptachlor, the area in which this exceedance will occur will be very small and therefore will have minimal impact, especially at Site 5.

For a primary discharge the predicted concentration of the trace metal mercury at the edge of the mixing zone will be almost four times greater than CCC criteria at Sites 2 and 4 and two times greater at Site 5. Under secondary treatment the level of exceedance is much lower at Sites 2 and 4, with no exceedance at Site 5. The CCC for mercury states that the 4-day average concentration of mercury should not exceed 0.025 mg/l more than once every three years. A life-cycle experiment with a mysid shrimp indicated that inorganic mercury significantly affected the time of first spawn and productivity at a concentration of 1.6 mg/l (U.S. EPA, 1986a). This concentration is an order of magnitude higher than that predicted at the edge of the mixing zone. Also, mysid shrimp are known to be very sensitive to stressed conditions and are not abundant in the study area. It is likely that organisms in the study area will be more tolerant than the mysids.

PCB is predicted to exceed CCC criteria by relatively small amounts (Table 5.1.3.f) at all three sites at the edge of the mixing zone under primary treatment only. The CCC for PCB is 0.03 ug/l. PCBs are bioaccumulated and can be biomagnified. Therefore, their toxicity increases with length of exposure and position of the exposed species on the food web.

Under primary treatment, copper is predicted to be 2.1 and 1.3 times greater than CMC at Sites 2 and 4 respectively. Copper is not expected to exceed criteria under secondary treatment. The CMC value for copper is 2.9 mg/liter. According to U.S. EPA (1986) acute sensitivities of saltwater animals to copper range from 5.8 mg/l for the blue mussel to 600 mg/l for the green crab. A chronic life-cycle experiment conducted with a mysid produced adverse effects at 77 mg/l copper (U.S. EPA, 1986). These studies and the fact that the copper exceedance will only occur over a relatively small area, indicate that copper in the water column will not have a significant effect on the biota.

In general, Site 5 has the fewest predicted water quality criteria exceedance and the lowest magnitude of exceedances of the three alternative outfall sites while Site 2 has the most. Generally speaking, while actual criteria exceedances do exist at all three alternative outfall locations, they are not expected to have a significant impact on the ecosystem due to the small areal extent in which they are predicted to occur and the conservativeness of the criteria.

5.1.3.1.5 Dissolved Oxygen Deficits. The State of Massachusetts Surface Water Quality Standard for dissolved oxygen (DO) concentration is 6 mg/l anywhere in the water column after hydaulic mixing. However, marine communities can be exposed to lower concentrations for short periods without adverse effects. Short-term (less than one week) DO concentrations from 4.5 to 6.0 have been shown to cause no adverse effects to biota (in terms of increased mortality or decreased reproductive potential) in experimental wastewater studies (Oviatt et al., 1987; Oviatt et al., 1986; Maughan, 1986; Nixon et al., 1984; Frithsen et al., 1985; Keller et al., 1987). In these experiments, DO levels below 6.0 mg/l occurred several times in late summer in systems with moderate nutrient enrichment and to a lesser extent in controls. The benthic and zooplankton assemblages showed no adverse effects in these systems; in fact, several of the systems supported higher densities of organisms. In contrast, systems with high enrichment experienced DO concentrations well below 3 mg/l, and adverse effects, including mass mortality, were observed. Two cases of decreases in DO were considered as described in Section 5.1.1 and Appendix A. Table 5.1.3.g summarizes the minimum DO concentrations at each site.

For the stratified summer conditions, predicted DO levels are above 6 mg/l for all sites for discharge of secondary effluent, therefore no marine ecosystem impacts are anticipated. Similarly for Sites 4 and 5 under primary treatment values are above 6 mg/l. However, for a primary discharge at Site 2 predicted values are below 4.0 mg/l. As discussed above this could produce adverse marine ecosystem impacts including potential mortality over the affected area.

The predicted resuspension events produce lower DO levels than average conditions. As discussed in Section 5.1.1 above and in Appendix A, these events occur very infrequently and only over a few hours to a day. None of the predicted values are anticipated to produce concentrations below 6.0 mg/l for secondary effluent and thus no adverse effects are anticipated.

For primary discharge at Site 2 the DO values could be very low, and because the community could be stressed due to exposure to lower DO prior to a resuspension event (as discussed above for summer stratified conditions) the impacts could be severe. At the other sites, for primary discharge the predicted minimum DO from resuspension is much higher (5.0 to 5.7 mg/l). As discussed above rare short-term exposure to concentrations in the 5.0 to 6.0 mg/l range will not have adverse effects on the marine community.

5.1.3.1.6 Impacts on Protected Species. The only protected species to potentially occur in the study area are whales and sea turtles (Chapter 4). Since these species are very mobile and are distributed seaward of the project area. It is unlikely

TABLE 5.1.3.g. PREDICTED MINIMUM WATER COLUMN DISSOLVED OXYGEN CONCENTRATION (mg/l) UNDER RESUSPENSION EVENTS FOR PRIMARY AND SECONDARY TREATMENT

	Primary Treatment	Secondary Treatment
Site 2	2.2	5.9
Site 4	5.0	6.3
Site 5	5.7	6.4

that they will be directly affected by the discharge of effluent. It is possible that nutrient enrichment may cause an increase in zooplankton production and certain fish species which are the primary food sources for right whales, fin whales, and humpback whales. This increase in food supply in the vicinity of the outfall may result in attraction of the marine mammals to these areas; however, this is not expected to have a negative impact on these protected species since toxic effects from the outfalls are expected to be minimal, especially at Site 5. Review by NMFS has indicated that the project would not jeopardize these species or the occasional turtles that may occur in the area (letter dated 1988, Appendix G).

5.1.3.2 Operation Consequences Inside the Mixing Zone

The mixing zone is the area in the immediate vicinity of the diffuser discharge in which initial dilution of the effluent occurs. The areal extent of the mixing zone is the same for all alternative discharge sites. Within the water column, the mixing zone is predicted to be approximately 1.5 km^2 (Section 5.1.1). The areal extent of impact on the bottom sediments will be greater than the water column since the mixing zone is constantly moving. The predicted sediment area directly impacted by the mixing zone is approximately 4 km^2.

A significant amount of continuous jet turbulence will occur in the mixing zone as a result of the discharge. This turbulence will prevent most mobile organisms from passing through the zone. For those organisms that do enter the mixing zone, their residence time will be very brief due to the turbulence. These organisms (mainly plankton) will generally not be in the mixing zone long enough to experience acute or chronic exposure to toxic constituents in the effluent. Ten constituents are expected to exceed criteria U.S. EPA (1986a) water quality criteria at the point of discharge under primary treatment while four constituents are expected to exceed under secondary treatment (Appendix A). The ocean bottom in the mixing zone will be exposed to a high rate of effluent particle deposition ranging from 2.6 to 12.6 g/m^2/day with primary treatment and from 0.3 to 2.2 g/m^2/day with secondary treatment. These relatively high sedimentation rates will likely result in a degraded benthic community structure in this zone where the community dominated by pollution-tolerant organisms such as capittellids and oligochaetes (Swartz et al., 1986). These impacts are not projected to occur beyond the 4 km^2 area for primary and not at all for secondary.

5.1.4 PUBLIC HEALTH

Public health impacts were evaluated from each of two perspectives: (1) exposure of human populations to potential bacterial and viral pathogens and (2) food-web exposure of seafood consumers to chemical contaminants discharged from the proposed outfall.

5.1.4.1 Pathogens

The potential for direct exposure of human populations to bacterial and viral pathogens will be reduced over existing conditions by the overall wastewater treatment facilities improvements in the Secondary Treatment Facilities Plan. These include the proposed shift to an offshore discharge location and redundancy of the plant which would prevent incomplete disinfection (Appendix H). Bacterial contamination from various sources including sewage overflows continues to contribute to periodic beach and shellfishing closures in and around Boston Harbor. As described in Section 5.1.1 and Appendix A, the wastewater flows which will receive treatment at the future Deer Island facilities, upon discharge at any of three sites considered in detail in this SEIS (Sites 2, 4 or 5), would no longer contribute to such closures or to any discharge-related exposure to bacterial or viral pathogens.

5.1.4.2 Chemical Contaminants

Projections are less certain concerning potential impacts of chemical contaminants on seafood consumers. At a minimum, it is expected that replacement of the present Deer Island, Nut Island and related inner harbor wastewater and sludge discharges by a discharge of treated wastewater to Massachusetts Bay will lead to significant net reduction in the availability of contaminants to inner-harbor populations of edible fish and shellfish. However, the rate and extent of reductions of problematic chemicals in the fish/shellfish body-burdens in the harbor is uncertain. Similarly, the extent to which a Massachusetts Bay discharge may or may not create an exposure pathway for seafood contamination is not easily or accurately quantifiable. This subject is discussed below.

EPA's Quality Criteria for Water 1986 identifies water column concentrations for a number of chemicals, which correspond to three levels of potential excess lifetime cancer risk due to consumption of seafood containing these chemicals. The three lifetime cancer risk levels are one in one-hundred thousand (1×10^{-5}), one in one million (1×10^{-6}) and one in ten million (1×10^{-7}). All of these levels are in the generally acknowledged range of many voluntary and involuntary risks experienced in everyday life (Wilson and Crouch, 1987) and not subject to regulatory response within that range. For seafood consumption, these 'carcinogenicity criteria' (as they are referred to in the water quality discussions throughout this Draft SEIS) are based on an assumed bioconcentration factor in seafood and the assumed lifetime consumption of an average of 6.5 g/day (about 5.2 lbs/yr) of seafood from the area exposed to the water column concentration. It is possible, although unlikely, that 5.2 lbs/yr of seafood consumption over a long-term could occur during the time-frame of the secondary discharge at any of the alternative outfall sites if commercial and recreational fishing were allowed within and at the edge of the mixing zone of initial dilution. However, the expected duration of the primary discharge is too short for those public health considerations to be realistic. The validity of assumed bioaccumulation factors varies, as discussed below.

Table 5.1.1.i compares the projected secondary discharge quality at the edge of the mixing zone at Sites 2, 4 and 5 with both the one-in-one million (10^{-6}) and one-in-one-hundred thousand (10^{-5}) EPA carcinogen criteria, for those chemicals projected in Section 5.1.1 to potentially exceed one or more such criteria.

It is important to note that two of the compounds (PCBs and arsenic) presently exceed the criteria in the ambient waters by up to 100 times. Discharge at any of the sites would increase the amount of the exceedance over a relatively small area; however, the addition from the effluent is not expected to significantly increase the public health risk.

It is expected that the modeled arsenic exceedences will be of no significance to public health for the following reasons:

1. Arsenic has been shown not to bioaccumulate in at least some tissue of resident demersal food fish around large municipal wastewater outfalls from which arsenic is discharged (de Goeij et al., 1974); and

2. The carcinogen criterion for arsenic exposure from seafood consumption is hypothetical, rather than emperical. Evidence for arsenic as a human carcinogen water ingestion comes from epidemiological studies of drinking water ingestion in Taiwan (EPA, 1980). Evidence is lacking for any similar epidemiology of arsenic ingestion in the forms in which it is present in seafood.

The alternative discharge locations can be compared by evaluating the potential 10^{-5} public health risk for the compounds not already exceeding criteria in the ambient water. For the discharge of primary effluent there are four (aldrin, DDT, heptachlor, dieldrin), three (aldrin, DDT, heptachlor) and two (aldrin, DDT) such exceedances at Sites 2, 4 and 5, respectively. The exceedances range from 0.5 to 12 times the criteria and could be cause for concern. At Sites 4 and 5 the exceedances are less than 5 times the criteria and thus are of less concern. Since the criteria are developed for lifetime exposure, the primary discharge is only for about 5 years, and the magnitude of exceedance is much lower at Sites 4 and 5, the public health impacts are substantially less at the two more offshore sites.

Discharge of secondary effluent is predicted to produce much less public health risk compared to primary. Using a 10^{-5} risk factor and excluding the ambient exceedances, there are only two exceedances (aldrin and DDT) predicted for Site 2 and none for the other sites. This implies no substantial increase in risk at Sites 4 and 5 and minor increased risk at Site 2.

There is also potential concern over sediment contamination, particularly for PCB's. However, there are many uncertainties. All of the water and effluent projections in this Draft SEIS for PCBs are based on extrapolations from measurements made at or below analytical detection limits. Also, the projections of the levels of PCBs on particles and build-up in the sediments are based on conservative assumptions.

PCBs do accumulate and biomagnify relatively quickly in edible seafood in proportion to their availability in sediments, food organisms and the water column (Rubenstein, et al., 1984, Hillman et al., 1987, and Boehm, et al., 1984). Given the uncertainties involved in the water column and sediment projections and the complexities of the discharge environment, monitoring of PCB levels in plant influent and in ambient water, biota and sediment around the proposed and existing outfall site is the only likely means of accurate representation of impacts and possible mitigation needs. If the modeling projections for water column PCB levels are verified, monitoring and mitigation needs would likely be more driven by PCB accumulation in sediments and subsequent transfer to seafood, as discussed below.

The projected sediment concentrations of several contaminants around the proposed wastewater outfall (Appendix B Section B.3.4) could, if verified, be a basis for potential concerns over seafood contamination. Specifically, the maximum range of projected PCB concentrations are:

Site	Primary	Secondary
2	0.4 to 1.4 ug/g	0.2 to 0.3 ug/g
4	0.2 to 1.0	0.1 to 0.3
5	0.1 to 0.8	0.1 to 0.2

In addition, during the summer PCB concentrations could reach 5.6 ug/g for primary and 1.9 ug/g for secondary on vertical hard rock surfaces for any of these sites. These concentrations would be 40 (soft bottom) to 500 (hard bottom) times higher than concentrations presently characteristic of the sites. They fall within the range of 0.3-78 ug/g reported for the New Bedford Outer Harbor closure area where edible tissues of flounder and lobster continue to exceed 2 ppm, a value used by the FDA for regulating PCB content of seafood (Boehm, et al., 1984, and Hillman, et al., 1987). The soft bottom sediments are below the maximum concentrations found in Quincy Bay (EPA, 1987). There is no documented relationship between the PCB sediment and tissue concentrations in these areas, but the potential for a relationship does give cause for concern over public health risk from sediment PCB.

Similar considerations may apply to the projected sediment concentrations of other contaminants for which carcinogen criteria exist, including aldrin and heptachlor. However, unlike PCB's, there is insufficient evidence to judge whether these concentrations, if verified, would be expected to result in seafood contamination.

The issue of potential public health impacts from sediment-related seafood contamination does not appear to differ among alternative outfall sites, as the projected concentrations for all sites have some uncertainty and are within about a factor of two.

Because of the variety of conservative assumptions (e.g., contaminants present at full value of detection limits and fully conserved in deposited sediment) and the considerable uncertainty surrounding all of these projections, there does not appear to be a basis for classifying the expected public health impacts at any of the three sites as unacceptable. However, there does appear to be a need for a process of monitoring and possible mitigation, if the latter is shown to be necessary by monitoring results.

5.1.5 HARBOR RESOURCES

This section relates harbor resources described in Section 4.2.4 to the potential environmental consequences resulting from the operation of the effluent outfall at the alternative locations.

5.1.5.1 Navigation, Shipping and Water Transportation

The operation of the effluent diffuser will not directly affect any form of marine transportation. Even at Site 2 the diffuser will be well below any navigation depth. During times when the effluent plume surfaces it will not interfere with traffic moving through the area. Since all alternative locations are well removed from any maintained channels, no interference with any potential dredging projects is envisioned.

5.1.5.2 Commercial Fishing

Commercial fishing could potentially be impacted at any of the alternative locations. Disruption of habitat could reduce the stocks and thus affect fisheries over a relatively large area. However, as discussed in Section 5.1.3, except for primary discharge at Site 2, where water winter flounder spawning occurs, no marine ecosystems impacts great enough to affect fisheries populations are predicted. Therefore on this basis commercial fisheries impacts are expected to be minimal, but largest at Site 2.

Impacts can also potentially occur from physical interference with fishing activities. The magnitude of the imapct is dependent on the amount of commercial fishing directly over the discharge site. As discussed in Appendix D, there is very little documentation of commercial fishing activity at a scale sufficient to differentiate alternative discharge locations. Although there is some indication that fishing activity varies among sites, it is assumed that the potential for this type of fisheries impact are equal at all sites. These impacts can be minimized by proper diffuser design which would minimize potential interferences for the fishermen. It is likely that commercial fishing in an area of Massachusetts Bay along the length of the diffuser may have restrictions to certain types of gear.

5.1.5.3 Recreation

There are potential recreation impacts both at the discharge site and at the shore line. The impacts at the site are largely related to aesthetics. At sites closer to shore there is a greater potential for small boat activity (Appendix B), thus the potential for recreation impact is greater. Also, the more frequently the effluent plume rises to the surface, the greater the aesthetic impact. This occurs more often at Site 2 (Section 5.1.1).

As demonstrated in the analysis of onshore transport of effluent during extreme wind events, effluent concentrations on the shore are projected to be highest if the discharge is at Site 2. Although the concentration expected for these short-term events generally would not be expected to threaten recreation value, some perceived effect could impact recreation. This would be greatest at Site 2 and likely minimal at Site 5.

Adverse impacts on Boston Harbor recreational resources are not expected from a discharge at any of the sites. As shown in Section 5.1.1 water quality will be preserved in the Harbor. Similarly effluent discharged at any of the sites will not be directly transported into the harbor. Therefore, the recreational value of the Harbor should be generally the same or much improved over present conditions by discharge from any of the sites.

5.1.5.4 Sensitive and Protected Areas

No significant impacts on any of the sensitive resources described earlier are expected. Since insufficiently diluted effluent reaching these resources would cause impact, the measures of relative shoreline impacts are the time for effluent to reach the shore under an extreme on-shore wind event and the concentration of effluent at the shoreline under such an extreme event. The differences in travel time to shore from the various sites is relatively small (6.6 to 15.5 hours). However, the travel time from Site 2 to the shoreline (6.6 hours) is close to the duration of a flood tide so effluent could travel to shore with minimal dilution beyond the mixing zone. Travel time from the other sites exceeds a flood tide and thus would not travel directly to shore but would oscillate back and forth before reaching shore, causing additional mixing and dilution. Discharge from all the sites is predicted to have minimal shoreline impacts and will represent a significant improvement over existing conditions. Sites 4 and 5 provide even more protection for important shoreline resources than does Site 2.

5.1.5.5 Cultural and Archaeological Resources

Impacts on cultural and archaeological resources are limited to the area around the effluent outfall, where artifacts (shipwrecks) could be disturbed by dredging trenches or drilling riser shafts. The density of potential wrecksites decrease from southwest to northeast along the line formed by the alternative outfall sites (MWRA, STFP V,L, 1987). Site 5 has the least chance of containing a wrecksite, Site 4 a moderate chance, and Site 2 a good chance (MWRA, STFP V,B, 1987). Site specific investigations are required to define the exact location of wrecks, and to formulate avoidance or mitigation plans. It is anticipated that wrecksites can be avoided by adjusting diffuser riser locations or mitigated through recovery of artifacts.

5.1.6 REGULATORY AND INSTITUTIONAL CONSIDERATIONS

Permit requirements and laws applicable to the outfall location are described in detail in Appendix G. The major regulatory and institutional considerations affecting outfall location involve water quality and discharge permit laws. All of the alternative outfall sites require the same permits. Conditions at the various outfall sites may affect the likelihood of violation of Massachusetts Water Quality Standards or Federal NPDES standards, but all the sites will be compared to the same sets of standards. All sites are subject to the same MEPA and NEPA reviews, navigation regulations, and endangered species laws.

Concerns regarding timely implementation, external coordination, internal coordination, and demand for unique or scarce resources are equal for all sites.

5.1.7 BOSTON HARBOR CONSEQUENCES

The current wastewater discharges for Nut and Deer Island Wastewater Treatment Plant discharges are the major source of pollution causing environmental stress in the Harbor. As discussed in the above sections, removal of these discharges by relocation of the discharge to Site 4 or beyond will result in removal of these discharges to the Harbor.

Water and sediment quality will improve upon removal of the current discharges. Water column nutrient enrichment and associated low DO levels will be reduced as will concentrations of toxic compounds in the water. Sediment quality will improve due to reduction in organic and toxic loading associated with settling of effluent particulates throughout the Harbor.

Corresponding to the predicted improved water and sediment quality in the harbor, the ecology of the harbor will also change. Biological communities will become more like those characteristic of naturally occurring populations under non-stressed conditions. Decreases in nutrient and organic enrichment will likely result in more diverse benthic communities with lower densities indicative of more naturally occurring communities (Swartz et al., 1986). This predicted increase in benthic biomass may also result in a corresponding decrease in demersal species which feed on these benthic organisms. Reduction of toxic constituents in the water column and sediments will also likely result in reduced tissue contamination in demersal species and reduction in biomagnification of toxic compounds in the food web.

The recreational value of the harbor will also improve as a result of water quality improvements by reducing beach closings and improving aethetics throughout the Harbor especially in high use and high visibility areas of the shoreline and islands. The quality of extensive water based recreation (including boating, swimming and site seeing) in the harbor will improve. Finfish and shellfish resources will likely improve in quality producing greater opportunity for commercial and recreational fishing and reducing the potential for public health risk through ingestion.

5.2 OUTFALL TUNNEL CONSTRUCTION

A deep rock tunnel effluent conduit system is evaluated in detail in this Draft SEIS. This outfall alternative includes a vertical access shaft on Deer Island which would be connected to the tunnelled conduit. The vertical shaft would be excavated deep enough to allow for a 0.25 percent (or less) positive tunnel slope to assure a minimum of 60 feet of bedrock overlying the outfall tunnel. The outfall conduit would be mined using a tunnel boring machine (TBM). In some areas, drill and blast techniques may be needed. The times required to construct a tunnelled effluent outfall to Sites 2, 4 and 5 are 47, 51 and 56 months, respectively. Excavated tunnel material would be removed through the access shaft on Deer Island. The tunnel would be lined with reinforced concrete (MWRA, STFP V, 1987).

The selection criteria for the tunnel outfall are applied below. There would be no impacts on the marine ecosystem as a result of the outfall tunnel construction since all construction would occur within the bedrock beneath the sea floor.

5.2.1 ENVIRONMENTAL - (OUTFALL TUNNEL CONSTRUCTION)

Air Emissions Control. Ventilation of the outfall conduit would be required during tunnel construction. Gases could be created during blasting or released from the bedrock during tunnelling. Dust would be created during tunnelling. Air exchange would also be required to rid the system of carbon dioxide formed by worker respiration.

Noise Control. According to Massachusetts Department of Environmental Quality Engineering guidelines, operation of a new facility may increase ambient noise a maximum of 10 dBA above the existing L90 ambient noise (the noise level which is exceeded 90 percent of the time). Thus, the L90 ambient noise level represents the background noise which occurs when temporary noise is not present.

MWRA measured sound levels at Point Shirley and Nut Island (MWRA, STFP III, 1987). The ambient sound levels (L90) at Point Shirley are 39 dBA for nighttime and 45 dBA for daytime.

MWRA predicted noise impacts due to the 12-year period of all construction at Deer Island. Included in this analysis are noise impacts due to the outfall tunnel construction. It is estimated that the noise level at Point Shirley will range between 50 and 54 dBA during 83 percent of the daytime hours. During the remaining 17 percent of the daytime hours, sound levels at Point Shirley are predicted to range between 60 and 65 dBA. An agreement exists between MWRA and the Town of Winthrop concerning mitigation of noise associated with construction on Deer Island (MWRA, Winthrop, 1988). Construction noise between 7:00 pm and 7:00 am will not exceed 36 dBA such that when combined with the ambient noise level of 36 dBA, the noise level will not exceed 39 dBA. Noise levels on weekdays between 7:00 am and 7:00 pm must conform with noise level predictions by MWRA (MWRA, STFP III,D, 1987). These noise levels apply unless otherwise arranged between the Court, MWRA and the Town of Winthrop. The impacts of noise from the construction of the new treatment facilities will be addressed further in a separate EPA environmental review of these facilities.

Noise due to the construction of the tunnelled outfall will be a relatively minor component of total construction-related noise impacts on Deer Island and will be at or below the ambient sound levels of 45 dBA during the day and 39 dBA during the night. If barging of excess tunnel spoils to the Foul Area Disposal Site is required, noise at Deer Island would be 49 dBA due to barge operation (MWRA, STFP III, 1987). Therefore, noise impacts on Point Shirley, due to outfall tunnel construction alone, are expected to be insignificant. Barging of tunnelled material would have only a minor noise impact on Point Shirley and would never be louder than the expected noise levels caused by the entire Deer Island construction project. MWRA plans to mitigate noise impacts at the Deer Island construction site by constructing soundproofing berms which will act as a barrier between Deer Island and Point Shirley.

5.2.2 ENGINEERING FEASIBILITY - (OUTFALL TUNNEL CONSTRUCTION)

Reliability. Tunnel construction has been successfully used throughout the world for wastewater conduits. The tunnelled outfall system is expected to operate reliably over the range of expected conditions for its design life.

Constructability. MWRA indicates that the longest tunnel constructed to date is 8.5 miles (MWRA, STFP V,E, 1987). Given the available tunnelling technology, however, constructing a tunnelled outfall to Site 5 is considered feasible, although it might push on the edge of technological limitations. The technological uncertainties associated with tunnel construction to Site 5 would probably not be of concern during tunnel construction to Site 2. Thus, tunnel construction to Site 2 is considered to be less risky than to Site 5. It is expected that the tunnel boring machine will proceed at an average rate of 50 to 70 feet per day. Tunnel construction would not be affected by weather and could proceed throughout the year.

5.2.3 COST - (OUTFALL TUNNEL CONSTRUCTION)

Capital Cost. The cost of the access shaft on Deer Island for a tunnel outfall system to either Site 2, 4 or 5 is approximately $10 million (G. Sankey, 1988) (Table 5.2.3.a). The total cost for Site 2 is $151 million. Therefore, the average

TABLE 5.2.3.a. COSTS OF THE TUNNELLED OUTFALL SYSTEM ALTERNATIVES

Site	Tunnel Length (feet)	Cost		
		Shaft ($ million)	Tunnel ($ million)	Total ($ million)
2	28,000	10	141	151
4	43,000	10	238	248
5	54,000	10	313	323

Sources: MWRA STFP V, 1987 and Sankey, 1988.

cost of tunnel construction to Site 2 is $5,036 per foot, (the quantity $151 million minus $10 million, divided by 28,000 feet). Similarly, the average cost of tunnel construction to Site 4 is $5,535 per foot, and to Site 5, the average cost of tunnel construction is $5,796 per foot. Cost of tunnel construction per linear foot increases with distance. One reason for this trend is that as distance increases, so does travel time for construction workers. Thus, while they would be paid for a full day of work, the workers may only spend 5 to 6 hours on the actual construction at some sites. In addition, with increased distance from Deer Island, the tunnel boring machine will require increased maintenance. For Site 5, a one-month overhaul period would be required for the tunnel boring machine, thus incurring costs for overhauling and construction down-time. Construction to Site 4 would be 64 percent more costly than to Site 2, while to Site 5, construction would be 114 percent more expensive than to Site 2. In addition, construction cost per foot increases with the distance of the tunnel. Tunnelling expenses to Site 4 would be 10 percent greater per foot than to Site 2. The cost per foot for tunnel construction to Site 5 would be 15 percent higher than to Site 2.

5.2.4 MATERIALS DISPOSAL - (OUTFALL TUNNEL CONSTRUCTION)

Disposal of Tunnelled Material. Some materials excavated from the shaft on Deer Island and the outfall tunnel will be disposed at upland areas other than Deer Island (MWRA, STFP V, 1987). Amounts of tunnelled materials for each of the outfall locations are 770,000 cu yd for Site 2, 1.28 million cu yd for Site 4, and 1.86 million cu yd for Site 5. Difference in amounts of excavated materials for various outfall lengths is not the major factor in outfall site selection, since the materials are not expected to be contaminated and possibilities for disposal or beneficial use of the materials exist. Possibilities for using the materials as aggregate for low-strength concrete or as backfill in the Third Harbor Tunnel/Central Artery highway project are being evaluated (MWRA, STFP V, 1987). Materials will likely be shipped via roll-on/roll-off ferry or barge to onshore facilities for final truck or rail transport for disposal (MWRA, WTFP 7, 1987). When the disposal site for the tunnelled material has been designated (after environmental impact analysis), all applicable permits will have to be applied for and permits will have to be adhered to.

5.2.5 INSTITUTIONAL - (OUTFALL TUNNEL CONSTRUCTION)

Construction Duration. MWRA predicted outfall tunnel construction to Site 2 would be complete by August 1994 to Site 4 by December 1994, and to Site 5 by May 1995 (MWRA, STFP V,E, 1987). A tunnelled outfall at any site would not meet the court schedule of July 1994 for completion of the outfall system. However, a tunnelled outfall for any sites would be available by the court-ordered completion date of July 1995 for the new primary treatment plant at Deer Island.

Permitting. Only U.S. ACOE Section 10 permitting for the construction of the tunnelled outfall system is anticipated (Appendix G). Tunnelled materials could be used in local construction projects such as construction of the Third Harbor Tunnel. Unused material would be disposed at an on-land disposal site which would require certain permits depending on the sites selected.

Demand for Unique or Scarce Construction Resources. There will be a major demand for tunnel construction resources, equipment and workers during construction of the tunnelled outfall system. This project will be in competition for construction resources with the Massachusetts Department of Public Works (Mass DPW) Third Harbor Tunnel project and MWRA's inter-island conduit system. A shortage of these resources could occur. Coordination within MWRA as well as between MWRA and MassDPW for proper allocation of tunnel construction resources is necessary to prevent project delays.

5.2.6 HARBOR RESOURCES - (OUTFALL TUNNEL CONSTRUCTION)

Protection of Cultural and Historical Resources. The average depth to the top of the tunnelled outfall will be between 210 and 235 feet. This includes a minimum of 60 feet of bedrock which will overlie the tunnel. Therefore, no cultural or historical resources will be affected by tunnel construction.

Water Traffic. Tunnelling of the effluent outfall system would be conducted below the surface of the sea floor. Tunnel spoils would be removed through the Deer Island access shaft. It is possible that tunnel spoils which are not used in the site preparation of Deer Island could be barged through Quincy to upland disposal sites or to construction sites for reuse. The equivalent of one 3,000-ton barge trip per day would be required to keep pace with tunnel boring at all sites.

5.3 DIFFUSER

Two diffuser construction alternatives are evaluated in detail, using the criteria presented in Chapter 3. The first diffuser alternative (drilled risers) is a tunnelled diffuser with approximately 50 to 100 risers drilled through the overlying sediment and bedrock and attached to the tunnel. Each drilled riser would be fitted with a multi-port (8 to 10 ports) cap. The second alternative (pipeline) is a tunnelled outfall connected to a pipeline diffuser system by one to ten risers.

5.3.1 DRILLED RISER DIFFUSER

5.3.1.1 ENVIRONMENTAL - (DRILLED RISER DIFFUSER)

Noise Control. MWRA estimated the noise levels on Point Shirley, Winthrop and in Nahant due to construction of a drilled riser diffuser between Sites 4.5 and 5

(MWRA, STFP V, 1987). During construction of the tunnelled diffuser with drilled risers, sound levels in Winthrop would be 20 dBA or less during normal conditions and 35 dBA during conditions of atmospheric thermal inversion. In Nahant, predicted noise levels were 27 dBA or less during most atmospheric conditions and up to 41 dBA during inversion weather conditions. These estimates are based on a rate of 6 decibels per doubling of distance during usual hemispherical radiation and 3 decibels per doubling of distance during periods of thermal inversion.

5.3.1.2 ENGINEERING FEASIBILITY - (DRILLED RISER DIFFUSER)

Reliability. The riser caps of the drilled diffuser would not protrude much and therefore, would not be susceptible to much damage. Purging of this system would be an issue during diffuser operation and therefore must be considered in final design.

Constructibility. The drilling of risers is a proven technology and there are relatively few unknowns which could cause difficulties during construction. It is anticipated that weather-related down-time will occur during four months of each year of diffuser construction. Each drilled riser is expected to require 1 to 1½ weeks to drill (MWRA, STFP V, 1987).

5.3.1.3 MATERIALS DISPOSAL - (DRILLED RISER DIFFUSER)

Disposal of Excavated Material. Approximately 50 cu. yds of material every 1 to 2 weeks would be excavated during the four to five year drilled riser diffuser construction period. A total of 12,000 cubic yards of material will result from this excavation (MWRA, STFP V, 1987). Disposal of this material would be minor and would likely occur at the Foul Area, as described in 5.3.2.4. Since the vast majority of the material excavated from drilled risers would originate far below the sea floor and thus be clean, acceptance of the material for disposal is not likely to be a problem, so no major differences among the outfall site alternatives occur.

5.3.1.4 INSTITUTIONAL - (DRILLED RISER DIFFUSER)

Construction Duration. MWRA estimated that construction of an 80 drilled riser diffuser would require up to 36 months. This estimate assumes a 1 to 1½ week period for the drilling of each riser, 6 months of initial mobilization and 4 months down-time each year during winter months. Diffuser construction would begin in July 1991 and be completed by the court-ordered deadline of July 1994 for outfall construction completion. Therefore, the tunnel construction, not the diffuser construction, will be the critical factor in meeting the court's deadline.

Disposal permitting would require time, in addition to external and internal coordination, but should not cause project delay.

Permitting. Drilled riser construction and ocean disposal of dredged material would require a permit from the U.S. Army Corps of Engineers (USACE) subject to approval by EPA. In addition, material which is excavated during drilling could be barged from the construction site to an onshore facility and trucked to upland disposal or use as construction fill. It is possible that the material could also be ocean dumped, which would require an ocean dumping permit from EPA (Appendix G).

Demand for Unique or Scarce Construction Resources. No other major offshore drilling projects are planned for the Boston area in the near future. Therefore, competition with other projects for obtaining a semi-submersible drilling platform or a jack-up barge for drilled riser construction should not be a significant problem. The construction of a drilled riser diffuser could be in competition for skilled workers with other local projects, including some of MWRA's projects. However, this is not anticipated to be a significant problem since the increased construction work in the Boston area is likely to attract workers from other regions of the country.

5.3.1.5 MARINE ECOSYSTEM - (DRILLED RISER DIFFUSER)

Protection of Water Quality. The drilling of 80 risers is expected to result in temporarily increased turbidity which would cause a reduction in available light necessary for primary productivity. Drilled material would be disposed at the Foul Area Disposal Site. Impacts due to drilling and disposal would be short-term, as the disturbed sediments would settle rapidly, and minor since only 150 cu. yds of material would be excavated and disposed of every one to two weeks.

Protection of Sensitive Biota and Habitat. Construction of the drilled riser diffuser will result in some minimal temporary impacts to the benthic community. Construction of the diffuser risers is expected to result in the permanent removal of a total of 2,200 square feet of benthic habitat over a four to five year period (MWRA, STFP V,B, 1987). Because of the length of the diffuser and the heterogeneity of the sea floor, it is likely that both hard and soft bottom communities will be removed. Because of the relatively small area of habitat removal, it is unlikely that there will be any long term effect on local communities in the study area (Appendix C). Due to the small volume of material to be disposed at the Foul Area Disposal Site, adverse impacts on benthos in the vicinity of the disposal site are expected to be minor and limited in range.

5.3.1.6 HARBOR RESOURCES - (DRILLED RISER DIFFUSER)

Protection of Cultural and Historical Resources. Impacts on cultural resources are limited to the area disturbed by the actual drilling of riser shafts. Because this area is small, impacts are anticipated to be minimal and could be mitigated. It is anticipated that precise locations of resources (wrecksites) can be determined and avoided by adjusting diffuser riser locations or mitigated through recovery documentation of resources in accordance with State and Federal guidelines.

Water Traffic. The installation of a drilling platform is required for the construction of the drilled riser diffuser. Potential adverse impacts on water traffic will not be a factor in selecting the discharge location. Despite the presence of the drilling platform, most of the construction-related traffic would occur outside of the major shipping lanes. Minimal barging would be required for transporting workers to the construction site and for removal of material from drilling the risers.

Protection of Commercial Fishing Activities. Anticipated impacts on commercial fisheries at the outfall locations include a five year disruption of fishing in the vicinity of construction when access to the area will be precluded by the presence of drilling equipment. During diffuser operation, the riser structures will be obstacles which may foul fishing nets. Minimal impacts are anticipated because only a small portion of the sea floor is actually affected by drilled risers, and the distance between the risers may be large enough for small nets to pass through. Also, riser design is expected to minimize fouling of nets.

5.3.2 PIPE DIFFUSER

5.3.2.1 ENVIRONMENTAL - (PIPE DIFFUSER)

Noise Control. It is anticipated that the above ground construction of a pipeline diffuser, involving trench and riser excavation, would create more noise than would construction of a tunnelled diffuser with 50 to 100 risers. This assumption is based on the fact that all of the construction of a pipeline diffuser will be conducted above the earth's surface as opposed to a tunnelled diffuser with drilled risers which would mainly be constructed beneath the bedrock. Therefore, based on MWRA's estimate of noise levels due to the construction of a drilled riser diffuser between Sites 4.5 and 5, noise levels due to construction of the pipeline diffuser could be higher than 20 dBA during normal weather conditions and 35 dBA during thermal inversions at Point Shirley, and higher than 27 dBA during normal conditions and 41 dBA during temperature inversions in Nahant.

5.3.2.2 ENGINEERING FEASIBILITY - (PIPE DIFFUSER)

Reliability. The dynamic head required to purge seawater from the diffuser and prevent intrusion of seawater to the system would be minimal for the pipeline diffuser (MWRA, STFP V,D, 1987). However, the risers of the pipeline diffuser would be susceptible to damage due to wave action, anchors and dragger fishermen since its risers will be exposed to such elements. In addition, the pipeline diffuser could be at risk of damage by earthquakes since it could cross geological faults in the bedrock.

Constructibility. Some difficulty could be expected with the construction of a pipeline diffuser. This type of construction could be subject to weather delays during winter months. In addition, dredging is not typically conducted in water depths of approximately 100 feet. Therefore, a clamshell digger may have to be used for excavation which would likely require more time than MWRA anticipated for dredging.

5.3.2.3 MATERIALS DISPOSAL - (PIPE DIFFUSER)

Disposal of Excavated Material. Dredged material from the trench excavated for a pipe diffuser would be the only material requiring disposal. To establish a conservative estimate of the amount of dredged material to be disposed of, the assumptions of a 6,600-foot-long diffuser pipe, an average of 35 feet for trench depth, and 1 to 4 slope for trench sides have been made. This yields a conservative total estimate of 1.4 million cubic yards of dredged material which must be disposed. Disposal would likely take place at the Foul Area Disposal Site (See Section 4.4).

Sediment quality at the proposed outfall sites has been sampled and analyzed (Appendix B) (MWRA, STFP V,S, 1987) and compared to Foul Area sediments. Dredged material from Sites 2, 4 and 5 would likely be approved for disposal at the Foul Area by the U.S. Army COE.

5.3.2.4 INSTITUTIONAL - (PIPE DIFFUSER)

Construction Duration. It is anticipated that the pipeline diffuser construction schedule will adhere to the court-ordered deadlines of July 1991 for initiation and July 1994 for completion of construction. Therefore, the tunnel construction, not the diffuser construction will be the critical factor in meeting the court's deadline.

Disposal permitting would require time, in addition to internal and external coordination, but should not cause project delay.

Permitting. Construction of a pipeline diffuser would require a permit for the dredging and disposal. Dredging material will be disposed at the Foul Area Disposal Site.

Demand for Unique or Scarce Construction Resources. While there could be other major offshore dredging projects in the Boston area in the near future, it is unlikely that dredging equipment would be difficult to obtain. The construction of a pipeline diffuser could be in competition for skilled workers with other local construction projects including some of MWRA's projects. This is not anticipated to be a significant problem, however, as the increased construction work in the Boston area is likely to attract workers from other regions of the country.

5.3.2.5 MARINE ECOSYSTEM - (PIPE DIFFUSER)

Protection of Water Quality. Dredging activity may cause a temporary increase in water column turbidity which may result in reduction of light available for primary production. These impacts are expected to be minimal since sediments will settle rapidly. Disposal of dredged material at the Foul Area could temporarily increase turbidity and depress dissolved oxygen concentrations in the water column. Impacts due to disposal are not expected to be significant since disposal will be conducted over an extended period of time.

Protection of Sensitive Biota and Habitat. The construction of a pipe diffuser will require the dredging of a maximum of approximately 1.4 million cubic yards of sediment (based on assumed 35-foot-deep trench with 4:1 slope) resulting in the alteration of approximately 175,000 square yards of benthic habitat. Blasting may be required in some areas, this would kill or injure marine organisms around the explosions. These impacts are judged to be minor because of the relatively small area. After the diffuser is placed in the dredged trench, the trench will be filled and covered with armoring rocks and boulders. This armoring material will provide new habitat on which hard bottom species (such as those described in Appendix C, section C.1.2.2) will colonize. Disposal of 1.4 million cu. yds. of material at the Foul Area Disposal Site would have a greater adverse impact on benthos and fish habitat than would disposal of material from drilled riser diffuser construction (12,000 cu. yds.). However, the material excavated for the pipeline diffuser would be clean and therefore could be used to cap more contaminated projects if the timing is appropriate.

Impacts on sensitive biota and habitat are expected to be minimal, but because excavated trench construction disrupts a much greater area than drilled riser construction, and changes soft bottom habitat to hard bottom, the dredged trench construction is more likely to impact sensitive biota and habitat than drilled riser construction.

5.3.2.6 HARBOR RESOURCES - (PIPE DIFFUSER)

Protection of Cultural and Historical Resources. The likelihood of impacting cultural and archaeological resources is also greater for dredged trench construction than for the drilled riser diffuser because of the large bottom area which would be disturbed (Appendix D).

Water Traffic. Traffic impacts due to construction of a pipeline diffuser are expected to be moderate since pipeline diffuser construction would require barge-mounted equipment at the construction site. In addition, barges would be used to transport workers to the site and to carry the excavated material from the construction site to the shore. However, most of the construction related traffic would occur outside of the major shipping lanes. Potential adverse impacts on water traffic will not be a factor in selecting the discharge location.

Protection of Commercial Fishing Activities. Dredged trench construction will impact commercial fishing by changing the bottom character from soft to hard bottom, creating more obstacles to commercial fishing than drilled risers (Appendix D). In addition, the pipeline diffuser would have approximately 640 risers extending through the sea floor, as opposed to the drilled riser diffuser which would have 80. Therefore, interference with fishing activities, such as dragging, would be more significant with the pipeline diffuser than with the drilled riser diffuser.

5.4 INTER-ISLAND CONDUIT

The inter-island conveyance alternative selected for detailed evaluation is an 11-ft. inside diameter deep rock tunnel from Nut Island to Deer Island. Vertical access shafts would be excavated on both Nut and Deer Islands. The 24,800-ft.-long tunnel would begin at Deer Island, sloping positively towards Nut Island. Tunnel spoils would be removed through the Deer Island access shaft. The tunnel would be lined with reinforced concrete (MWRA, STFP IV, 1987).

Impacts due to construction of a tunnelled inter-island conduit system are described below. No impacts on the marine ecosystem would occur due to the inter-island tunnel construction since all construction activity would take place completely within the bedrock below the sea floor.

5.4.1 ENVIRONMENTAL - (INTER-ISLAND CONDUIT)

Air Emissions Control. Ventilation requirements of the inter-island conduit during construction will be similar to those required during construction of the outfall system.

Noise Control. Noise due to construction of the vertical access shafts for the inter-island tunnel is expected to be audible in the communities adjacent to Nut and Deer Islands. In the Point Shirley area, where ambient daytime noise is 45 dBA and ambient nighttime noise is 39 dBA, the highest expected noise due to construction of the access shaft would be 55 dBA. This noise would be due to the operation of the clamshell digger and trucks. Silenced sheet piling activities are predicted to result in impulse sound levels of 51 dBA at Point Shirley.

According to MWRA's analysis, the daytime ambient sound level at Nut Island is 47 dBA. A nighttime ambient sound level for Nut Island was not measured by MWRA but was estimated to be 35 dBA based on sound data available for typical suburban residential areas. Operation of the clamshell digger and trucks during construction of the access shaft would cause levels of 58 dBA on nearby Great Hill. Silenced sheetpile driving would cause a noise level of 62 dBA.

5.4.2 ENGINEERING FEASIBILITY - (INTER-ISLAND CONDUIT)

Reliability. The tunnelled inter-island conveyance system is expected to operate reliably over the range of expected conditions during its design life.

Constructibility. With a tunnel boring machine (TBM) expected to progress at a rate of 50 to 70 ft/day, construction of the inter-island tunnel is expected to take 36 months. Tunnel construction is not affected by weather and can proceed throughout the year. The 24,800-ft. conduit is well within the range of tunnel lengths previously constructed.

5.4.3 COST - (INTER-ISLAND CONDUIT)

Present Worth Cost. The present worth cost of a tunnelled inter-island conduit between Nut and Deer Islands is $63 million. This cost is the sum of all costs for construction and operation of the tunnelled inter-island conduit system through the year 2020. The value is presented in the form of a single investment in September 1986 dollars.

Project Cost. The project cost for the tunnelled inter-island conduit system is $83 million. This value includes all capital costs to construct the system, costs for equipment replacement through the year 2020 and 35 percent for contingencies and engineering costs. Cost is presented in September 1986 dollars.

5.4.4 MATERIALS DISPOSAL - (INTER-ISLAND CONDUIT)

Disposal of Tunnelled Material. All of the excavated materials resulting from the construction of the inter-island conduit will be utilized during construction of the secondary treatment plant (MWRA, STFP IV, 1987). Materials excavated from the conduit total 197,000 cubic yards. Most will be used on Deer Island as fill for vision and noise screening landforms. Three thousand cubic yards of materials removed from the Nut Island shaft will be used as fill on Nut Island (MWRA, STFP IV, 1987).

5.4.5 INSTITUTIONAL - (INTER-ISLAND CONDUIT)

Construction Duration. MWRA estimated that construction of the inter-island conduit system would begin in December 1991. This misses the April 1991 court-ordered deadline by eight months (MWRA, STFP IV, 1987). Construction is expected to proceed, uninterrupted, for 36 months. Completion of construction would coincide with the court-imposed date of December 1994.

Permitting. Only a Section 10 permit for the construction of the tunnelled inter-island conduit system is anticipated. The tunnelled materials obtained during construction will be used during site preparation of the construction at Deer Island. Therefore, no disposal permitting for the tunnelled material will be required.

Demand for Unique and Scarce Construction Resources. The demand for tunnel construction resources, equipment and workers due to the inter-island conduit struction will be similar to demand due to construction of the effluent outfall system.

5.4.6 HARBOR RESOURCES - (INTER-ISLAND CONDUIT)

Protection of Cultural and Historical Resources. The depth to the top of the tunnelled inter-island conduit will range between 200 and 300 feet. This includes a minimum of 30 feet of bedrock which will overlie the tunnel. Therefore, no cultural or historical resources will be affected by tunnel construction.

Water Traffic. Tunnelling of the inter-island conduit system would be conducted below the surface of the harbor floor. Tunnel spoils would be removed through the Deer Island access shaft. All tunnel spoils from the inter-island conduit construction would be used in the site preparation of the Deer Island Wastewater treatment plant. Thus no barging of the material would be required. Since all construction of the tunnelled inter-island conduit system would be below the ground's surface and no barging of the tunnelled material would be required, this alternative would have no impact on marine traffic.

5.5 SUMMARY OF ECONOMIC IMPACTS

Appendix E presents a full evaluation of economic impacts. This section summarizes these impacts.

A complete review of the financial impacts of the new treatment facilities on the MWRA's cash flow requirements was completed for MWRA's Secondary Treatment Facility Plan (MWRA, STFP VII, 1987). The assumptions made for the STFP concerning inflation; MWRA capital expenditures, operating expenditures, and revenue requirements; and estimates of local expenses for the communities analyzed were used as the base for determining the financial impact of each of the selected outfall alternatives.

Outfall alternatives Site 2, Site 4 and Site 5 have estimated construction costs of $276 million, $389 million, and $468 million, respectively (Chapter 3). The financial impacts on individual sewer users for each of the outfall locations is considered.

As a part of its current revenue system, the MWRA charges the 43 member communities for their use of the MWRA facilities. The member communities pass the costs on to the individual users through sewer use charges and/or property taxes, depending on the type of recovery programs the individual towns employ. Two communities, Boston and Needham, were selected as examples to illustrate what the impact on sewer charges will be if each of the three alternatives were selected.

In order to evaluate the financial impact of the three alternative outfall locations, the same bond amounts having the same duration were assumed for each outfall site, with all construction scheduled to be complete by 1996. Therefore, the sewer use charge would be the same for each site for each type of user for each of the years 1997 to 2005. However, the sewer use charge would increase annually.

5.5.1 BOSTON

In the City of Boston, a financially independent agency, the Boston Water and Sewer Commission (BWSC), is responsible for operating the water, sewer and drainage services, as well as recovering all costs for their expenses. All costs are recovered through water and sewer rates. For this analysis, only the impacts on the sewer portion of a user's bill is considered.

Financial impacts on three categories of sewer users are evaluated: single-family residential (10,000 cu ft/yr), commercial (500,000 cu ft/yr) and large commercial (5,000,000 cu ft/yr). The sewer use charges for the three types of users for each outfall site from the year 1990 to 1997 are presented in Table 5.5.1.a. The complete financial analysis for Boston is presented in Appendix E.

5.5.2 NEEDHAM

Needham recovers its sewer expenses through a combination of sewer use charges and property tax assessments. A recent policy was adopted regarding wastewater expense recovery whereby the last Metropolitan District Commission (MDC) assessment charge to the town, which was $297,575, plus all local wastewater-related expenses will be recovered through a property tax assessment. All MWRA assessments in excess of the last MDC assessment will be recovered through a local sewer use charge system. Using this methodology, the majority of sewer charges attributable to the new MWRA wastewater treatment facilities will be recovered through the sewer rate charge. For the purposes of determining the impacts of the three outfall alternatives, property tax assessment would remain equal for each alternative. Only the sewer rate portion of the user charge would vary.

The categories of users evaluated for Needham are residential (10,000 cubic ft/yr) and large volume (30,000 cubic ft/yr). The sewer charges, which includes a sewer rate charge plus a property tax, for both types of users for each outfall site location are presented in Table 5.5.2.a. The complete financial analysis for Needham is presented in Appendix E.

TABLE 5.5.1.a. SUMMARY OF SEWER USE CHARGES FOR THE OUTFALL ALTERNATIVES, BOSTON

	YEAR							
	1990	1991	1992	1993	1994(1)	1995(1)	1996(1)	1997(2)
Residential (10,000 cu ft/yr)								
Site 2	$180	$225	$260	$301	$340	$313	$370	$446
Site 4	182	229	265	307	348	370	370	446
Site 5	183	230	267	310	352	375	406	446
Commercial (500,000 cu ft/yr)								
Site 2	$11,716	$14,656	$16,980	$19,637	$22,146	$20,410	$24,112	$29,105
Site 4	11,849	14,906	17,275	20,035	22,711	24,109	24,112	29,105
Site 5	11,911	15,023	17,413	20,222	22,975	24,489	26,515	29,105
Large Commercial (5,000,000 cu ft/yr)								
Site 2	$98,767	$123,547	$143,138	$165,533	$186,688	$172,053	$203,261	$245,348
Site 4	99,882	125,654	145,623	168,896	191,449	203,324	203,261	245,348
Site 5	100,405	126,641	146,786	170,471	193,678	206,440	223,519	245,348

1. Site 2 construction completed in 1994, resulting in a decrease in user charges for 1995. Site 4 construction completed in 1995, resulting in approximately equal charges for 1995 and 1996. Site 5 construction completed in 1996.

2. From 1997 to 2005, the sewer use charge for all three sites for each category of user remains equal.

TABLE 5.5.2.a SUMMARY OF SEWER CHARGES FOR THE OUTFALL ALTERNATIVES, NEEDHAM

	YEAR							
	1990	1991	1992	1993	1994(1)	1995(1)	1996(1)	1997(2)
Residential, (10,000 cu ft/yr)								
Site 2	$222	$279	$326	$379	$428	$390	$466	$568
Site 4	225	284	332	387	441	469	466	568
Site 5	226	287	335	391	446	477	517	568
Large User, (30,000 cu ft/yr)								
Site 2	$483	$649	$787	$943	$1,089	$972	$1,196	$1,498
Site 4	492	665	805	968	1,125	1,208	1,196	1,498
Site 5	496	672	814	980	1,142	1,232	1,349	1,498

1. Site 2 construction completion in 1994, resulting in a decrease in user charges for 1995. Site 4 construction completed in 1995, resulting in approximately equal charges for 1995 and 1996. Site 5 construction completed in 1996.
2. From 1997 to 2005, the sewer use charge for all three sites for each type of user remains equal.

CHAPTER 6
CUMULATIVE IMPACTS
AND
OPERATIONAL RELIABILITY

6.1 OVERVIEW

EPA's Environmental Review Procedures for the Wastewater Treatment Construction Grants Program (40 CFR Ch.1, Sec. 6.506) require analysis of the direct, indirect and cumulative environmental effects of alternatives. Chapter Five of this Draft SEIS covers the direct and indirect environmental effects of the inter-island conveyance and effluent outfall alternatives; this chapter focuses on cumulative effects. Section 6.2 provides background information on the proposed project's relationship to other major projects that could contribute to cumulative impacts and thus affect the comparison of alternatives. Section 6.3 evaluates the prediction of impacts and comparison of alternatives presented in Chapter Five in light of the other projects described in Section 6.2. Section 6.4 presents a summary of the operational characteristics of the Deer Island Wastewater Treatment Plant, as they relate to the predicted effluent quality (full discussion in Appendix H). These analyses insure that factors other than the location of the discharge are considered when alternatives are compared.

Each alternative could have slightly different cumulative effects in each area of analysis. Emphasis is placed in this discussion on those areas where the inter-island conduit and effluent outfall are expected to contribute a significant share of the total cumulative impact when compared to the contributions of other projects. Those areas are:

(1) Marine Water Quality, Sediment Quality and Marine Ecosystems
(2) Disposal of Excavated Material
(3) Traffic and Transportation
(4) Socioeconomic Considerations

Regarding water/sediment quality, the alternative effluent discharges will interact within Massachusetts Bay with the effluent discharges from other wastewater treatment facilities and combined sewer overflows (CSO). The disposal of excavated material from the inter-island conduit and the effluent outfall will occur simultaneously with that from the Central Artery/Third Harbor Tunnel and other dredging projects in Boston. Regarding traffic and socioeconomic considerations, the construction impacts of the inter-island conduit and outfall will constitute significant fractions of the total on-land and marine traffic and socioeconomic impacts brought about by the entire Secondary Treatment Facilities Plan (STFP).

Figure 6.1.a shows the schedules for the STFP projects. Other projects which could contribute to cumulative impacts (e.g. other wastewater discharges in Hull and Gloucester) were given initial consideration but are not discussed in detail here because their relative contributions were judged likely to be too small and/or remote to add significantly to the impacts of the MWRA inter-island conduit and/or effluent outfall.

6.2 CUMULATIVE IMPACT SCENARIO

The following subsections contain summary descriptions of projects, including STFP projects, that could interact and cause cumulative impacts.

6.2.2 WATER QUALITY, SEDIMENT QUALITY AND MARINE ECOSYSTEMS

There are several other discharges to Massachusetts Bay which could affect the water quality predictions done for the MWRA discharge (Figure 6.1.b). These include:

- Lynn Outfall - 22.4 mgd
- Southeast Essex Sewerage District (SESD) Outfall - 26.8 mgd
- Swampscott Outfall - 2.19 mgd
- Boston Inner Harbor Combined Sewer Overflow (CSO) and Stormwater - 7.0 mgd.

In addition, other discharges in the study area, such as Hull and Gloucester, have been judged either too small or too far from any of the alternative discharge sites to influence water quality projections for the MWRA discharge (MWRA, STFP V,A, 1987).

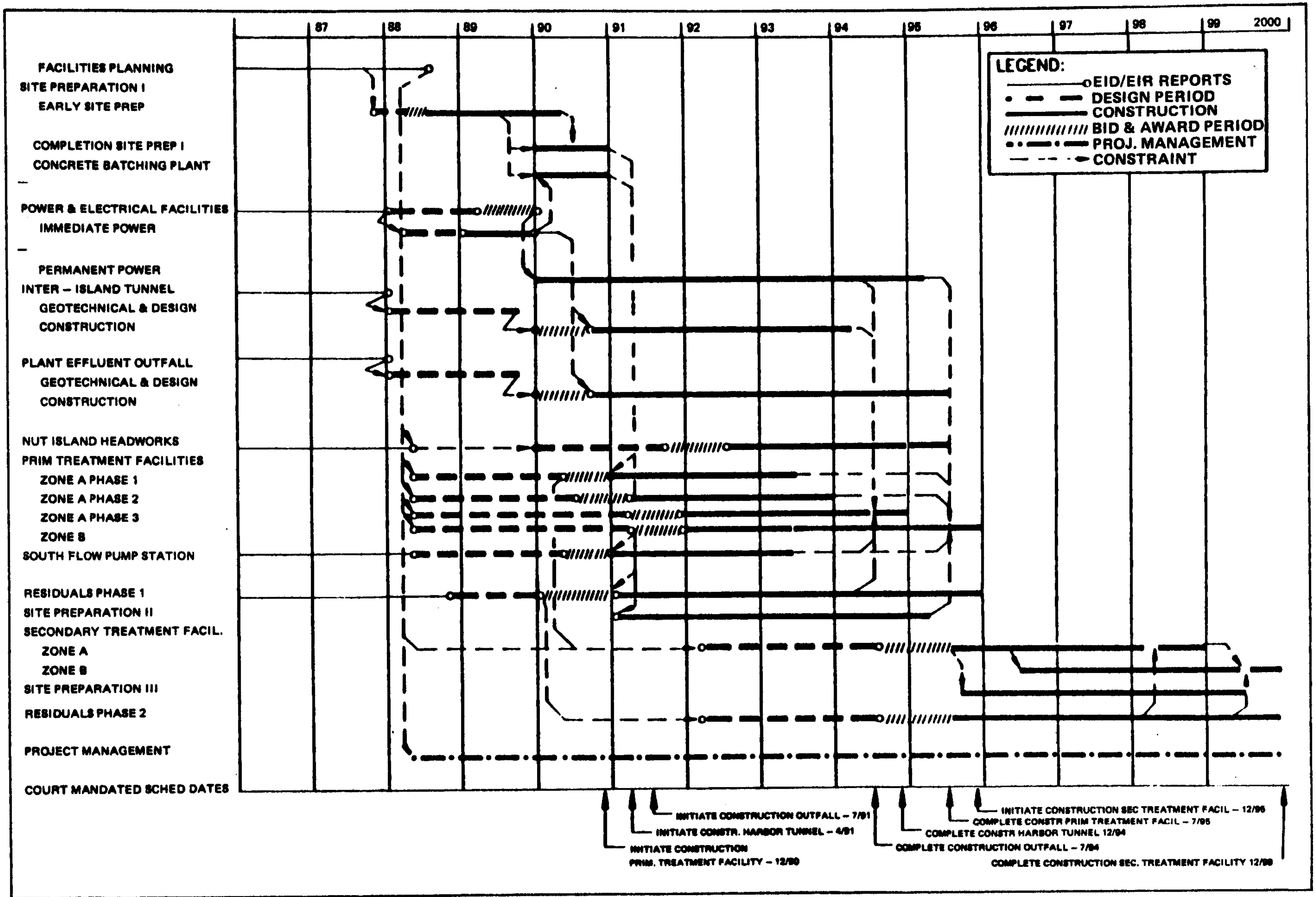
6.2.3 DISPOSAL OF EXCAVATED AND DREDGED MATERIAL

The combined volume of excavated tunnel waste requiring reuse or disposal from the MWRA inter-island conduit and outfall tunnel alternative will range from about 1 to 2 million cubic yards (MWRA, STFP IV and V, 1987). About 200,000 cubic yards would be from the inter-island conduit and would be used on Deer Island along with approximately 1.6 million cubic yards of drumlin material (MWRA, STFP I and IV, 1987). In an overlapping timeframe, excavations by the Massachusetts Department of Public Works associated with depression of the Central Artery and construction of a Third Harbor Tunnel in Boston are expected to generate some 7 million cubic yards of material requiring disposal. The cumulative generation of material from all of these projects could affect disposal options for excavated tunnel material.

Construction of MWRA's on-island and on-shore pier facilities will contribute an estimated 275,000 cubic yards of dredged material. The Third Harbor Tunnel/Central Artery Project will generate approximately one million cubic yards of dredged material. Estimated totals of dredged material from other projects is 3 million cubic yards per decade. All of this material could potentially be disposed of at the Foul Area Disposal Site. In addition, proposed Boston Harbor Navigation Improvement projects would generate 2 to 3 million cubic yards.

6.2.4 TRAFFIC AND TRANSPORTATION

Mitigation requirements established in EPA's Record of Decision (ROD) on the siting of the Deer Island treatment plant are designed to reduce project-related impacts of cumulative truck traffic to and from Deer Island through Winthrop. The resulting approach includes reliance on marine transportation by barge, ferry and roll-



SOURCE: MWRA STFP VII, 1987

FIGURE 6.1.a. PROJECT TIME FRAME

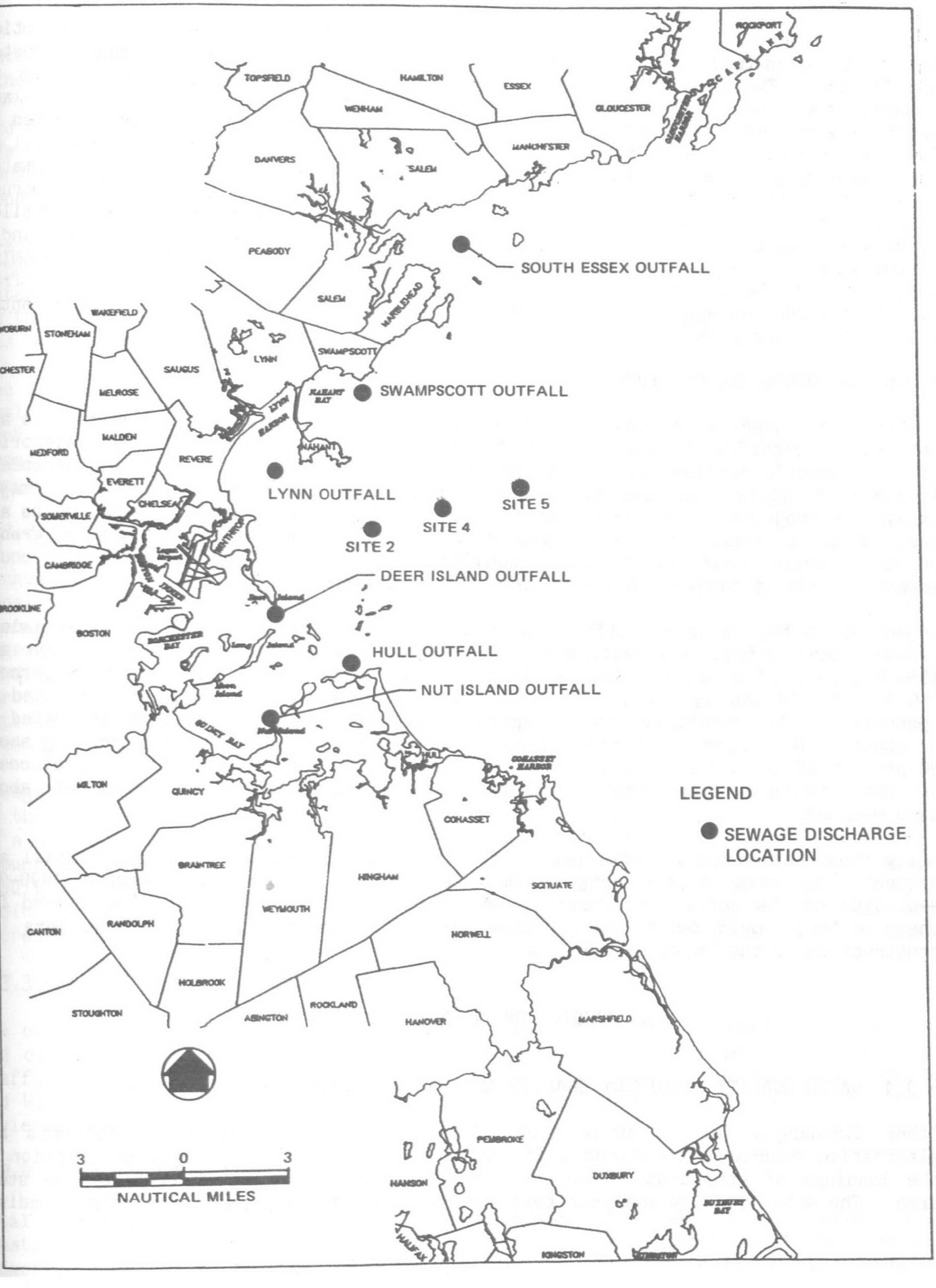


FIGURE 6.1.b. SEWAGE DISCHARGE TO MASSACHUSETTS BAY

on/roll-off (RO/RO) vessels between Deer Island and proposed pier and construction staging areas in Quincy and Charlestown and personnel ferry piers in Hingham, Boston and Quincy. There will be cumulative marine traffic/transportation impacts in Boston Harbor and these are discussed in Appendix D. Cumulative on-land traffic/transportation effects will occur near the staging areas and are covered in EPA's environmental review of the WTFP. However, the magnitude of the individual or cumulative traffic movements has yet to be reconciled among various estimates presented in different elements of the STFP documentation. In particular, truck traffic estimates for the tunnel and outfall construction have yet to be reconciled by MWRA between those presented in Volumes III and V of the STFP and Volumes 8 and 9 of the WTFP. There will also be traffic impact due to interim residuals processing activities at the Quincy staging site between 1991-95 and potential impacts from long term sludge management facilities. This will be addressed in the environmental reviews now being prepared for residuals management.

6.2.5 SOCIOECONOMIC CONSIDERATIONS

The combined inter-island conduit and outfall construction could make measurable and potentially significant contributions to total cumulative impacts on two categories of socioeconomic considerations: these are the total capital costs of the Secondary Treatment Facility Plan and the construction labor force requirements for major excavation projects in the Boston area in the 1990-95 time frame. Capital costs are part of EPA's considerations in its environmental review of construction grants projects, while construction labor requirements are of concern because they could impact the timely implementation of the harbor cleanup.

Depending on the selected outfall location, construction costs of the inter-island conduit and outfall are estimated by MWRA to range between $350 million and $550 million, of which the inter-island conduit represents about 15 to 25 percent (MWRA, STFP IV and V, 1987). Detailed discussion of these costs is presented in Appendix E. The cumulative total capital costs of the STFP have been estimated to be about $2.8 billion, with the inter-island conduit and outfall representing about 20 percent of the total (MWRA, STFP III, 1987). These figures do not reflect costs of the residuals management facilities, which have been projected at about $650 million.

Daily construction labor requirements for the inter-island conduit and outfall are projected by MWRA in the range from 100 to 600 workers each between 1990-94, depending on the activities underway (MWRA, STFP IV and V, 1987). The demand for these workers would occur at the same time as a demand for similar workers for construction of the Third Harbor Tunnel.

6.3 PREDICTION OF CUMULATIVE IMPACTS

6.3.1 WATER QUALITY, SEDIMENT QUALITY AND MARINE ECOSYSTEMS

Other discharges in the study area affect various wastewater constituents and alternative discharge locations differently. Appendix A provides a description of the loadings of compounds of concern in the other major discharges in the study area. The water quality analyses performed in Appendix A takes these other loadings into account in predicting the potential for exceeding Water Quality Criteria. The other discharges make a larger contribution at the alternative discharge site closer to shore (Site 2). For the metals arsenic, cadmium, chromium, copper and mercury and for bis(2-ethylhexyl) phthalate, most of the differences among sites are due to the different contributions from other discharges. Consequently these cumulative impacts were taken into account when a comparison of sites based on the concentrations of these metals was made (Chapter 7).

Predictions of sediment quality did not specifically include other discharge sources within the study area. However, existing background levels of both sediments and water column particulates were used in the analyses, and since the other discharges in the study area are the predominant modeled sources of these materials, the effect was to take these sources were effectively taken into account.

The prediction of impacts on marine ecosystems was based on alterations in water quality and sediment quality. Since the water and sediment analyses in Chapter 5 took other sources into account as described above, the evaluation of marine ecosystems did also. Therefore, these cumulative impacts are discussed in the Chapter 5 treatment of alternatives.

6.3.2 DISPOSAL OF EXCAVATED AND DREDGED MATERIAL

Excavated materials from the inter-island conduit and effluent outfall tunnels will consist of crushed rock and may be utilized in the construction of the Third Harbor Tunnel/Central Artery Depression highway project for low-strength concrete aggregate. Any tunnel materials which cannot be utilized will exacerbate demand for landfill space by adding to the 7 million cubic yards of materials from the Third Harbor Tunnel/Central Artery Depression requiring landfilling. The amount of tunnel material requiring disposal is greatest for Site 5, less for Site 4, and least for Site 2.

Dredged materials resulting from diffuser construction would likely be disposed of at the Foul Area Disposal Site. The amount of material resulting from construction of a drilled riser diffuser (12,000 cubic yards) would not add significantly to the amount of material normally disposed of at the site. The amount of material resulting from the construction of a dredged trench pipe diffuser (1 to 1.4 million cubic yards), however, when added to the materials from other projects, would represent an increase in the amount of materials normally disposed of at the site.

6.3.3 TRAFFIC AND TRANSPORTATION

The evaluations in Appendix D and Chapters 4 and 5 present a cumulative description and discussion of marine traffic from all sources. A complete evaluation of land traffic at the shore facilities cannot be performed until MWRA reconciles the STFP and WTFP evaluations as discussed in Section 6.2.4, but will be addressed in EPA's review of the water transportation program.

6.3.4 SOCIOECONOMIC CONSIDERATIONS

Total capital costs (which will be reflected in sewer rate increases) and construction labor requirements are the factors that contribute to cumulative impacts. As explained in Appendix E, the financial impacts of the MWRA rate increases required to fund treatment facility and related construction are significant. The construction of the inter-island conduit and effluent outfall are major contributors to the increase and thus to the cumulative impacts. Appendix E addresses all projected MWRA sewer costs and thus addresses cumulative economic impacts. However, as discussed in the appendix, the cost difference among outfall location alternatives averages less than $15 per user per year. This is less than 5 percent of the total projected sewer user fee and thus does not indicate that cumulative economic impact analyses would make a substantial difference in the overall economic analyses done on outfall alternatives in Appendix E.

Demand for labor for treatment plant, inter-island conduit, and outfall construction will occur at the same time as the peak labor demand for the Third Harbor Tunnel/Central Artery Depression highway project. A shortfall in availability of construction workers could occur. Investigation and prospective mitigation of this situation has begun with the establishment of a Task Force by the Governor's Office of Economic Development which is specifically concerned with the concurrent MWRA and Third Harbor Tunnel projects. The Task Force is developing a model of regional construction labor demand and is promoting increasing the number of construction apprenticeships to provide for future needs.

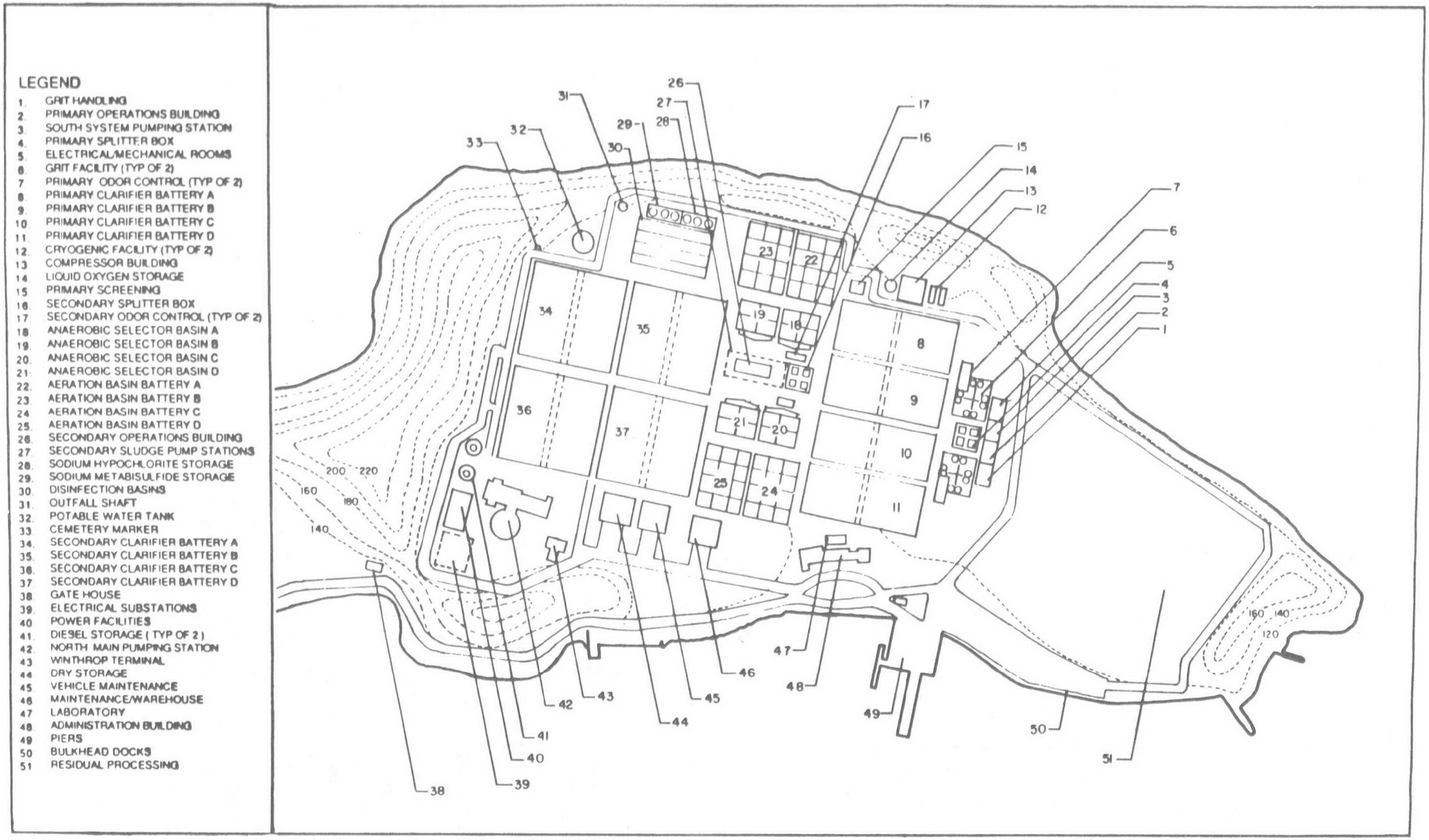
The demand for construction resources is greater for the longer outfall alternatives. This difference among sites is accentuated by the cumulative construction demand in the area. The Governor's Task Force provides a vehicle for mitigation if a longer alternative is selected.

6.4 OPERATIONAL RELIABILITY

The effluent characteristics described for this Draft SEIS are based on the operational reliability of the recommended secondary treatment plant. For the STFP, the concept of reliability was viewed as enhancing the overall integrity of the wastewater treatment system. For the secondary treatment plant, stress was placed on the need for a design which could, even with anticipated power outages, variable loading and mechanical failure, produce an effluent that consistently satisfied the NPDES permit. A detailed review of the operational reliability of the recommended treatment plant is given in Appendix H of this Draft SEIS. The conclusion of this review is that adequate standby equipment, extra volume in the clarifiers, and off-site and on-site power supply is available to ensure that the plant will be able to function properly and produce an effluent that consistently satisfies the NPDES permit. Operating scenarios that are likely to occur during the life of the treatment plant are considered based on the operational reliability.

6.4.1 TREATMENT PLANT OVERVIEW

The recommended plan for the MWRA secondary treatment plant is a pure oxygen-activated sludge process with stacked primary and secondary clarifiers. A site layout of the recommended treatment facilities on Deer Island is presented in Figure 6.4.1.a. The stacked clarifier concept has been used widely in Japan for the past 13 years, but has not yet been constructed in the United States.



SOURCE: MWRA, STFP III, 1987

600 0 600
SCALE IN FEET

FIGURE 6.4.1.a. RECOMMENDED MWRA TREATMENT FACILITIES

The anticipated operation of the treatment plant assumes that the primary treatment facilities will be on-line in 1995, with primary treatment only until mid-1000 when the secondary treatment facilities come on-line. The primary treatment facilities are designed for a maximum flow of 1270 mgd. Secondary treatment facilities are designed for a maximum flow of 1080 mgd. During peak flow periods, up to 190 mgd of primary treated effluent and 1080 mgd of secondary treated effluent are mixed prior to disinfection.

6.4.2 REDUNDANCY

In terms of reliability, the recommended treatment plant was reviewed to determine the adequacy of the mechanical backup system and volume of tankage provided. More than adequate redundancy has been provided for the mechanical systems to eliminate the possibility of one piece of equipment or process failing and causing a disruption in the wastewater treatment process. A summary of the standby units provided is presented in Table H.2.a in Appendix H.

Approximately 12 and 14 percent standby tank capacity is available for the primary and secondary clarifiers, respectively, during periods when maintenance of tanks is required. The reliability of the various treatment processes depends upon expeditious repair or maintenance of the equipment or tanks. Reliability could be reduced if long periods elapsed before the equipment or tanks were repaired and standby equipment were to break down, consequently reducing the total number of standby units available.

6.4.3 POWER

Adequate power supply is essential to the operational reliability of the treatment plant. To ensure a reliable power supply, power must be provided by two separate and independent sources (USEPA, 1974). The recommended plan includes the installation of two Boston Edision Company 115Kv, 70 MW permanent feeder cables. One cable will originate from the K Street substation in South Boston and the second from the Chelsea substation. A 25,700 Kw combined cycle power plant will be constructed on Deer Island to provide power during peak periods of power usage and provide protection for periods of catastrophic off-site power failure.

6.4.4 OPERATING SCENARIOS CONSIDERED

Based on review of the various components of the recommended treatment plant, probable operating scenarios were developed. During the primary only treatment phase, two scenarios were considered: 1) primary treatment of wastewater and 2) primary treatment with less than adequate disinfection. For the period after the secondary treatment facilities come online in 1999, three operating scenarios were considered: 1) secondary treatment of up to 1080 mgd, 2) 1080 mgd of secondary treated effluent mixed with 190 mgd of primary treated effluent, and 3) during major power outages, up to 1270 mgd of primary treated effluent flowing through secondary treatment facilities. Effluent concentrations of conventional and non-conventional pollutants listed on the Chemicals of Concern List (MWRA, STFP V,A, 1987) are calculated for each of these operating scenarios (Tables 6.4.4.a through 6.4.4.f).

TABLE 6.4.4.a EFFLUENT CONCENTRATIONS AFTER PRIMARY TREATMENT YEAR 1999, AVERAGE FLOW CONDITIONS(1)

Pollutant	Average Influent Loadings, lb/d(2)	Removal Rate, Percent	Effluent Loadings, lb/d	Effluent Conc., mg/l
BOD	537,000	36	380,000	121
TSS	481,000	60	211,000	67
METALS				
Arsenic	7.6	25	5.7	0.00181
Cadmium	8.4	15	7.1	0.00227
Chromium	88.5	40	53.1	0.01689
Copper	399.8	35	259.9	0.08265
Lead	69.5	46	37.5	0.01194
Mercury	5.0	22	3.9	0.00124
Nickel	79.1	15	67.2	0.02138
Selenium	53.3	10	48.0	0.01526
Silver	18.0	30	12.6	0.00401
Zinc	866.2	40	519.7	0.16530
ACID BASE NEUTRALS				
Butylbenzyl Phthalate	63.7	0	63.7	0.02026
Bis (2-Ethylhexyl) Phthalate	78.3	0	78.3	0.02490
Di-N-Octyl Phthalate	65.8	0	65.8	0.02093
Florene	16.5	0	16.5	0.00525
VOLATILE ORGANICS		(3)		
Bromomethane	62.3	NA	62.3	0.01981
Methylene Chloride	120.3	0	120.3	0.03826
Chloroform	22.3	NA	22.3	0.00709
Trichloroethylene	43.6	20	34.9	0.01109
Benzene	16.5	0	16.5	0.00525
Tetrachlorethylene	61.7	0	61.7	0.01962
Ethylbenzene	33.4	0	33.4	0.01062
Styrene	37.5	0	37.5	0.01193
PESTICIDES AND PCB				
PCB	3.2	0	3.2	0.00102
Aldrin	0.7	0	0.7	0.00022
DDT	0.2	0	0.2	0.00006
Heptachlor	0.8	10	0.7	0.00023
Dieldrin	0.1	0	0.1	0.00003

1. Wastewater flow of 377 mgd was used to calculate effluent concentrations.
2. Average influent loadings were estimated during the Facilities Plan (MWRA, STFP III, 1987).
3. "NA" represents no information available. No removal of pollutant was assumed.

TABLE 6.4.4.b NON-CONVENTIONAL POLLUTANT EFFLUENT CONCENTRATIONS AFTER PRIMARY TREATMENT YEAR 1999, MAXIMUM LOADING CONDITIONS ON STORM DAY(1)

Pollutant	Maximum Influent Loadings, lb/d(2)	Removal Rate, Percent	Effluent Loadings, lb/d	Effluent Conc., mg/l
BOD	1,305,000	21	1,026,000	971
TSS	1,480,000	40	882,000	83
METALS				
Arsenic	12.3	25	9.23	0.00087
Cadmium	14.8	15	12.58	0.00119
Chromium	157.4	40	94.44	0.00892
Copper	639.3	35	415.54	0.03923
Lead	130.2	46	70.31	0.00664
Mercury	17.5	22	13.65	0.00129
Nickel	149.8	15	127.33	0.01202
Selenium	153.9	10	138.51	0.01308
Silver	26.8	30	18.76	0.00177
Zinc	2840.1	40	1704.06	0.16088
ACID BASE NEUTRALS				
Butylbenzyl Phthalate	120.5	0	120.50	0.01138
Bis (2-Ethylhexyl) Phthalate	124.4	0	124.40	0.01174
Di-N-Octyl Phthalate	115.2	0	115.20	0.01088
Florene	16.5	0	16.50	0.00156
VOLATILE ORGANICS		(3)		
Bromomethane	106.8	NA	106.80	0.01008
Methylene Chloride	293.3	0	293.30	0.02769
Chloroform	42.8	NA	42.80	0.00404
Trichloroethylene	90.0	20	72.00	0.00680
Benzene	22.6	0	22.60	0.00213
Tetrachlorethylene	134.0	0	134.00	0.01265
Ethylbenzene	63.7	0	63.70	0.00601
Styrene	55.7	0	55.70	0.00526
PESTICIDES AND PCB				
PCB	4.0	0	4.00	0.00038
Aldrin	0.8	0	0.80	0.00008
DDT	0.2	0	0.20	0.00002
Heptachlor	0.8	10	0.72	0.00007
Dieldrin	0.1	0	0.10	0.00001

1. Wastewater flow of 1270 mgd was used to calculate effluent concentrations.
2. Maximum influent loadings were estimated during the Facilities Plan (MWRA, STFP VA, 1987).
3. "NA" represents no information available. No removal of pollutant was assumed.

TABLE 6.4.4.c EFFLUENT CONCENTRATIONS AFTER SECONDARY TREATMENT, YEAR 2020[1]

Pollutant	Average Influent Loadings, lb/d[2]	Removal Rate, Percent	Effluent Loadings, lb/d	Effluent Conc., mg/l
BOD	570,000	28	408,000	125
TSS	515,000	56	227,000	70
METALS				
Arsenic	7.6	50	3.8	0.00117
Cadmium	8.4	50	4.2	0.00129
Chromium	88.5	76	21.2	0.00653
Copper	399.8	82	72.0	0.02213
Lead	69.5	57	29.9	0.00919
Mercury	5.0	75	1.3	0.00038
Nickel	79.1	32	53.8	0.01654
Selenium	53.3	50	26.7	0.00819
Silver	18.0	90	1.8	0.00055
Zinc	866.2	76	207.9	0.06391
ACID BASE NEUTRALS				
Butylbenzyl Phthalate	63.7	95	3.2	0.00098
Bis (2-Ethylhexyl) Phthalate	78.3	90	7.8	0.00241
Di-N-Octyl Phthalate	65.8	90	6.6	0.00202
Florene	16.5	90	1.7	0.00051
VOLATILE ORGANICS				
Bromomethane	62.3	95	3.1	0.00096
Methylene Chloride	120.3	95	6.0	0.00185
Chloroform	22.3	90	2.2	0.00069
Trichloroethylene	43.6	95	2.2	0.00067
Benzene	16.5	95	0.8	0.00025
Tetrachlorethylene	61.7	90	6.2	0.00190
Ethylbenzene	33.4	95	1.7	0.00051
Styrene	37.5	90	3.8	0.00115
PESTICIDES AND PCB				
PCB	3.2	92	0.3	0.00008
Aldrin	0.7	90	0.1	0.00002
DDT	0.2	90	0.0	0.00001
Heptachlor	0.8	90	0.1	0.00002
Dieldrin	0.1	90	0.0	0.00000

1. Wastewater flow of 390 mgd was used to calculate effluent concentrations.
2. Average influent loadings were estimated during the Facilities Plan (MWRA, STFP III, 1987).

TABLE 6.4.4.d EFFLUENT CONCENTRATIONS AFTER SECONDARY TREATMENT, YEAR 2020[1]

Pollutant	Average Influent Loadings, lb/d[2]	Removal Rate, Percent	Effluent Loadings, lb/d	Effluent Conc., mg/l
BOD	1,227,000	71	360,300	40
TSS	1,391,000	74	360,300	40
METALS				
Arsenic	7.6	50	3.8	0.00042
Cadmium	8.4	50	4.2	0.00047
Chromium	88.5	76	21.2	0.00236
Copper	399.8	82	72.0	0.00799
Lead	69.5	57	29.9	0.00332
Mercury	5.0	75	1.3	0.00014
Nickel	79.1	32	53.8	0.00597
Selenium	53.3	50	26.7	0.00296
Silver	18.0	90	1.8	0.00020
Zinc	866.2	76	207.0	0.02308
ACID BASE NEUTRALS				
Butylbenzyl Phthalate	63.7	95	3.2	0.00035
Bis (2-Ethylhexyl) Phthalate	78.3	90	7.8	0.00087
Di-N-Octyl Phthalate	65.8	90	6.6	0.00073
Florene	16.5	90	1.7	0.00018
VOLATILE ORGANICS				
Bromomethane	62.3	95	3.1	0.00035
Methylene Chloride	120.3	95	6.0	0.00067
Chloroform	22.3	90	2.2	0.00025
Trichloroethylene	43.6	95	2.2	0.00024
Benzene	16.5	95	0.8	0.00009
Tetrachlorethylene	61.7	90	6.2	0.00069
Ethylbenzene	33.4	95	1.7	0.00019
Styrene	37.5	90	3.8	0.00042
PESTICIDES AND PCB				
PCB	3.2	92	0.3	0.00003
Aldrin	0.7	90	0.1	0.00001
DDT	0.2	90	0.0	0.00000
Heptachlor	0.8	90	0.1	0.00001
Dieldrin	0.1	90	0.0	0.00000

1. Wastewater flow of 1080 mgd was used to calculate effluent concentrations.
2. Average influent loadings were estimated during the Facilities Plan (MWRA, STFP III, 1987).

TABLE 6.4.4.e EFFLUENT CONCENTRATIONS AFTER SECONDARY TREATMENT YEAR 2020, MAXIMUM LOADING CONDITIONS[1]

Pollutant	Maximum Influent Loadings, lb/d[2]	Removal Rate, Percent	Effluent Loadings, lb/d	Effluent Conc., mg/l
BOD	1,227,000	71	360,300	40
TSS	1,391,000	74	360,300	40
METALS				
Arsenic	12.3	50	6.2	0.00068
Cadmium	14.8	50	7.4	0.00082
Chromium	157.4	76	37.8	0.00419
Copper	639.3	82	115.1	0.01278
Lead	130.2	57	56.0	0.00622
Mercury	17.5	75	4.4	0.00049
Nickel	149.8	32	101.9	0.01131
Selenium	153.9	50	77.0	0.00854
Silver	26.8	90	2.7	0.00030
Zinc	2840.1	76	681.6	0.07568
ACID BASE NEUTRALS				
Butylbenzyl Phthalate	120.5	95	6.0	0.00067
Bis (2-Ethylhexyl) Phthalate	124.4	90	12.4	0.00138
Di-N-Octyl Phthalate	115.2	90	11.5	0.00128
Florene	16.5	90	1.7	0.00018
VOLATILE ORGANICS				
Bromomethane	106.8	95	5.3	0.00059
Methylene Chloride	293.3	95	14.7	0.00163
Chloroform	42.8	90	4.3	0.00048
Trichloroethylene	90.0	95	4.5	0.00050
Benzene	22.6	95	1.1	0.00013
Tetrachlorethylene	134.0	90	13.4	0.00149
Ethylbenzene	63.7	95	3.2	0.00035
Styrene	55.7	90	5.6	0.00062
PESTICIDES AND PCB				
PCB	3.2	92	0.3	0.00003
Aldrin	0.7	90	0.1	0.00001
DDT	0.2	90	0.0	0.00000
Heptachlor	0.8	90	0.1	0.00001
Dieldrin	0.1	90	0.0	0.00000

1. Wastewater flow of 1080 mgd was used to calculate effluent concentrations.
2. Maximum influent loadings were estimated during the Facilities Plan (MWRA, STFP VA, 1987).

TABLE 6.4.4.f MIXED PRIMARY-SECONDARY EFFLUENT, YEAR 2020[1]

Pollutant	Average Influent Loadings, lb/d	Primary[2] Removal Rate, Percent	Primary[2] Effluent Loadings, lb/d		Primary[2] Effluent Conc., mg/l	Secondary[3] Removal Rate, Percent	Secondary[3] Effluent Loadings, lb/d	Secondary[3] Effluent Conc., mg/l	Plant Effluent Loading, lb/d	Plant Effluent Conc., mg/l
BOD	1,305,000	25	146,500		94	68360,300	40	506,800	48	
TSS	1,480,000	50	111,100		70	71360,300	40	471,400	44	
METALS										
Arsenic	7.6	25	0.9	0.00054	40	3.9	0.00043	4.7	0.00045	
Cadmium	8.4	15	1.1	0.00067	40	4.3	0.00048	5.4	0.00051	
Chromium	88.5	40	7.9	0.00501	60	30.1	0.00334	38.0	0.00359	
Copper	399.8	35	38.9	0.02454	70	102.0	0.01132	140.9	0.01330	
Lead	69.5	46	5.6	0.00354	70	17.7	0.00197	23.3	0.00220	
Mercury	5.0	22	0.6	0.00037	70	1.3	0.00014	1.9	0.00018	
Nickel	79.1	15	10.1	0.00635	30	47.1	0.00523	57.1	0.00540	
Selenium	53.3	10	7.2	0.00453	40	27.2	0.00302	34.4	0.00325	
Silver	18.0	30	1.9	0.00119	80	3.1	0.00034	4.9	0.00047	
Zinc	866.2	40	77.8	0.04907	70	221.0	0.02453	298.7	0.02820	
ACID BASE NEUTRALS										
Butylbenzyl Phthalate	63.7	0	9.5	0.00601	70	16.3	0.00180	25.8	0.00243	
Bis (2-Ethylhexyl) Phthalate	78.3	0	11.7	0.00739	50	33.3	0.00370	45.0	0.00425	
Di-N-Octyl Phthalate	65.8	0	9.8	0.00621	70	16.8	0.00186	26.6	0.00251	
Florene	16.5	0	2.5	0.00156	70	4.2	0.00047	6.7	0.00063	
VOLATILE ORGANICS		(4)								
Bromomethane	62.3	NA	62.3	0.03932	75	13.2	0.00147	75.5	0.00713	
Methylene Chloride	120.3	0	18.0	0.01136	40	61.4	0.00681	79.4	0.00749	
Chloroform	22.3	NA	22.3	0.01407	50	9.5	0.00105	31.8	0.00300	
Trichloroethylene	43.6	20	5.2	0.00329	70	11.1	0.00123	16.3	0.00154	
Benzene	16.5	0	2.5	0.00156	70	4.2	0.00047	6.7	0.00063	

TABLE 6.4.4.f (Continued) MIXED PRIMARY-SECONDARY EFFLUENT, YEAR 2020[1]

Pollutant	Average Influent Loadings, lb/d	Primary[2] Removal Rate, Percent	Primary[2] Effluent Loadings, lb/d		Primary[2] Effluent Conc., mg/l	Secondary[3] Removal Rate, Percent	Secondary[3] Effluent Loadings, lb/d	Secondary[3] Effluent Conc., mg/l	Plant Effluent Loading, lb/d	Plant Effluent Conc., mg/l
VOLATILE ORGANICS (Cont.)										
Tetrachlorethylene	61.7	0	9.2	0.00583	70	15.7	0.00175	25.0	0.00236	
Ethylbenzene	33.4	0	5.0	0.00315	70	8.5	0.00095	13.5	0.00128	
Styrene	37.5	0	5.6	0.00354	70	9.6	0.00106	15.2	0.00143	
PESTICIDES AND PCB										
PCB	3.2	0	0.5	0.00030	70	0.8	0.00009	1.3	0.00012	
Aldrin	0.7	0	0.1	0.00007	70	0.2	0.00002	0.3	0.00003	
DDT	0.2	0	0.0	0.00002	70	0.1	0.00001	0.1	0.00001	
Heptachlor	0.8	10	0.1	0.00007	70	0.2	0.00002	0.3	0.00003	
Dieldrin	0.1	0	0.0	0.00001	70	0.0	0.00000	0.0	0.00000	

1. Flow conditions are up to 190 mgd primary treated effluent mixed with 1080 mgd secondary treated effluent for a total of 1270 mgd.
2. Estimates based on 190 mgd.
3. Estimates based on 1080 mgd.
4. "NA" represents no information available. No removal of pollutant was assumed.

CHAPTER 7

SELECTION AND EVALUATION OF THE RECOMMENDED PLAN

7.1 ALTERNATIVE COMPARISON AND RECOMMENDATION

7.1.1 COMPARISON AND RECOMMENDATION FOR DISCHARGE LOCATION

The objective of the alternative outfall site comparison is to select a location for the long-term discharge of effluent from a secondary wastewater treatment plant. To accomplish this objective, the sites are evaluated using the criteria listed in Chapter 3 and then compared. The comparison is based on the impacts expected from the discharge of secondary effluent. However, under the court-ordered schedule for construction, the secondary facilities is to be phased. Primary facilities are to be built first, followed by secondary facilities, and there will be an interim discharge of primary effluent at the outfall site for approximately 5 years. This primary discharge is also evaluated for each site to determine if it would cause unacceptable or irreversible impacts. If so, the recommendation for secondary discharge will be revisited.

The consequences of effluent discharge at each of the alternative sites are described in Chapter 5 using the site comparison criteria presented in Chapter 3. When the consequences are applied to the criteria (Tables 7.1.1.a and 7.1.1.b), it becomes obvious that there are a limited number of criteria that show potentially significant differences among sites. After evaluation, certain criteria showed no major differences among sites. These include:

- Air Emission
- Noise
- Safeguarding Protected Species
- Sensitive and/or Important Habitat
- Cultural and Historic Resources
- Commercial Fishing Activities
- Water Traffic
- Reliability
- Constructability
- Permitting
- Demand on Unique or Scarce Resources

TABLE 7.1.1.a SITE COMPARISON FOR NON-DETERMINATIVE CRITERIA

	SITES		
	2	4	5
Air Emissions	Minor	Minor	Minor
Noise	Minor	Minor	Minor
Safeguarding Protected Species from Habitat Modifications	Minor	Minor	Minor
Sensitive and/or Important Habitat	Minor	Minor	Minor
Cultural and Historical Resources	Moderate Potential (Mitigable)	Low Potential (Mitigable)	Low Potential (Mitigable)
Commercial Fishing Activities	Moderate	Moderate	Moderate
Water Traffic	Minor	Minor	Minor
Reliability	Reliable	Reliable	Reliable
Constructability	Moderate	Moderate	Moderate
Permitting	Moderate	Moderate	Moderate
Demand of Unique or Scarce Construction Resources	Extensive	Extensive	Extensive

TABLE 7.1.1.b SITE COMPARISON FOR DETERMINATIVE CRITERIA

Criteria	Measure	Secondary Sites			Primary Sites			Draft SEIS Reference
		2	4	5	2	4	5	
Mass Surface Water Quality Standards	Min DO (mg/l)	5.9	6.3	6.4	2.2	5.0	5.7	Ch. 5.1.1.8.1; App. A.3.8.1
U.S. EPA Aquatic Life Water Quality Criteria	Number of Exceedances	2	1	0	5	5	4	Ch. 5.1.1.8.3; 5.1.3.1.4; App. A.3.8
U.S. EPA Public Health Water Quality Criteria	Number of Exceedances	4	2	2	6	5	4	Ch. 5.1.4
Pollutants at Shoreline/ Offshore Recreation and Aesthetics	Hours to Shore	6.6	9.4	15.5	6.6	9.4	15.5	MWRA, STFP V,A, 1987
	% Effluent at Shore	1.3	0.6	0.6	1.3	0.6	0.6	Ch. 5.1.1.7; App. A.3.7.1
Sediment Enrichment	km^2 Degraded	1	0	0	2	1	1	Ch. 5.1.3.1.1
	km^2 Changed	5	3	3	33	19	12	
Water Column Enrichment	km^2 Degraded	1	0	0	1	0	0	Ch. 5.1.3.1.3
	km^2 Changed	158	5	4	158	5	4	
Sediment Toxicity	km^2 of Effect	0	0	0	3	2	2	Ch. 5.1.3.1.2
	PCB km^2 >0.1 ppm	6	5	4	18	13	10	
Commercial and Recreational Species	Relative	Moderate	Minor	Minor	Minor	Minor	Minor	Ch. 5.1.5
Cost	$ Millions	276	389	468	276	389	468	Ch. 5.2.3
Construction Duration	Months	47	51	56	47	51	56	Ch. 5.2.5
Disposal of Excavated Material	Million yds^3	0.8	1.3	1.9	0.8	1.3	1.9	Ch. 5.2.4

Effluent discharge at Sites 2, 4 and 5 and are predicted to have similar and acceptable impacts for each of these categories.

Criteria which do demonstrate differences among sites are:

- Water Quality Standards
- Aquatic Life Water Quality Criteria
- Public Health Water Quality Criteria
- Shoreline and Recreation Impacts
- Sediment Enrichment
- Water Column Enrichment
- Sediment Toxicity
- Commercial and Recreational Species
- Cost
- Duration of Construction
- Materials Disposal

The site evaluations and comparisons for each criteria are detailed in Appendices A through E and the corresponding sections of chapter 5. This Chapter presents a summary of the results for each criteria for each site with a specific reference to the detailed treatment of the critical areas of comparison (Table 7.1.1.b) Also presented is a brief comparison of the results for each criterion and an integration of all criteria to form a recommendation.

7.1.2.1 Comparison of Long-Term Impacts From Secondary Effluent Discharge

Massachusetts Water Quality Standards

For a secondary discharge, conformance with the current dissolved oxygen (DO) standard of 6 mg/l (considering natural background conditions and hydrologic conditions (314 CMR 4.02)) is the site determinative measure for this decision criterion. During most of the year, Massachusetts Bay is unstratified and the effluent from any site mixes throughout the water column (Appendix A and Section 5.1.1). Under these conditions DO depletion would be minimal and DO would be well over 7.0 mg/l at all sites. During summer stratified conditions, DO concentrations would be above 6.0 mg/l at all sites and above 7.0 mg/l at Sites 4 and 5.

The worst case DO concentrations were predicted after a quiescent period where sediments build up and then are resuspended during a storm or breakup of stratification. This type of significant resuspension event occurs at most once or twice a year and may occur to some degree every year. For such a major resuspension event, predicted minimum DO levels are 6.3 and 6.4 mg/l for discharges at Sites 4 and 5, respectively, and 5.9 mg/l for a Site 2 discharge. Although the prediction for Site 2 is slightly below the Mass. standard, it is not expected to have adverse effects on the marine ecosystem because of its rare occurrence and short duration.

U.S. EPA Aquatic Life Water Quality Criteria

Measurement of this decision criterion involves comparing aquatic life Water Quality Criteria with the predicted concentration at the edge of the mixing zone. For secondary effluent discharge, there are no exceedances predicted for Site 5. Only heptachlor at Site 2 and mercury at both Sites 2 and 4 exceed the criteria (Appendix A and Section 5.1.1). As discussed in Section 5.1.3, no significant marine ecosystem effects are expected from these exceedances due to: the relatively small areal extent of exceedance; the continuous exposure assumption for the criterion (Section 5.1.1); and the level of exceedance (1% for heptachlor and 90% and 26% for mercury at Sites 2 and 4, respectively). Therefore, no significant effects are expected at any site and there are only minimal differences in impacts exist among sites.

U.S. EPA Public Health Water Quality Criteria

EPA's Public Health Water Quality Criteria are based on risks assessed from lifetime consumption of fish from the affected area, i.e., the mixing zone. Differences among the sites evaluated here are seen in the application of the Public Health Water Quality Criteria. Four compounds (PCB, arsenic, aldrin and DDT), exceed the criteria for one in 100,000 (10^{-5}) risk level at Site 2 while only two compounds (PCB and arsenic) exceed the criteria at the other sites. However, ambient levels of two of the compounds currently exceed criteria by significant amounts at all sites.

Without such high ambient levels, the MWRA discharge alone would exceed the criteria for arsenic (Appendix A). MWRA discharge alone would exceed the criteria for PCB by an additional 50%, 20% and 10% at Sites 2, 4 and 5, respectively (Section 5.1.1), but since the ambient exceedances are already so large, the increase in risk as well as the differences among sites for PCB is small. The additional exceedances at Site 2, although small, (1.4 and 1.2 times criteria for aldrin and DDT respectively), could produce some additional risk and thus make Site 2 less acceptable for this criterion.

Criteria representing a one in 1,000,000 (10^{-6}) risk can also be used to evaluate sites (Section 5.1.5). Although this lower risk factor has been set as a goal it does not represent a regulatory requirement. Comparison using criteria for a one in 1,000,000 (10^{-6}) risk predict more exceedances at all sites, but the relative comparison of sites is the same.

Shoreline and Recreation Impacts

As discussed in Appendices A and D, discharge at any of the sites is not predicted to produce significant shoreline impacts even under extreme events. However, increased protection of the shoreline is a benefit because the area supports a sensitive marine ecosystem, is highly used for recreation and is highly visible. Also, assurance of decreased impact at the shoreline can provide extra protection in the event of less than full treatment.

The measures of relative shoreline impacts are the time for effluent to reach shore under an extreme onshore wind event and the concentration of effluent at the shore during such an extreme event. The difference in travel time to share among sites is relatively small (6.6 to 15.5 hours). However, the travel time from Site 2 to the shoreline (6.6 hours) is close to the duration of a flood tide. Consequently, the effluent could, during extreme events, travel directly to the shore with minimal additional dilution beyond the mixing zone. This is reflected in the highest percent effluent (1.3%) at the shore from Site 2 discharge. Travel time from the other sites is in excess of a flood tide duration and thus would not travel directly to shore but rather would oscillate back and forth before reaching the shore. During this oscillation additional dilution would be achieved and thus there would be a lower concentration of effluent (0.6%) from discharge at Sites 4 and 5.

Discharge at any of the proposed sites is predicted to have minimal shoreline impacts and all sites will represent a significant improvement over existing conditions. Sites 4 and 5 provide a significant extra level of protection of the important shoreline resources.

Benthic Enrichment

Discharge from any of the sites is not expected to produce a "degraded" benthos (see Section 5.1.3 for definition), event within the mixing zone (Table 7.1.1.b). There is an area of changed benthos about the size of the mixing zone predicted for each of the sites. This changes area would have a higher density of organisms and could have a higher relative abundance of certain species. However, there would be no effect on the larger marine community outside the immediate area. The differences in sites is small compared to the precision of the prediction method and thus this criterion does not show much difference between sites. All sites have an acceptable level of impact.

Water Column Enrichment

The comparison of sites based on water column enrichment shows that discharge at any site will not produce a potentially "degraded" (see Section 5.1.3 for discussion) area outside the mixing zone. There will however be a change in the level of phytoplankton production due to the discharge. The area of increased production is generally similar for Sites 4 and 5 but much larger for Site 2. The predicted impact at Site 2 is of particular concern because it will occur over a larger area which includes Boston Harbor. Boston Harbor is already stressed and receives pollutant discharges from numerous other sources. The cumulative effect on the Harbor could have significant implications for the biological community in the Harbor and could also affect the aesthetics which could impact other Harbor uses. Therefore, Site 2 is substantially less acceptable than Sites 4 and 5 for this criterion, and there is no difference between Sites 4 and 5.

Sediment Toxicity

In EPA's evaluation of sediment toxicity, two approaches were used to assess impacts and compare alternative discharge locations. The first was to determine the area of seafloor where sediment concentrations of various compounds are above the "no effect level" reported for marine ecosystems (see Section 5.1.3 for a description of these levels). The discharge of secondary effluent at any of the sites is not predicted to result in any area with sediment concentration above the presumed "no effect level" (Table 7.1.1.b and Section 5.1.3). Therefore, no adverse effects are expected from deposition of these compounds and there is no significant difference among sites.

The second approach for assessment and comparison of sediment toxicity was an evaluation of PCB concentrations. No direct toxic effects on marine organisms are expected to result from sediment PCB concentrations from a discharge at any of the sites (Section 5.1.3). However, PCB's can bioaccumulate and thus potentially create food web effects. There are no established sediment threshold concentrations for predicting where food web or other potential impacts can be expected.

In the absence of criteria or other applicable PCB sediment concentrations reported in the literature, a level of 0.1 ug/g PCBs was used in this analysis as a threshold concentration for site comparison purposes only. This level was chosen as representing a midway point between levels of PCBs in areas known to have negligible PCB effects, and levels of PCBs in areas known to have potentially adverse bioaccumulation.

The existing background concentration at the alternative outfall sites is approximately 0.01 ug/g. This level is representative of areas where little to no PCB effects are reported. Areas where potentially adverse bioaccumulation is occurring include Quincy Bay and New Bedford Harbor. Maximum sediment levels in Quincy Bay are about 1.0 ug/g and levels generally range from 0.5 to 0.9 ug/g (USEPA, 1987). High levels of PCBs in the tissues of bottom dwelling organisms have been found in the same areas in the Bay. Similarly, sediment PCB levels in New Bedford Harbor ranging from 0.3 to 78 ug/g are reported for areas closed to fishing due to high PCB levels in fish and shellfish tissue (Boehm, 1984).

The level of 0.1 ug/g chosen for this analysis represents a conservative estimate of sediment PCBs which could result in bioaccumulation. This level has no established regulatory or accepted scientific basis, but is used to differentiate sediment PCB impacts between sites for this analysis.

As discussed in Section 5.1.2, PCB concentrations are predicted to build up during discharge of primary effluent. With the cessation of primary discharge and the initiation of secondary treatment, the amount of both PCBs and solids discharged will be greatly reduced. Also, the constant addition of relatively uncontaminated background sediment will also dilute the PCB concentration built up during the primary discharge, sediment resuspension and resettlement are predicted to redistribute to the sediment PCB's. The result of these processes is that after 5 years of secondary discharge, the area of sediment with a PCB concentration greater than the comparison level of 0.1 ug/g will be largely confined to the mixing zone and similar for all sites. Consequently, long-term build up of PCB in the sediment is similar and of minimal impact for all sites.

Commercial and Recreational Species

As discussed in Appendix D and Section 5.1.4 predicted impacts on commercial species are moderate at Site 2 and minor at the other sites. Site 2 is inside the winter flounder spawning closure line. Discharge of the solids associated with primary effluent could have an effect on the incubating flounder eggs in the sediments in the vicinity of Site 2. Consequently, Site 2 is less acceptable for this criterion.

Cost

The cost of constructing a tunnelled outfall system increases with distance from Deer Island (Table 7.1.2.a). Site 2 is the least expensive discharge location alternative while Site 5 is the most expensive. In addition, the cost per foot of tunnel construction increases with distance from Deer Island. The range of $172 million from Site 2 to Site 5 represents a substantial difference among sites.

TABLE 7.1.2.a COSTS OF THE TUNNELLED OUTFALL SYSTEM TO THE ALTERNATIVE DISCHARGE SITES

Site	Tunnel Length (feet)	Cost of Tunnel ($ million)	Cost per foot of Tunnel ($)	Average Annual User Cost ($) 1990-1996
2	28,000	141	5,036	284
4	43,000	238	5,535	296
5	54,000	313	5,796	303

Duration of Construction

MWRA (STFP V, 1987) has estimated that the time required for completion of outfall construction of Sites 2, 4 and 5 would be 47, 51 and 56 months, respectively. Such estimates have not yet been accepted by the EPA and should not be construed as EPA approval or agreement to modification of the court-ordered schedule for outfall completion. Construction of Site 2 would be completed one month after the court-ordered deadline of July 1994 while construction to Sites 4 and 5 would require five and ten months, respectively, beyond the court-ordered deadline. However, construction completion to all sites is estimated to coincide or precede completion of the new primary facility. Therefore, based on MWRA's estimates, Site 2 would be the preferred site for maintaining the court-ordered schedule but all are equal for connecting to the new facility.

Material Disposal

Disposal of tunnelled material from construction of the outfall conduit will become increasingly more difficult with an increase in volume of material (Chapter 5). MWRA estimated that construction of an outfall to Site 2, 4 and 5 would create 0.77, 1.28 and 1.86 million cubic yards of excavated material respectively. The impacts of disposal are greatest for Site 5 but acceptable for all sites.

Summary

Based on the above criteria, it is apparent that discharge of secondary effluent at Site 2 is not preferred. There are major differences in the level of impacts expected from discharge at this site as opposed to Sites 4 or 5. In particular, the following criteria are of concern at Site 2:

- Pollutants in the effluent could travel to shoreline receptors in less than one tidal cycle (under extreme shoreward wind events), resulting in levels of effluent at the shore over twice that expected from either Site 4 or Site 5 under the same conditions;

- Nutrients from the discharge would travel into Boston Harbor and impact primary production over a much larger area than that predicted for Sites 4 or 5. Additionally, this impact will occur in the Harbor area which is already stressed and receives pollutant discharges from numerous other sources;

- Nominal excursions of the Dissolved Oxygen standard could occur under late summer resuspension scenarios. While these excursions are not of biological concern, they pose regulatory problems.

In contrast, the differences in impacts between Sites 4 and 5 are relatively small, and are generally within the precision of the prediction methods. The major differences between these two sites is the additional cost ($79 million) required to construct the tunnel to Site 5.

Considering the impacts of secondary discharge then, Site 2 is not preferred. Sites 4 and 5 are acceptable and produce similar levels of impacts. These conclusions will be cross-checked with the conclusions reached after evaluating the impacts of any interim primary discharge at any of the sites. Should any unacceptable or irreversible impacts be seen, these conclusions may be revised.

7.1.1.2 Evaluation of Interim Impacts From Primary Effluent Discharge

Impacts on predicted cost, materials disposal, construction duration, recreation and aesthetics, and water column enrichment are identical for both long term discharge of secondary effluent and interim discharge of primary effluent. An evaluation of each of the other potentially site determinative criteria follows.

Massachusetts Water Quality Standards

The predicted DO concentrations for a primary discharge are substantially different from those for a secondary discharge and show major differences among sites (Appendix A and Section 5.1.1). Under summer stratified conditions, DO concentrations at Site 2 are expected to be below 4 mg/l, levels for potentially extended periods of time. During worst case resuspension events, Site 2 DO levels could drop close to 2 mg/l. Not only are these violations of standards, they could produce significant adverse impacts on the marine community over the area experiencing frequent DO concentrations below 5 mg/l (Section 5.1.3). In contrast, DO levels at Sites 4 and 5 will not be below 6 mg/l for normal stratified conditions and not below 5 mg/l for resuspension events. Even with standard violations occurring during resuspension events, no significant marine ecosystem impacts are projected for these events of short duration and infrequent occurrence. Examination of this criterion for the interim primary discharge indicates that there are differences among sites and that the impacts at Sites 2, although predicted to be infrequent, would be significant.

U.S. EPA Aquatic Life Water Quality Criteria

There are four (Site 5) or five (Sites 2 and 4) exceedances of Aquatic Life Criteria for a primary discharge as compared to two, one and none (at Sites 2, 4 and 5, respectively) for a secondary discharge. The magnitude and implications of the exceedances are discussed in Section 5.1.3. These exceedances represent a greater impact than for secondary; however, the relative comparison of sites is generally the same for the interim primary discharge and the impacts are neither unacceptable nor irreversible.

U.S. EPA Public Health Water Quality Criteria

The number of exceedances of Public Health Water Quality Criteria (for a one in 100,000 (10^{-5}) risk factor) is greater for the interim primary discharge than for secondary effluent (4 to 6 versus 2 to 4). Again, although this represents a greater impact, the relative comparison of the sites remains the same and the impacts are not considered to be unacceptable or irreversible, particularly because public health criteria are based on life time exposure and the primary discharge is only for 5 years. The impact for primary do not affect the relative comparison of sites.

Benthic Enrichment

In contrast to the conditions predicted for long-term impacts of secondary effluent discharge, during the interim discharge of primary effluent, there would be areas of predicted "degraded" benthos (Table 7.1.1.b). However the area is similar for all sites and is generally within the mixing zone. There is also an area of "changed" benthos for all sites. The area is substantially larger than the mixing zone and varies among sites (Figure 7.1.1.b). The predicted "changed" area for Sites 4 and 5 are similar, but the area for Site 2 is about twice as large. For this criterion, Site 2 appears to be less acceptable but the resulting impact due to primary effluent would not be irreversible.

Sediment Toxicity

As for secondary effluent, two approaches were used to assess impacts of sediment toxicity from primary effluent discharge: comparison to "no effect levels" for various toxic compounds, and comparison to the 0.1 ug/g level for PCBs. For primary effluent, there are either one or two compounds predicted to exceed the presumed "no effect level" at all sites (Table 7.1.1.b, Chapter 5). These exceedances are confined to the mixing zone and thus are acceptable and not site determinative.

The area of sediments with PCB concentrations greater than the 0.1 ug/g level (Table 7.1.1.b) is of concern for all sites during the interim primary treatment period. Areas of 18, 13 and 10 km^2 respectively at Sites 2, 4 and 5 constitute potentially unacceptable impacts.

One alternative for decreasing this potential impact is to reconsider discharge of primary effluent at President Roads. Although the PCB discharge rates for a primary outfall at Presidents Roads would be identical to those for a primary outfall at Site 2, 4 or 5, the potential impacts may be decreased due to the already degraded condition of Boston Harbor. The primary discharge would simply exacerbate conditions in the Harbor, where sediment PCB levels are already at or above 0.1 ug/g. However, as discussed in Chapter 3 and Appendix F, discharge of primary effluent at Presidents Roads would result in increased Water Quality Criteria exceedances at the edge of the mixing zone, increased percentages of effluent at the shorelines of Winthrop, Hull and Nahant, decreased compliance with the Massachusetts dissolved oxygen standard and more chance of further stressing the Boston Harbor ecosystem.

As discussed earlier, the 0.1 ug/g level used in this analysis represents a conservative estimate of sediment PCBs potentially associated with bioaccumulation. In addition, in order to arrive at the areas shown in Table 7.1.b, three other very conservative assumptions were made:

- Because PCBs were not detected in the influent sampling program, the level of PCBs entering the plant was assumed to be equal to the detection limit (0.5 ug/l) for that analysis. Actual PCB levels lower than this assumed level could result in decreases in the extent of impacted areas at all discharge sites.

- No removal of PCBs was assumed during the interim primary period, even though 60 percent solids removal normally is achieved, and it is likely that PCBs will preferentially remain with the solids. Should PCB removal actually take place during treatment, significant decreases in the predicted impacted areas would occur.

- It was conservatively assumed that mixing of the sediments by benthic organisms (bioturbation) involved only the top 3 cm of sediments. Some MWRA survey data shows that bioturbation is taking place over a much deeper level, mixing as much as 8 cm of sediments. Mixing to a deeper level would result in dilution of the PCB solids from the discharge with cleaner sediments, and decreases in the impacted areas.

As seen in the discussion of sediment toxicity for secondary treatment, the impacts of PCB accumulation are temporary and reversible. The areas containing sediments with PCBs greater than 0.1 ug/g reduce from 18 km^2 at Site 2, from 13 km^2 to 5 km^2 at Site 4 and from 10 km^2 to 4 km^2 at Site 5 after five years of secondary treatment.

As discussed in Appendix B, this is due to sediment concentrations building up during primary discharge and then decreasing during secondary discharge. This reduction is predicted based on dilution with cleaner background sedimentation and natural redistribution of inplace sediments. Assessment of present sediment concentrations (MWRA, STFP V,S, 1987) indicate that there is an area of relatively high sediment concentrations in the area between Sites 2 and 4. Neither the source of this material nor the mechanisms which produce the concentrations are known. However, the data indicate that reduction in concentrations built up during discharge of primary in this area may be reduced. This would make any discharge in the area between Sites 2 and 4 less desirable.

These impacts would be judged as unacceptable if long-term in nature or irreversible. However, because of the conservative assumptions made in this analysis, the temporary and reversible nature of the impact, the negative impacts of discharging primary effluent into Presidents Roads, and the sediment toxicity impacts at Sites 2, 4 or 5, EPA determines that these impacts are acceptable. Therefore, they will not alter the siting decision made for secondary discharge.

Summary

Based on application of the above criteria for a 5-year interim primary discharge, only a discharge at Site 2 would result in unacceptable impacts. Specific concerns at Site 2 are:

- Dissolved Oxygen standards would be violated under several scenarios, with DO levels dropping down as low as 2.2 mg/l for summer resuspension events. These levels could result in adverse impacts to the marine community in the area of the discharge, including some mortality. The impacts on the marine community are unacceptable, although reversible.

- Accumulation of PCBs in the sediments surrounding the discharge could reach levels that have been associated with bioaccumulations of the PCBs in the tissue of benthic organisms, including lobster and flounder. Sublethal effects of PCB bioaccumulation on the health of individual marine organisms has not been established. The accumulation of PCBs in the individual organisms is irreversible, but the overall community impacts would be reversible when PCB levels in the sediments decreases after startup of secondary treatment.

- A relatively large area of sediment would be impacted by deposition of carbon, which could cause changes to the benthic community species composition and density. These changes would be reversible after the onset of secondary treatment.

- Impacts on shoreline receptors and phytoplankton production similar to those discussed for discharge of secondary effluent are predicted.

Sites 4 and 5 also would not meet DO standards (Table 7.1.1.b) under certain conditions, but the predicted DO levels are not expected to impact the health of the marine community. Also, concerns related to sediment PCB accumulation and organic enrichment remain at Sites 4 and 5. As discussed above, however, these concerns are reversible.

The analysis of discharge of interim primary effluent results in Site 2 being determined unacceptable. Impacts at Sites 4 and 5, although of concern, are reversible. Therefore, the analysis undertaken for secondary effluent for Sites 4 and 5 is not changed after consideration of interim primary effluent impacts.

7.1.1.3 Recommended Discharge Location

Site 2 is not preferred for discharge of secondary effluent due to potential long-term impacts. Consideration of interim impacts further reveals that discharge at

Site 2 would incur unacceptable impacts. Sites 4 and 5 show little difference in impact for a secondary discharge and both appear to be acceptable. In addition, during the interim discharge of primary effluent, the impacts predicted for Sites 4 and 5 are similar and not predicted to be severe or irreversible. Given the minor differences in impacts between Sites 4 and 5 and the substantial cost differences, the area between these sites would be acceptable as a discharge location.

Therefore the recommended plan for discharge location is to build a diffuser which lies entirely with in the area shown in Figure 7.1.3.a. This area is bounded to the west by Site 4 and extending to the east of Site 5 and north and south by one diffuser length as necessary to accommodate geotechnical conditions in the area.

7.1.2 RECOMMENDED PLAN FOR OUTFALL CONDUIT CONSTRUCTION

The tunnelled outfall alternative was evaluated in detail in Chapter 5. Impacts due to tunnel construction are not expected to be major, therefore, the recommended plan for construction for the effluent outfall conduit is the deep rock tunnel alternative.

7.1.3 RECOMMENDED PLAN FOR DIFFUSER CONSTRUCTION

Either the drilled riser on the pipeline diffuser alternative can be selected as the recommended diffuser alternative. The major difference between the two diffuser alternatives, aside from construction techniques, is that the pipeline diffuser alternative would generate 1.4 million cu. yds. of material while the drilled riser alternative would generate only 12,000 cu. yds. of material. Material from either construction alternative would be disposed at the Foul Area Disposal Site. Trench excavation for the pipeline diffuser would cause the loss of significantly more benthic habitat than would the drilling of 80 risers. Construction of the pipeline diffuser would also have a larger temporary adverse impact on water quality conditions at the construction and disposal sites than would the drilled riser diffuser. Despite these differences, it would be difficult to select one diffuser type as preferred. A recommended diffuser type could be selected when both the collection of geologic data by MWRA in spring 1988 and cost estimates of the two diffuser types are complete.

7.1.4 RECOMMENDED PLAN FOR INTER-ISLAND CONDUIT CONSTRUCTION

The tunnelled inter-island conduit alternative was evaluated in detail in Chapter 5. Impacts associated with tunnel construction are not expected to be major, therefore the recommended plan for construction of the inter-island conduit is the deep rock tunnel.

7.2 MITIGATION

Based on the recommendation made above and the adverse impacts associated with these recommendations (Chapter 5), several mitigation measures should be implemented.

A more thorough understanding of the physical, chemical and biological processes of Massachusetts Bay is needed. MWRA should implement a monitoring program to better understand these processes. The program could include a regular sampling and

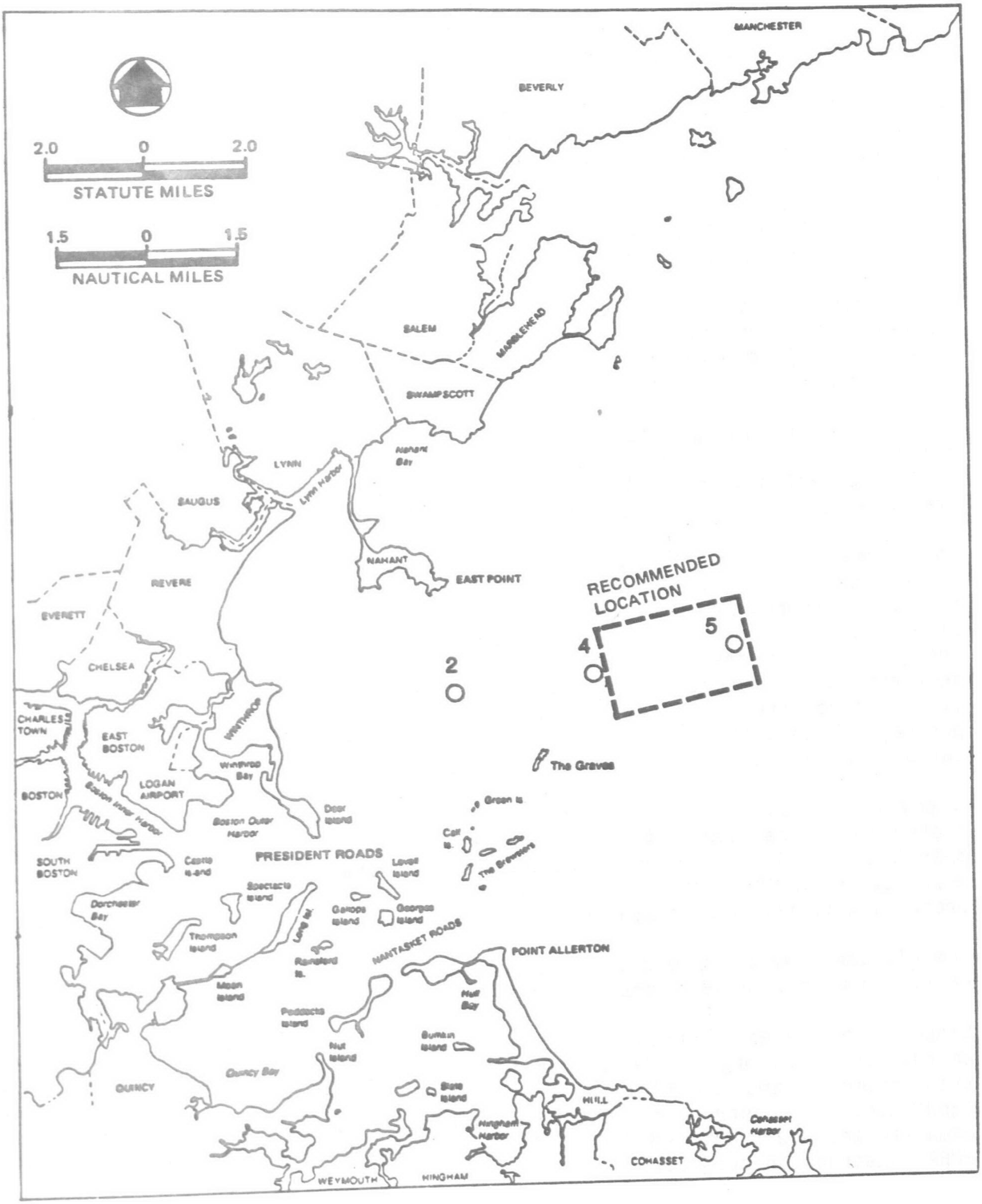


FIGURE 7.1.3.a RECOMMENDED LOCATION OF THE DEER ISLAND WWTP DISCHARGE

analysis of PCBs and other constituents of concern, in water, sediment and animal tissue in the vicinity of the proposed and existing discharges. This would allow post operation assessment and provide a better understanding of sediment bioaccumulation relationships.

This program should include a two to three years of preoperational ecological sampling to establish an adequate statistical baseline. In addition, the monitoring program should include regular bioassay and bioaccumulation testing around the outfall site to continue to assess long-term impacts of the discharge. This is a requirement of the existing NPDES permit for the discharge aznd may also be required by the new NPDES discharge permit. This monitoring program should be developed in close coordination with State and Federal agencies.

A pollutant source identification and control program should be implemented by MWRA to help identify and reduce concentrations of pollutants of concern which would enter the MWRA system and to estimate pollutant concentrations at the edge of the mixing zone.

A pilot treatment program should be run by MWRA to determine actual removal efficiencies of pollutants which would be expected to occur at the Deer Island WWTP during operation of both primary and secondary treatment to ensure that the analysis presented in this Draft SEIS and MWRA's STFP are accurate.

To ensure proper site selection for the diffuser and to gain more information concerning the economic and environmental benefits associated with each of the diffuser alternatives, a thorough geotechnical investigation of the proposed discharge location should be conducted prior to design and construction of either the pipeline or the drilled riser diffuser alternative. In addition, a complete geotechnical investigation of the subsurface bedrock will be necessary to determine if tunnel construction will be able to proceed at the expected rate of 50 to 70 feet per day. This information is necessary to determine when construction of either the outfall or the inter-island conduit would be completed.

A physical model of the selected diffuser alternative should be constructed and tested to assure that initial dilutions predicted by the computer modeling done in this Draft SEIS will actually be achieved during diffuser operation. The physical model of the diffuser should also be used to determine if the diffuser will function properly with respect to hydraulic requirements, such as purging of seawater.

The diffuser system should be designed to incorporate features which would minimize conflicts with fishermen dragging activities.

Disposal of material from tunnel construction of the outfall should be closely coordinated with ongoing local construction projects to maximize beneficial use of this material and to minimize the volume of material which would have to be landfilled. Construction projects which could potentially use the tunnelled excavate include the Third Harbor Tunnel, depression of the Central Artery and other MWRA construction projects.

Demand for scarce or unique construction resources by the several major construction projects planned for the Boston region could potentially slow the pace of construction of the outfall and inter-island conduits. MWRA should continue to develop an integrated construction management approach and should participate in the Governor's Office of Economic Development Task Force (see Chapter 6).

CHAPTER 8

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CHAPTER 9

PUBLIC PARTICIPATION

9.1 INTRODUCTION

The Environmental Impact Statement (EIS) process ensures that the public is offered an opportunity for involvement in assessing the environmental impacts of projects. In addition, U.S. EPA's National Environmental Policy Act regulations for implementation of projects funded by the Clean Water Act (under 40 CFR Parts 6 and 25) and the Council of Environmental Quality's regulations (40 CFR 1500 et seq.) require a public participation program. The public participation program conducted for this Draft SEIS, consisting of EPA's program supplemented by and coordinated with MWRA's full-scale public participation program for its Deer Island Secondary Treatment Facilities Plan (STFP), satisfies these requirements.

The purposes of the public participation program for this Draft SEIS have been:

- to provide the public with information on the Draft SEIS and SEIS processes and the related technical studies being performed; and
- to ensure that the public has ample opportunity to provide input to the SEIS study team and responsible agencies.

Throughout development of this Draft SEIS the public was supplied with background information needed to understand the Draft SEIS work program, to make informed comments, and to ask pertinent questions. The major areas of activity include:

- Public scoping meetings
- Public participation coordination
- Public participation workplan
- Citizen's Advisory Committee (CAC) formation, participation and presentations
- Technical Advisory Group (TAG) participation
- Public meetings and hearing
- Informational activities
- Summary of public comments for public hearing

These activities were timed to solicit public input at important decision points in the SEIS process. The activities are described in more detail below.

9.2 PUBLIC PARTICIPATION ACTIVITIES

9.2.1 SCOPING

The Notice of Intent (NOI) for the preparation of this Draft SEIS, distributed to the public in November 1986 prior to the scoping meetings, outlined the purpose of the SEIS and the key issues to be addressed (Attachment 1).

In preparing this Draft SEIS, EPA held two public scoping sessions in December 1986 to solicit citizen and public agency views on alternative locations, routes, and construction techniques for the inter-island conduit and effluent outfall. Public comments on the environmental, economic, legal, institutional, and other issues that the SEIS would evaluate were received. Principal comments received at the scoping sessions included the need for evaluation of the interim primary discharge, the need for locating the diffuser in water deep enough to guarantee significant initial dilution, the concern for water quality in areas from Nahant northward and the desire of some people to have the secondary treatment plant in operation sooner than scheduled to avoid interim primary discharge. The comments received at the scoping meetings, as well as those received by EPA during the siting EIS project and by MWRA during the STFP preparation, served as a basis for developing the Draft SEIS scope and were considered in the evaluation of the principal siting and technology alternatives in this Draft SEIS. The public issues responded to by this Draft SEIS are discussed in Section 9.4.

9.2.2 WORKPLAN AND COORDINATION

A public participation workplan was developed by EPA. The workplan included all the activities summarized here and was modified as appropriate to meet the changing needs of EPA and the public.

Many public agencies and consultants were involved in MWRA's STFP and EPA's SEIS processes. The U.S. Army Corps of Engineers (U.S. ACOE) cooperated on this Draft SEIS because of a requirement for a Department of Army Permit. EPA also coordinated or consulted with U.S. and State senators and representatives, local officals, federal and state agencies, regional and local entities, and concerned citizens (Table 9.2.a). EPA conducted Section 7 consultation under the Endangered Species Act with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service (Appendix G). In compliance with the National Historic Preservation Act, EPA also consulted with the Massachusetts Historical Commission and other parties in conducting a Section 106 review (Appendix G). EPA will submit a Memorandum of Agreement to the Advisory Council on Historic Preservation.

EPA coordinated its public participation program with MWRA's full-scale public participation program for the STFP. EPA participated in MWRA's program which included:

- Citizen's Advisory Committee formation, participation, and support
- Technical Advisory Group participation

- Public meetings, including forums, information and community meetings, and public hearings

- Preparation of responsiveness summaries of all public meetings and hearings

- Production of informational materials

Throughout the preparation of this Draft SEIS and the STFP the SEIS project team attended meetings at least weekly (since June 1987) to coordinate with other agencies and consultants, obtain information and data from MWRA, and hear the concerns of the CAC and other interested public groups. From these meetings an understanding of concerns was developed by EPA so that these concerns could be addressed in this Draft SEIS. A weekly meeting schedule was maintained by the public participation coordinator to ensure that EPA and the SEIS study team were informed of all upcoming events.

9.2.3 FORMATION OF THE CITIZEN'S ADVISORY COMMITTEE

A Facilities Planning Citizen's Advisory Committee (CAC) was formed in October 1986 to serve both MWRA and EPA by reviewing MWRA's STFP and this SEIS. The CAC was appointed by Secretary James S. Hoyte of the Massachusetts Executive Office of Environmental Affairs (EOEA). The 27 members and 13 alternates to the CAC represent various interests: environmental, business, community, government, scientific, and others (Table 9.2.a). The CAC has been supported by staff from MWRA's STFP project.

9.2.4 CITIZEN'S ADVISORY COMMITTEE MEETINGS: PARTICIPATION AND PRESENTATIONS

EPA actively participated in CAC monthly meetings and in the CAC's Outfall and Deer Island Secondary Treatment Plant subcommittee meetings throughout the STFP and SEIS projects. EPA informed the CAC and subcommittees of its study results and recommendations as they became available and responded to CAC questions and suggestions. All efforts were made to incorporate the CAC's concerns into this Draft SEIS.

In addition to regularly attending the CAC meetings, EPA made three formal presentations to the CAC. In June 1987, the scope of work for this Draft SEIS was mailed to the CAC and a detailed presentation made at its monthly meeting. A second presentation, at the December 1987 CAC meeting, covered the relationship of EPA's SEIS to MWRA's STFP, the detailed outline of this Draft SEIS, and the scope of the public participation program. EPA presented the results of the Draft SEIS investigations and the report's recommendations at the March 1988 meeting. Appropriate handouts were prepared and distributed in advance of the meetings or at the presentations.

EPA participated in two community-sponsored outfall meetings during the preparation of this Draft SEIS. EPA was represented at the South Shore Coalition outfall meeting in August 1987 and at the North Shore town meeting in September 1987. At both meetings EPA presented its role in the outfall siting process and the relationship of MWRA's STFP to EPA's SEIS.

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TABLE 9.2.a COORDINATION LIST (Continued)

CONCERNED CITIZENS

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CAC Representative

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CAC Alternate

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TABLE 9.2.a COORDINATION LIST (Continued)

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Jack Walsh
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CAC Representative

Diane Wood
Save the Harbor/Save the Bay
Boston, MA 02108
CAC Representative

Walter Woods
Wellesley, MA 02181

Nicholas Yannoni
Newton, MA 02162
CAC Alternate

EPA also participated in the CAC sponsored Outfall Forum on August 11, 1987. The purpose of the forum was to bring together and elicit information from the involved agencies and interested scientific and community groups. The CAC used the information received as a basis for its recommendations concerning the scope of the treatment plant outfall siting studies.

EPA attended three public informational meetings sponsored by MWRA: Winthrop in October 1987; Weymouth in November 1987; and Revere in November 1987. The concerns voiced by the citizens attending these meetings were considered by EPA in preparing this Draft SEIS.

EPA maintains a reference system by which comments received by EPA and MWRA on the STFP and Draft SEIS and related projects are tracked. EPA has considered the comments in the this Draft SEIS.

9.2.5 TECHNICAL ADVISORY GROUPS: FACILITIES PLAN TAG AND EOEA TAG

The Facilities Plan Technical Advisory Group (TAG), formed by the Massachusetts Environmental Policy Act Unit (MEPA), has provided the CAC with technical assistance and scientific input. The TAG has 19 members from state and federal agencies, the scientific community, former members of the original EPA treatment plant siting EIS TAG, and the public (Table 9.2.a). The TAG members have met periodically and often attend the CAC and its subcommittee meetings.

The Secretary of Environmental Affairs, James Hoyte, created the Executive Office of Environmental Affairs' TAG (EOEA TAG) in 1985. Scientists from Massachusetts institutions and public agencies were requested to serve in an advisory capacity on matters of environmental concern related to projects in Boston Harbor (Table 9.2.a). The EOEA TAG's focus has been expanded since its formation to include projects in all coastal areas of Massachusetts. The EOEA TAG is currently being re-formed to coincide with the EOEA Massachusetts Bay/Cape Cod Bay Program. The EOEA TAG meets monthly at the Massachusetts Coastal Zone Management Offices.

EPA has attended and participated in the Facilities Plan and EOEA TAG meetings. The interaction between EPA and the TAGs has been beneficial to EPA. EPA's knowledge of the TAGs' concerns and questions allowed EPA to consider them in this Draft SEIS.

9.2.6 PUBLIC MEETINGS

9.2.6.1 Information Meetings

Two public information meetings will be held in April 1988 on the North and South Shores after the release of this Draft SEIS. The purposes of these meetings are to brief the public on the results of the Draft SEIS investigations and the recommended alternatives for the inter-island conduit and effluent outfall. These meetings will occur at a key point in the SEIS analysis process to encourage public input. The meetings' format will consist of presentations by EPA and its technical consultants, followed by a public question and answer session.

9.2.6.2 Public Hearing

A public hearing is scheduled to be held in May 1988 after the release of this Draft SEIS. Public testimony will be recorded. The Final SEIS will then be prepared and will contain a summary of the public comments and EPA's responses to the issues raised by this Draft SEIS.

9.2.7 INFORMATIONAL ACTIVITIES

9.2.7.1 Fact Sheets

Two fact sheets were prepared and mailed to the project mailing list (described in Section 9.3.1). A fact sheet published in early March 1988 included a summary of the project background and status and EPA's selection of outfall location alternatives for detailed evaluation. A second fact sheet, to be distributed in early April 1988, will summarize the results of this Draft SEIS and the recommended alternatives for both the inter-island conduit and effluent outfall.

9.3 OTHER SERVICES

9.3.1 MAILING LIST

The mailing list for this project includes both EPA's Boston Harbor mailing list and MWRA's STFP and On The Waterfront mailing lists, together containing over 3200 names of concerned Federal and State officials, citizens, agencies, organizations, and media representatives. The list is continually updated and used for distribution of fact sheets and announcements of public participation events.

9.3.2 INFORMATION REPOSITORIES

This Draft SEIS has been distributed to information repositories in the project area (Table 9.3.a) where the public can review it, or interested persons can obtain a copy by contacting Dave Tomey at U.S. EPA Region I, Boston, MA (see cover page). The appendices of this Draft SEIS and fact sheets published by EPA for the project were also placed in the repositories.

9.3.3 ANNOUNCEMENTS

Public notices will be prepared announcing the public meetings, public hearing, and comment period for this Draft SEIS, and placed in the local media. Press releases and public service announcements were also produced as appropriate during the study.

TABLE 9.3.a
LIST OF REPOSITORIES

University Library
Attn: William Thompson
U/Mass Amherst
Amherst, MA 01003
413-545-0150
Mon.-Thurs. 8-12; Fri. 8-10;
Sat. 10-6; Sun. 10-12

Boston Public Library
Attn: Lloyd Jameson
P.O. Box 286
Boston, MA 02117
536-5400
Mon.-Thurs. 9-9; Fri.-Sat. 9-5;
Sun. 2-6

State House Library
Attn: Jennifer Nason
State House Room 341
Boston, MA 02133
727-2590
Mon.-Fri. 9-5

MWRA Library
Attn: Mary Lydon
100 First Ave.
Charlestown, MA 02129
242-6000
Mon.-Fri. 8:30-4:30

Malden Public Library
Attn: Dina Malgeri
36 Salem Street
Malden, MA 02148
324-0218
Mon.-Thurs. 9-9; Fri.-Sat. 9-6

Nahant Public Library
Attn: Doug Cisney
15 Pleasant Street
Nahant, MA 01908
581-0306

Morrill Memorial Library
Attn: Mrs. Maddox
Walpole Street
Norwood, MA 02062
769-0200
Mon.-Fri. 9-9; Sat. 9-5;
Sun. 1-5

Thomas Crane Public Library
Attn: Linda Beeler - Reserve Dept.
40 Washington Street
Quincy, MA 02169
984-1950
Mon.-Thurs. 9-9; Fri.-Sat. 9-5

Hough's Neck Community Center
Attn: Patricia Redlen
1193 Sea Street
Quincy, MA 02169
471-8251
Mon. 9-8:30; Tues.-Fri. 9-4

U.S. EPA Technical Library
15th Floor
JFK Federal Building
Boston, MA 02203
565-3715
Mon.-Fri. 8:30-4:30

Wellesley Public Library
Attn: June Robertson
530 Washington Street
Wellesley, MA 02181
235-1610
Mon.-Thurs. 10-9; Fri 10-7;
Sat. 9-5; Sun. 2-5

Winthrop Public Library
Attn: George Pillion
2 Metcalf Square
Winthrop, MA 02152
846-1703
Mon., Tues., Thurs. 1-9; Wed. 10-9;
Fri. 10-6; Sat. 10-5

9.4 PUBLIC ISSUES

During the preparation of this Draft SEIS and EPA's participation in the public participation process as described above, several issues of concern about the project were raised by the public and various agencies. The major areas of concern are presented below, along with a description of how they are addressed in this Draft SEIS. Many issues raised are not contained in this discussion because they are not within the scope of an EIS or are too general.

9.4.1 DISCHARGE OF INTERIM PRIMARY

Concern was raised over the location of the primary effluent discharge. This Draft SEIS has addressed this issue by first screening the potential discharge locations for acceptability of primary effluent (Chapter 3), and then evaluating in full the impacts from primary effluent at each of the alternative sites considered in detail (Chapter 5). The evaluation includes assessment of shoreline impacts at Winthrop, Nahant, and Hull. Methods used to assess impacts were consistent with the methods used for primary treatment waiver studies.

9.4.2 ALTERNATIVES EVALUATED

The selection by MWRA of alternative sites for discharge of effluent was an issue raised during the public participation process. The potential for a site seaward of Site 5 was a particular question. This issue was addressed in this Draft SEIS by a thorough site screening process (Chapter 3 and Appendix F). This process eliminated clearly unsuitable areas and identified sites for detailed evaluation which represented the range of environmental conditions in the area.

9.4.3 EFFLUENT QUALITY

Several people were concerned that the wastewater treatment plant would not perform at specified levels or that unexpected conditions, such as equipment malfunction, would result in an effluent of significantly lower quality. This issue was addressed by a complete review of the proposed treatment removal efficiencies and an evaluation of the possibility of various less-than-full-treatment operational scenarios (Chapter 5 and Appendix H). Discharge modelling incorporates the mixture of primary and secondary effluent for maximum flows.

9.4.4 FATE AND EFFECT OF SOLIDS DEPOSITION

To address this concern this Draft SEIS predicts solids deposition and sediment resuspension for each of the alternative locations, estimates buildup of potentially toxic compounds (Appendix B), and compares these to literature values reported for marine impacts (Appendix C). A discussion of these analyses is contained in Chapter 5.

9.4.5 DISSOLVED OXYGEN (DO) CONCENTRATIONS DURING STRATIFIED CONDITIONS

The public was concerned about DO concentrations during stratified conditions. This concern was addressed in two ways. First the mathematical models used by MWRA were modified to determine DO concentrations throughout the area modelled. Next the models were modified to represent stratified conditions (Chapter 5 and Appendix A).

9.4.6 NUTRIENT ENRICHMENT

Concern was expressed about the effects of nutrient loading in the marine environment. The potential for enrichment was analyzed by first using the model to predict nutrient concentrations and then comparing the concentrations to literature values for comparable systems that resulted in excessive production (Section 5.1.3).

9.4.7 ASSESSMENT USING LIMITED DATA

Concern was raised over making a decision on outfall location with less than a full year of data. This was an issue both for biological and physical systems. The impacts on biota were assessed based on predicted levels of stress (such as concentrations of toxic compounds or nutrient enrichment) that were reported to affect marine biota at their most sensitive life stage, whenever the season. Therefore the impacts during all seasons were addressed.

Impacts on physical systems were based on measurements which covered the full range of environmental conditions such as: extreme freshwater runoff; maximum stratification; high temperatures; high shoreward currents (as determined from long term wind records); north and south boundary tilt; no net drift. Also the data covered the summer period which is most susceptible to discharge-related impacts, such as low DO, high sediment deposition, and maximum production.

9.4.8 CUMULATIVE IMPACTS

A major area of public concern was interaction of the MWRA discharge with discharges from other sources. This Draft SEIS presents an entire chapter on cumulative impacts (Chapter 6). Other discharges were input to the water quality assessment (Appendix A).

9.4.9 TOXIC COMPOUNDS

EPA recognizes the concern over toxic compounds. A modelling of all potential toxic compounds was included for both water column and sediments. The results of the evaluation were included in the site comparison. Where compounds exceed criteria at all sites, EPA recommends the control of these compounds at the source.

9.4.10 CONSTRUCTION SCHEDULE

Several people were concerned that the time allowed in the court schedule to construct the outfall would dictate the outfall length. The court schedule was not a criteria used to evaluate the alternative sites in this Draft SEIS (Chapter 7), although the length of time required to construct the outfall was considered. All outfall alternatives can be constructed prior to startup of the new primary treatment plant.

9.4.11 QUANTITATIVE EVALUATION OF BOATING ACTIVITIES

The issue of impacts on boating activities is addressed in Appendix D, existing conditions and impacts on harbor resources sections.

9.4.12 EVALUATION OF COMPOUNDS WITHOUT CRITERIA

The issue of evaluating all compounds was addressed for sediments by comparing predicted levels of sediment contamination to literature values of levels producing no effects (Appendix B). EPA criteria were considered sufficient to assess water column impacts.

9.4.13 SIZE OF THE MIXING ZONE

Although the mixing zone is a dynamic concept changing with ambient currents, Chapter 5 on stratification and wastewater flow provides a discussion of the potential size and location of the mixing zone.

9.4.14 FRESHWATER DISCHARGED TO MASSACHUSETTS BAY

The potential impact of freshwater discharged to Massachusetts Bay was not addressed in this Draft SEIS. The discharge at any site will be diluted a minimum of 50 times. This would lower the salinity a maximum of 2 percent, or change the ambient salinity (approximately 31 parts per thousand (ppt)) less than 1 ppt. This change is well within the normal seasonal and vertical salinity range.

ATTACHMENT 1

BOSTON HARBOR
MARINE WASTEWATER CONVEYANCE SYSTEMS
SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
NOTICE OF INTENT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION I
J. F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203

TO: All persons interested in the Marine Wastewater Conveyance Systems Supplemental Environmental Impact Statement (SEIS) for Boston Harbor

Enclosed for your review is the Notice of Intent for the preparation of a Supplemental Environmental Impact Statement (SEIS) on marine wastewater conveyance systems and outfall(s) for the Massachusetts Water Resources Authority's (MWRA) wastewater treatment facilities at Deer Island, Boston, Massachusetts.

This SEIS will be prepared by the U.S. Environmental Protection Agency. The MWRA is preparing an Environmental Impact Report (EIR) under the Massachusetts Environmental Policy Act on the facilities plan for all components of the Deer Island facilities. This SEIS will satisfy the need for further federal environmental review of the wastewater conveyance facilities and outfalls.

Full public participation by interested Federal, state and local agencies, concerned organizations, and private citizens is invited. A scoping meeting for the general public will be held on Thursday, December 11, 1986, 4:00-6:00 P.M., in the auditorium of the Department of Transportation at 55 Broadway, Kendall Square, Cambridge. A second scoping meeting for Federal and State agencies and public groups will be held on Monday, December 15, 9:30 A.M. in the Executive Dining Room, (Rm: E-226) JFK Federal Building, Boston, MA. Should you have any questions, please feel free to contact Mr. Ronald Manfredonia of EPA at (617) 565-3555.

Notice of Intent
To Prepare a Supplemental Environmental Impact Statement

Agency: U.S. Environmental Protection Agency (EPA), Region I

Action: Preparation of a Supplemental Environmental Impact Statement (SEIS) on the Marine Wastewater Conveyance Facilities and Outfall(s) for the Massachusetts Water Resources Authority (MWRA) wastewater treatment facilities at Deer Island, Boston, Massachusetts.

Purpose: The MWRA is undertaking facilities planning for the construction of major wastewater treatment facilities serving metropolitan Boston pursuant to a schedule mandated by the U.S. District Court, District of Massachusetts, in U.S. v. M.D.C. et al., Civil Action No. 85-0489-MA and a related case. In accordance with the EPA procedures for the implementation of the National Environmental Policy Act (NEPA), 40 CFR Part 6, EPA intends to prepare a SEIS on the marine wastewater conveyance facilities and outfall(s) associated with these facilities. This notice of intent is issued pursuant to 40 CFR §§ 6.510(a)(1) and 6.105(e). The decision to prepare a SEIS is consistent with Section 1502.9(c) of the Council on Environmental Quality (CEQ) Regulations, 40 CFR §1502.9(c).

This SEIS will be prepared concurrently with MWRA facilities planning for the wastewater treatment facilities. Other related actions being undertaken by the MWRA include facilities planning for residuals management (the subject of a separate SEIS) water transportation facilities, combined sewer overflows and scum removal facilities.

Preparation of the SEIS is consistent with EPA's Record of Decision (ROD) issued February 28, 1986 on the Final Environmental Impact Statement (FEIS) for the MWRA's Proposed Siting of Wastewater Treatment Facilities for the cleanup of Boston Harbor. The ROD specified that additional environmental reviews were required for the construction of an under-harbor tunnel or pipeline and for the water quality impacts and construction impacts of an outfall pipe or pipes. This SEIS will supplement the FEIS on the siting of the wastewater treatment facilities.

SUMMARY:

A. Background:

Planning for treatment of metropolitan Boston's wastewater has been proceeding for several years. A major aspect of this planning, the siting of the wastewater treatment facilities, culminated in February, 1986 with the MWRA's decision to site the treatment plant at Deer Island. The MWRA's siting decision was supported by EPA's ROD. The FEIS and ROD concluded that the environmental impacts of certain components of the facilities planning, which included the wastewater conveyance facilities and outfall(s), were not site determinative. This SEIS will satisfy the need, identified in the ROD, for further federal environmental review of the wastewater conveyance facilities and the outfall(s).

The MWRA is now preparing an Environmental Impact Report (EIR) under the Massachusetts Environmental Policy Act (MEPA) on the facilities plan for all components of the Deer Island facilities. The EIR will include evaluation of the wastewater conveyance facilities and outfall(s). The SEIS will be developed as a separate document from the EIR. However, to the maximum extent feasible, EPA, MWRA and other affected state agencies intend to coordinate this SEIS with the EIR, in accordance with 40 CFR §1506.2. The U.S. Army Corps of Engineers will act as a cooperating agency for this environmental review pursuant to 40 CFR § 1501.6.

B. Description of EPA Action:

EPA action in connection with construction of the wastewater conveyance systems and construction and operation of the outfall(s) may include Federal construction grants, requiring NEPA compliance. Other related federal actions requiring environmental review in connection with the wastewater conveyance systems and outfall(s) may include:

- dredge and fill permits and
- designation of an ocean disposal site for excavated materials resulting from construction and tunneling

C. <u>Principal Issues and Alternatives:</u>

1. Selection of the type of conveyance systems (pipelines, tunnels, combination and outfall/diffuser design) and the appropriate construction methods to be used. Key environmental issues associated with each technique are shown in Table 1.

2. Selection of the appropriate route for the conveyance systems.

3. Selection of the appropriate site for the outfall. Key environmental issues associated with the outfall location are shown in Table 2.

D. <u>Public and Private Involvement and Participation:</u>

Full public participation by interested Federal, state, and local agencies as well as other concerned organizations and private citizens is invited. Citizen advisory groups and committees will be utilized to facilitate effective public participation. All interested persons are encouraged to submit their names and addresses to the person listed above for inclusion on the mailing list for newsletters, the draft SEIS and related public information. A full public participation program will be managed by the MWRA and will be supplemented, as necessary, by EPA.

The Massachusetts Executive Office of Environmental Affairs (EOEA) and EPA have agreed to utilize a single Citizens Advisory Committee (CAC) for state and Federal environmental reviews of both the Residuals Management Facilities Plan and the Deer Island Wastewater Treatment Facilities Plan, of which planning for the wastewater conveyance system and the outfall(s) is a part. EPA, Region I, EOEA, and MWRA will conduct two scoping meetings to ascertain public and agency views on the options, sites, construction techniques, economic and environmental considerations, legal, institutional and other issues that should be evaluated in this SEIS. The first meeting will be for the general public and will assist EPA in developing the scope of work for the SEIS. This meeting will be held on December 11, 4:00-6:00 P.M. in the auditorium of the Department of Transportation at 55 Broadway, Kendall Square, Cambridge, MA. The second meeting will be held for Federal and State agencies and public groups on December 15, 9:30 A.M. in the Executive Dining Room (Rm E226), JFK Federal Building, Boston, MA. EPA invites written comments on the proposed scope of work for the SEIS until December 19, 1986. All comments on this Notice of Intent should be addressed to Director, Water Management Division, EPA, Region I, JFK Federal Building, Boston, MA.

It is anticipated that the draft SEIS will be available by September 1987 and the Final SEIS will be issued in February, 1988. Copies will be available at EPA, Region I and local depositories.

For Further Information Contact:

Ronald G. Manfredonia
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John F. Kennedy Federal Building
Boston, MA 02203
Telephone - (617) 565-3555
FTS 835-3555

Table 1

Summary of Key EIS Issues
Wastewater and Effluent Conveyance Systems

Conveyance Systems	Construction and Operational Issues
Pipelines	• indigenous ecosystem impacts plankton, benthos, fish during construction • dissolved oxygen depletion due to sediment resuspension during construction • toxicity due to sediment resuspension during construction • disturbance to recreational boating and fishery • disturbance to commercial shipping and fishery • wetland impacts • dredge material testing and disposal • traffic and storage of pipeline construction materials • ACOE and Coast Guard requirements with respect to anchorage areas, channel maintenance, LNG and explosives transport, etc. • construction feasibility • operational reliability
Tunnels	• blasting effects • excavated material transport and disposal • traffic and storage of tunnel construction material • land and/or water impacts due to shaft operation • wetland impacts

Table 1 Continued

Conveyance Systems	Construction and Operational Issues
Tunnels	• ACOE and Coast Guard requirements with respect to anchorage areas, channel maintenance, LNG and explosives transport, etc. during construction • construction feasibility • operational reliability
Diffusers	• issues the same as under Pipelines • impacts due to a single or a split discharge of primary and/or secondary wastewater treatment facility's effluents - see Table 2

Table 2

Summary of Key EIS Issues
Discharge of Primary and Secondary Effluents

Issues To Be Evaluated	Primary Reasons for Evaluation
• initial dilution modeling	• to determine water quality standards violations (WQC, toxicity, E. coli)
• long term dilution modeling	• determine water quality standards violations (dissolved oxygen)
• sedimentation and resuspension of effluent solids modeling	• determine water quality standards violations (dissolved oxygen, impacts on benthos)
• upwelling and surface transport modeling	• effects of average and peak flows on use of beaches and coastal resources
• modeling of other point sources	• possibility of combined impacts from several sources at a specific location
• toxicity of effluents	• possibility of adverse environmental impacts
• marine community structure and pathology	• possibility of adverse environmental impacts
• study of use of shoreline and marine resources	• possibility of impacts on recreational and commercial activities
• study of existing ambient water and sediment quality in relation to existing pollution sources and observed environmental impacts	• possibility of adverse environmental impacts

Above issues will be evaluated with regards to specific diffuser locations, degree of treatment of average and peak flows, under a split flow (two diffusers) and total flow (single diffuser) options.

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GLOSSARY

1st order kinetics - when modeling the decay of an effluent constituent as a first order process, the decay rate at any time is proportional to the remaining constituent concentration. This results in an exponential decrease in constituent concentrations over time

acute effects - lethal response resulting from short term exposure to toxicant(s). Ninety-six hours has been established as the generally accepted exposure time for bioassays determining acute toxicity

ambient - conditions, e.g., concentration, current speeds, etc., measured at a specific location or throughout the receiving waters, resulting from factors exclusive of future wastewater discharges

amphipod - a small crustacean

argillite - a metamorphic rock, intermediate between shale and slate, that does not possess true slaty cleavage

arochlor - mixture of PCB's

ascidians - a class of sessile tunicates or sea squirts

background buildup concentration - constituent concentrations in the receiving waters immediately outside the mixing zone, which provide dilution water for the initial dilution process. Background concentrations develop because of the return of previously discharged constituents to the diffuser area due to the tidally reversing currents

benthic - of or pertaining to the ocean floor

benthos - organisms that are attached to, live on or live in the ocean bottom

bimodality - two distinct peaks

bioaccumulation - accumulation of toxicants in tissues of organisms resulting from direct exposure or by ingestion

bioconcentration - concentration of contaminants by an aquatic organism through its digestive tract or gill tissues

biomagnification - transfer of bioaccumulated toxicants through the food web

biogenically bound mud - marine sediments

biomass - the amount of living material per unit area

bioturbulation - mixing of bottoms sediments by benthic organisms

bivalve - a mollusc with two shells hinged together as a clam

Broad Sound - coastal embayment of Massachusetts Bay, generally bound by Nahant and Deer Island

bryozoans - sessile, colonial marine organisms living attached to hard substrate

calibration - variation of model input parameters, e.g., mixing and decay rates, within reasonable bounds until model predictions match field measurements for the system under study

capitelled - a family of polychaete worms known for their pollution tolerance

carcinogencity - the ability of an effluent constituent or its reaction byproducts to cause tumors in organisms inhabiting the receiving waters

chemical tracer - a conservative or slowly decaying constituent within a discharge, which can be tracked following release into the receiving waters to provide information on rates of turbulent mixing and other data used for numerical model calibration

chlorophyll - green pigment in plant cells that is the receptor of light energy in photosynthesis

cirratulid - a family of polychaete worms

chronic effects - lethal response or debilitating damage to an organism(s) resulting from prolonged exposure to the toxicant(s). Exposure time may be several days, weeks, months or even years

coliforms - a group of bacteria characteristic of the intestinal tract of warm blooded vertebrates, which are used as indicators of the presence of domestic wastes

conduit - a tube-like structure that conducts fluid

copepods - very small crustaceans, usually planktonic living in the water column

coriolis force - a force perpendicular to the direction of motion due to the rotation of the earth

CTDO - indicates simultaneous field measurements of conductivity, temperature and dissolved oxygen at a given location

decay rate (conservative, 20, 60-day 1/2 life) - the rate of disappearance of an effluent constituent following discharge into a receiving water due to its transformation into other compounds. Expressed as a decay per unit time (k) or as a half-life, which is the amount of time required for loss of 1/2 the original constituent mass.

deep rock tunnel - a conduit which is constructed by boring a tunnel through bedrock

demersal - residing on the ocean bottom. Pelagic of or pertaining to the ocean bottom waters

density - the density of seawater is its mass per unit volume. It is frequently expressed in sigma-t units, which is the density in grams per cubic centimeter minus 1, times 1000, e.g., a density of 1.020 gm/cm^3 is equal to a sigma-t of 20.

depositional areas - areas of low wave energy where particulates in the water column settle to the ocean bottom

detection limit - the smallest quantity that can be measured with certainty by a given analytical method

diatoms - dominant planktonic algal form with a cell wall composed of silica; occurring as single cells or chains of cells

diffuser - a manifold at the end of an outfall which discharges wastewater, allowing the wastewater to be diluted with seawater

digested sludge - the thickened mixture of sewage solids with water that has been decomposed by anaerobic or aerobic bacteria

dinoflagellates - dominant planktonic algal form occurring as single cells

dragging - commercial fishing method using trawl

drifters - impermeable cards released in the water and to be mailed back upon discovery by third parties; used to characterize long-term water transport

drogue - floating object released and tracked with time to characterize water movements over a period of one to several days

dry ton - 2000 pounds of material (sludge) with approximately 20% moisture content

effluent - the outflow from a wastewater treatment plant

ELA - a two-dimensional element water quality transport model used for simulating the impacts of effluent discharges into tidal waters

entrainment - incorporation of ambient water into an effluent plume due to turbulence within the plume

epifauna - animals living on the surface of the ocean floor

euphotic zone - zone in the water column in which light penetration is sufficient for photosynthesis

euryhaline estuarine - wide range of salinities

facilities plan - the conceptual design of a wastewater treatment system

fall velocity - the downward vertical velocity at which suspended particles settle in the water column

farfield - zone removed from the discharge point where the effluent is affected by ambient transport, diffusion and decay independently from the design of the discharge structure

flaggellates - see dinoflagellates

flocculation - to become a loosely aggregrated mass of material suspended in liquid

forcing frequency - frequency of a force driving the water motion

Fourier amplitude & lag - amplitude and lag of the sinusoidal component of a signal (such as water surface elevation or current speed) at a given frequency

gillnetting - fish harvesting method utilizing stationary nets

harmonic analysis - analysis in which the Fournier amplitude and lag (q.v.) are determined as a function of frequency

headworks - where wastewater is collected and pumped to a wastewater treatment plant

hydroids - sessile, colonial invertebrates related to jellyfish with branched structure living attached to hard substratum

infauna - animals living within the sediments of the ocean bottom

influent - inflow to a wastewater treatment plant

initial dilution - dilution which occurs in the effluent plume close to the diffuser by entrainment of ambient water

interceptor system - a large sewer used to intercept a number of main or trunk sewers and convey the wastewater to treatment facilities

isolume - zone in water column in which light penetrates to the same degree

nannoplankton - the smallest plankton; generally less than 10 μ in size

marine pipeline - a conduit constructed by lying a pipeline on or below (in a trench) the ocean floor

mass flux - rate at which a constituent is discharge expressed in mass per unit time, e.g. mg/sec

multiport - having numerous openings for discharge

neap tide - tide of small amplitude which occurs when sun and moon influences are in opposition

nearfield - area close to the discharge where the effluent is rapidly diluted by turbulent entrainment of ambient fluid

neritic - of or pertaining to those regions of the ocean over the continental shelves

net drift - net movement of water over one or several complete tide cycles

non-tidal current - currents of driven by forces other than the tides

North System - the region of MWRA's system which receives wastewater treatment from the Deer Island Wastewater Treatment Plant

nutrients - anything other than the elements carbon, hydrogen and oxygen that is needed in the synthesis of organic matter. Common nutrients are nitrates and phosphates.

oceanic - of or pertaining to the deeper regions of the oceans beyond the continental shelves

oligochaetes - marine worm species related to the common earthworm living within the sediments

outfall - the conduit which conveys effluent from the wastewater treatment plant to its discharge location

oxygen demand - consumption of oxygen by bacteria to oxidize organic matter

palpi - mouth parts used in obtaining food

Pb-210 - lead radioactive isotope used to determine the date of deposited sediments

pH - a numerical measure of the acidity or alkalinity of a chemical solution

phytoplankton - a microscopic marine algae in the water column

pycnocline - zone of the water column where density changes rapidly with depth. The pycnocline separates upper and lower layers when the water column is stratified.

polychaete - annulated marine worm living in sediments

port - an opening on a diffuser through which effluent discharges

primary productivity - the rate at which organic matter is produced in photosynthesis

primary treatment - preliminary treatment of wastewater including: pumping, screening, grit removal and settling of heavy solids and floatable materials

progressive vector plots - plots of the horizontal movement of a small parcel of water or a neutrally buoyant particle over time, based on either continuous current measurements at one location or model predicted circulation fields

removal efficiency - the efficiency which a process has in reducing a constituent in an effluent

resuspension - lifting of inplace bottom sediments into the water column by waves or other bottom currents

riser - vertical tube from seafloor to deep rock tunnel for diffusing effluent

salinity - the total amount of solid material in grams contained in one kilogram of seawater when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter completely oxidized

saturation - seawater in contact with the atmosphere will tend to reach equilibrium with respect to dissolved gases, such that the partial pressures of gases in both will be equal. The seawater is said to be saturated with a given gas, such as oxygen, when this equilibrium is reached, for a specific pressure, temperature and salinity.

secchi disk measurements - measurement of light depth penetration in the water column

secondary treatment - biological treatment of wastewater following primary treatment involving removal of dissolved organics

sediment - soil and organic particles which accumulate on the sea floor

sedimentation - the deposition of sediment particles

semi-diurnal tides - the dominant tidal component along the east coast of North America, which has a period of 12.42 hours. There is little difference between the corresponding tides of successive half-day cycles, i.e., there is very little diurnal inequality

sewerage/sewage - liquid or solid waste which is transported through drains and/or by sewers to a wastewater treatment plant for processing

South System - the region of MWRA's system which receives wastewater treatment from the Nut Island Wastewater Treatment Plant

spionids - a family of polychaete worms

spring tide- the tides occurring about the times of new and full moon (twice per month) which rise higher and fall lower than during other times

stormwater - precipitation which either runs off or enters a sewer system

stratified conditions - during the spring and summer months, gradual warming of surface waters results in formation of a very stable vertical density profile, with less dense warm water near the surface and more dense cold water at greater depths. This vertically stable water column constitutes stratified conditions

sunken tube - a conduit constructed by sinking a tube such that it lies on or below (in a trench) the ocean floor

supersaturation - the partial pressure of a gas in seawater can exceed the saturation level. For example, algal production of oxygen can result in supersaturation of the seawater with respect to dissolved oxygen

taxa/taxon - a grouping of organisms with common characteristics

TEA-NL - model used to calculate circulation in Massachusetts Bay for the water quality analysis

thermocline - zone in the water column where temperature varies rapidly with depth. Usually coincident with the pycnocline (q.v.)

tidal current - currents due to the tide

tidal elevation - variations of the water level due to tides

tidal ellipse - locus of the end of the velocity vector at a point during a tide cycle

tidal prism - volume of water entering and leaving a tidal embayment during the flood and ebb parts of a tide cycle

tilt - difference in average sea level between Gloucester and Provincetown, which drives net drift in Massachusetts Bay

total keldahl nitrogen - total of organic and ammonia nitrogen

toxicity - degree to which an element or compound is capable of causing toxicosis when introduced into body tissues

trawling - commercial fishing method which utilizes a net towed behind a boat

tubiculous species - tube dwelling

turbidity - presence of suspended solids in the water, affecting its transparency

UDKHDEN - nearfield model used to calculate the dilution and final height of rise of the effluent plume in the zone of initial dilution

ULINE - nearfield model used to calculate the dilution and final height of rise of the effluent plume in the zone of initial dilution

UMERGE - nearfield model used to calculate the dilution and final height of rise of the effluent plume in the zone of initial dilution

wastewater - liquid waste collected in a sewer system and transported to a wastewater treatment plant for processing

zooplankton - microscopic animals living suspended in the water column and incapable of moving against currents

ACRONYMS

AMSA	Association of Metropolitan Sewerage Agencies
BWSC	Boston Water and Sewer Commission
CAC	Citizen Advisory Committee
CBOD	Carbonaceous biochemical oxygen demand
CCC	Criterion Continuous Concentration
CFR	Code of Federal Regulations
CMC	Criterion Maximum Concentration
CSO	Combined Sewer Overflows
CTDO	Conductivity, Temperature and Dissolved Oxygen
DDT	Dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Statement
DIFP	Deer Island Facilities Plan
DMF	Division of Marine Fisheries
DO	Dissolved Oxygen
DOD	Dissolved Oxygen Deficits
EC_{50}	Effluent Concentration at which 50% of the Test Organisms Exhibit Sublethal Effects
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ELA	Eulerian-Lagragian Analysis
EOEA	The Massachusetts Executive Office of Environmental Affairs
FEIR	Final Environmental Impact Report
FEIS	Final Environmental Impact Statement
L_{90}	Noise level which is exceeded 90 percent of the time

LC_{50}	The effluent concentrations at which 50% of the test organisms are killed
MARMAP	Marine Monitoring Assessment Program
MBO	Manomet Bird Observatory
MDC	Metropolitan District Commission
MDMF	Massachusetts Division of Marine Fisheries
MEPA	Massachusetts Environmental Policy Act
MLW	Mean Low Water
MWRA	Massachusetts Water Resources Authority
NBOD	Nitrogenous Biochemical Oxygen Demand
ND	Not Detected
NEA	New England Aquarium
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Services
NOEL	No Observed Effect Level
NOI	Notice of Intent
NPDES	National Pollution Discharge Elimination System
OTW	<u>On the Waterfront</u>
PAH	Poly Aromatic Hydrocarbons
PCB	Polychlorinated Biphenol
RO/RO	Roll-on/Roll-off
ROD	Record of Decision
SDEIS	Supplemental Draft Environmental Impact Statement
SEIS	Supplemental Environmental Impact Statement
SOD	Sediment Oxygen Demand

SS	Suspended solids
STFP	Secondary Treatment Facilities Plan
SWIM	Nahant Citizens Committee for Safer Waters in Massachusetts
Site PR	President Road Site
TAG	Technical Advisory Group
TBM	Tunnel Boring Machine
TEA-NL	Tidal Embayment Analysis - Nonlinear
TKN	Total Kjeldhahl Nitrogen
TPM	MIT Transient Plume Model
TRIGOM	The Research Institute of the Gulf of Maine
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USEPA/EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
VOHC	Volatile Halogenated Organic Compounds
WTFP	Water Transportation Facilities Plan
WWTP	Waste Water Treatment Plant
ZID	Zone of Initial Dilution

LIST OF UNITS

ft	foot
km	kilometer
hrs	hour
sec	second
m	meter
cm	centimeter
cm/sec	centimeter per second
g	gram
g/ccm	grams per cubic centimeter
mg	milligram
l	liter
mg/l	milligrams per liter
µg/l	micrograms per liter
ng	nanogram
ng/l	nanograms per liter
ppm	parts per million
µ	micron
d^{-1}	per day
mgd	millions of gallons per day
m^3/s	cubic meters per second
$g/m^2/day$	grams per square meter per day
m^2/sec	square meters per second
g/m^2	grams per square meter
cm^3	cubic centimeters

mm	millimeter
yr	year
cm^2	square centimeters
µg/g	micrograms per gram
km^2	square kilometers
lbs	pounds
dBA	decibals
yd	yard
cu yd (yd^3)	cubic yards
cu ft (ft^3)	cubic feet

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