TOTAL MAXIMUM DAILY LOAD ANALYSIS FOR GREENWICH BAY WATERS
PATHOGEN / BACTERIA IMPAIRMENTS

GREENWICH BAY
APPONAUG COVE
BRUSH NECK COVE
BUTTONWOODS COVE
GREENWICH COVE
WARWICK COVE

BAKER CREEK
DARK ENTRY BROOK
GORTON POND TRIBUTARY
GREENWOOD CREEK
HARDIG BROOK
MASKERCHUGG RIVER
MILL BROOK
SADDLE BROOK
SOUTHERN CREEK (CARPENTER BROOK)
TUSCATUCKET BROOK

WARWICK, RHODE ISLAND
EAST GREENWICH, RHODE ISLAND
WEST WARWICK, RHODE ISLAND

Photograph courtesy of the City of Warwick

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Office of Water Resources
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LIST OF ACRONYMS AND TERMS

Best Management Practices (BMP) means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of and impacts upon waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

CFR is the Code of Federal Regulations.

CRMC refers to the Rhode Island Coastal Resource Management Council.

CVA refers to the Clean Vessel Act.

Clean Water Act (CWA) refers to the Federal Water Pollution Control Act (33 U.S.C. § 1251) et seq. and all amendments thereto.

Combined Sewer Overflow (CSO) means flow from a combined sewer that is discharged into receiving waters without going to a treatment works. A CSO is distinguished from bypasses, which are diversions of waste streams from any portion of a treatment works.

DEM or RIDEM refers to the Rhode Island Department of Environmental Management.

Depuration is the artificial holding of shellfish for purification purposes.

Designated uses are those uses specified in water quality standards for each waterbody or segment whether or not they are being attained. In no case shall assimilation or transport of pollutants be considered a designated use.

DOT refers to the Rhode Island Department of Transportation.

EPA refers to the United States Environmental Protection Agency.

FDA refers to the United States Food and Drug Administration.

Fecal coliform bacteria are found in the intestinal tracts of mammals. Their presence in water or sludge is an indicator of pollution and possible contamination by pathogens, disease causing organisms.

GBI refers to the Greenwich Bay Initiative.

HEALTH refers to the Rhode Island Department of Health.

Load allocation is the portion of a receiving water's loading capacity that is attributed either to one of its nonpoint sources of pollution or to natural background sources.

Loading Capacity means the maximum amount of loading that a surface water can receive without violating water quality standards.

MS4 is a municipal separate storm sewer system.

MOS refers to the Margin of safety.

Marine Sanitation Device (MSD)

Marine toilet means any toilet or receptacle for the containment of human wastes located on or within any vessel, as defined herein, not including a portable potty.

Most Probable Number (MPN) is an estimate of microbial abundance per unit volume of water sample, based on probability theory.

NBC refers to the Narragansett Bay Commission.

NSSP refers to the National Shellfish Sanitation Program.

Natural background conditions are all prevailing dynamic environmental conditions in a waterbody or segment thereof, other than those human-made or human-induced.

No Discharge Area/Zone means an area of the surface waters of the state which has been requested by the Director of the Department of Environmental Management and declared by the United States Environmental Protection Agency, pursuant to Section 312 of the Clean Water Act, to be an area in which any discharge of sewage from vessels is prohibited.

Nonpoint Source (NPS) means any discharge of pollutants that does not meet the definition of Point Source in section 502.(14). of the Clean Water Act and these regulations. Such sources are diffuse, and often associated with land-use practices, and carry pollutants to the waters of the State, including but not limited to, non-channelized land runoff, drainage, or snowmelt; atmospheric deposition; precipitation; and seepage.

Point source means any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation or vessel, or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture.

Primary Contact Recreational Activities are those activities in which there is prolonged and intimate contact by the human body with the water, involving considerable risk of ingesting water, such as swimming, diving, water skiing and surfing.

Rhode Island Pollutant Discharge Elimination System (RIPDES) is the Rhode Island system for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing point source discharge permits and imposing and enforcing pretreatment requirements pursuant to Title 46, Chapter 12 of the General Laws of Rhode and the Clean Water Act.

Runoff means water that drains from an area as surface flow.

SRICD refers to the Southern Rhode Island Conservation District.

SWMPP is a storm water management project plan.

Secondary Contact Recreational Activities are those activities in which there is minimal contact by the human body with the water, and the probability of ingestion of the water is minimal, such as boating and fishing.

Storm water means precipitation induced runoff.

Surface waters are any waters of the state that are not groundwaters.

Total Maximum Daily Load (TMDL) means the amount of a pollutant that may be discharged into a waterbody and still maintain water quality standards. The TMDL is the sum of the individual wasteload allocations for point sources and the load allocations for nonpoint sources and natural background taking into account a margin of safety.

URI-CVE refers to the Department of Civil Engineering at the University Rhode Island.

Wasteload allocation is the portion of a receiving water's loading capacity that is allocated to its point sources of pollution.

Water quality criteria means elements of the State water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use.

Water quality standard means provisions of State or Federal law, which consist of designated use(s) and water quality criteria for the waters of the State. Water Quality Standards also consist of an antidegradation policy.

ABSTRACT

This Total Maximum Daily Load (TMDL) plan addresses fecal coliform impairments to Greenwich Bay, Brush Neck Cove, Buttonwoods Cove, Warwick Cove, Hardig Brook, Tuscatucket Brook, two additional Coves, and seven tributaries within the Greenwich Bay watershed, located in the City of Warwick and the Towns of East Greenwich and West Warwick, Rhode Island. These waters are listed on Rhode Island's 2002 303(d) List of Impaired Waters as Group 1 waters. Two of the Greenwich Bay coves and the seven other tributaries included in this TMDL were found to violate standards during the course of this project and are addressed in this TMDL. These waters do not support their designated uses. Designated uses for these waters include primary and secondary contact recreation, fish and wildlife habitat, and for those waters classified as SA, shellfish harvesting.

This TMDL aims to restore Greenwich Bay waters by identifying necessary pollutant reductions, locating pollution sources, and outlining an implementation strategy to abate fecal coliform sources such that water quality standards can ultimately be attained during all weather conditions.

With a few exceptions, bacteria impairments in the Greenwich Bay watershed arise directly following wet weather events. In dry weather, all stations in Greenwich Bay and the coves meet the geometric mean criterion, while five of the stations exceed the 90th percentile criterion for the shellfish use. Following rain events, only one station in Greenwich Bay meets both parts of the Class SA water quality standard. The Greenwich Bay coves exhibit the highest bacteria concentrations, with Apponaug Cove and Brush Neck Cove requiring the largest percent reductions for the entire bay.

The Greenwich Bay tributaries reflect the same water quality trends as Greenwich Bay. Water quality is generally good in dry weather and exceeds standards in wet weather. Required percent reductions in the tributaries range from no reductions at some stations along the Maskerchugg River to a 100 percent reduction required from Southern Creek in Brush Neck Cove. The largest bacteria sources to Greenwich Bay are found in Apponaug Cove (Hardig Brook) and Brush Neck Cove.

Recommended implementation activities focus on storm water and wastewater management. Ongoing efforts to ensure adequate treatment of wastewater through the planned sewer extensions, and the proper operation and maintenance of septic systems should continue. Achieving water quality standards will also require that both the amount of storm water and the bacteria concentrations in that storm water reaching Greenwich Bay are reduced. To reduce runoff volumes and treat storm water, use of infiltration basins or similar structures is recommended. A targeted approach to construction of storm water retrofit best management practices (BMPs) at state and locally owned storm water outfalls is recommended. Priority areas for BMP construction within the City of Warwick are Apponaug Cove and Brush Neck Cove, for the Town of East Greenwich, Greenwich Cove, and for the Town of West Warwick, the Hardig Brook headwaters. This TMDL also recommends pollution prevention efforts to discourage residents from feeding birds, encourage residents to pick up after their pets, and ensure that boats comply with the *No Discharge* requirements of Rhode Island marine waters.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act and Environmental Protection Agency's (EPA) implementing regulations in 40 CFR§130 direct each state to develop Total Maximum Daily Load (TMDL) plans for waterbodies that are not meeting their water quality standards. The primary pollutants of concern for Greenwich Bay waters on the 2002 303(d) List of Impaired Waters are pathogens, nutrients, and low dissolved oxygen (RIDEM, 2003c). This TMDL only addresses elevated fecal coliform concentrations, an indication of potential pathogen contamination.

1.1 Study Area

The Greenwich Bay estuary is composed of five shallow coves connected to Greenwich Bay proper, which then connects with the upper West Passage of Narragansett Bay. The Bay is located on the westerly side of Narragansett Bay, approximately 6.5 kilometers southwest of the mouth of the Providence River. The Greenwich Bay watershed, which includes parts of the City of Warwick and the Towns of East Greenwich and West Warwick, all located in central Rhode Island, is shown in Figure 1.1.

Table 1.1 contains a list of Greenwich Bay impaired waters, their water quality classifications, and their 2002 303(d) listing. Some of the waters included in this TMDL plan are not listed on the 303(d) List. A TMDL plan for nutrients and dissolved oxygen is in development.

Table 1.1 Greenwich Bay Impaired Waters Classifications and 2002 303(d) Listing (RIDEM, 2003c).

Waterbody ID	Name	Water Quality Classification	2002 303(d) Listing
RI0007025E-01	Apponaug Cove	SB	N, DO, AG
RI0007025E-02	Brush Neck Cove	SA	P, N, DO
RI0007025E-03	Buttonwoods Cove	SA	P, N, DO
RI0007025E-04A	Greenwich Bay	SA	P, N, DO
RI0007025E-04B	Greenwich Bay	SA	P, N, DO
RI0007025E-05A	Greenwich Cove	SB1	N, DO
RI0007025E-06A	Warwick Cove	SB	N, DO
RI0007025E-06B	Warwick Cove	SA	P, N, DO
RI0007025R-01	Hardig Brook	B	P, Pb, Bio
RI0007025R-03	Maskerchugg River	B	Pb, Cd, Cu
RI0007025R-04	Dark Entry Brook	B	
RI0007025R-05	Tuscatucket Brook	A	P
RI0007025R-06	Baker Creek	A	P
RI0007025R-09	Southern Creek	A	
RI0007025R-11	Greenwood Creek	B	
RI0007025R-13	Gorton Pond Tributary	B	
RI0007025R-14	Mill Brook	B	
RI0007025R-16	Saddle Brook	B	

P: Pathogens (fecal coliform), N: Nutrients, DO: Low Dissolved Oxygen, AG: Excess Algal Growth / Chlorophyll-a, Bio: Biodiversity Impacts, Pb: Lead, Cd: Cadmium, Cu: Copper

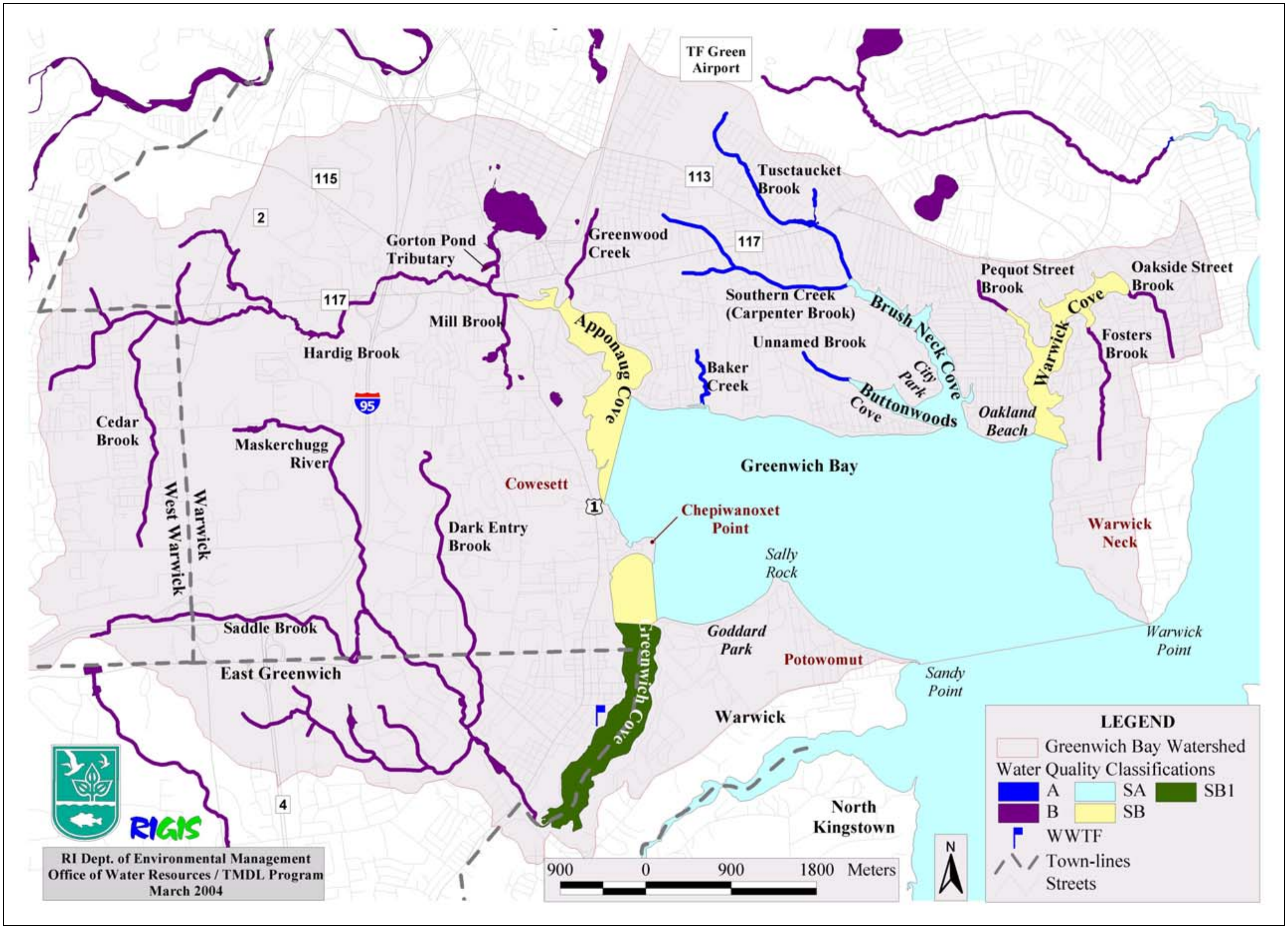

Figure 1.1 Greenwich Bay Watershed.

1.2 Pollutant of Concern

The pollutant of concern is fecal coliform, a parameter used by Rhode Island as an indicator of potential pathogen contamination.

1.3 Priority Ranking

Greenwich Bay is listed as a Group 1 waterbody in the 2002 303(d) List. Group 1 waters have the highest priority for TMDL development.

1.4 Applicable Water Quality Standards

Designated uses and water quality standards vary depending on the water quality classification of a waterbody. Both are described in the State of Rhode Island's Water Quality Regulations (1997). Greenwich Bay, its coves, and tributaries are composed of five different water quality classifications. Table 1.1 lists the water quality classifications of the waterbodies shown in Figure 1.1.

Designated Uses

Class A and Class B waters are designated for primary and secondary contact recreation and fish and wildlife habitat, and shall have good aesthetic value.

Class SA waters are designated for shellfish harvesting for direct human consumption, primary and secondary contact recreation, and fish and wildlife habitat, and shall have good aesthetic value.

Class SB waters are designated for primary and secondary contact recreation, fish and wildlife habitat, and shellfish harvesting for controlled relay and depuration, and shall have good aesthetic value.

Class SB1 waters are designated for primary and secondary contact recreation and fish and wildlife habitat, and shall have good aesthetic value. Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges. All Class SB criteria must be met.

Numeric Water Quality Criteria

Class A fecal coliform concentrations are not to exceed a geometric mean value of 20 and not more than 10% of the samples shall exceed a value of 200.

Class B fecal coliform concentrations are not to exceed a geometric mean value of 200 and not more than 20% of the samples shall exceed a value of 500. This is the swimming standard for freshwater.

Class SA fecal coliform concentrations are not to exceed a geometric mean MPN value of 14 and not more than 10% of the samples shall exceed an MPN value of 49 for a 3-tube decimal dilution.

Class SB/SB1 fecal coliform concentrations are not to exceed a geometric mean MPN value of 50 and not more than 10% of the samples shall exceed an MPN value of 500. This is the swimming standard for marine waters.

Table 1.2 Bacteria Water Quality Standards and Applicable Waterbodies (RIDEM, 1997).

Classification	Water Quality Standards	Applicable Waterbodies
Class SA	Not to exceed a geometric mean MPN value of 14 and not more than 10% of the samples shall exceed an MPN value of 49 for a 3-tube decimal dilution.	Greenwich Bay proper, Brush Neck Cove, Buttonwoods Cove, Warwick Cove
Class SB/SB1	Not to exceed a geometric mean MPN value of 50 and not more than 10% of the samples shall exceed an MPN value of 500.	Apponaug Cove, Greenwich Cove, Warwick Cove
Class A	Not to exceed a geometric mean value of 20 and not more than 10% of the samples shall exceed a value of 200.	Baker Creek, Tuscatucket Brook, Southern Creek (Carpenter Brook), Unnamed Brook – Buttonwoods Cove
Class B	Not to exceed a geometric mean value of 200 and not more than 20% of the samples shall exceed a value of 500.	Hardig Brook, Mill Brook, Gorton Pond and Tributary, Cedar Brook, Dark Entry Brook, Greenwood Creek, Maskerchugg River, Nichols Brook, Saddle Brook, Fosters Brook, Oakside Street Brook, Pequot Street Brook

Other Applicable Standards

The closure of shellfish areas to harvesting is not solely based on the ambient water quality data. In accordance with the National Shellfish Sanitation Program (NSSP), a shellfish growing area shall be classified as Prohibited if no current sanitary survey has been performed or if a sanitary survey or other monitoring program data indicates that fecal material may reach the area in excessive concentrations. If it has been determined that there is a good potential for harvested shellfish to be contaminated due to the nature of an upland source, then a growing a growing area is closed (NSSP, 1997).

Antidegradation Policy

Rhode Island's antidegradation policy requires that, at a minimum, the water quality necessary to support existing uses be maintained (see Rule 18, Tier 1 of the State of Rhode Island's Water Quality Regulations). If water quality for a particular parameter is of a higher level than necessary to support an existing use (i.e. bacterial levels are below Class A standards), that improved level of quality should be maintained and protected (see Rule 18, Tier 2 in the State of Rhode Island's Water Quality Regulations). Tier 2 does not apply to Greenwich Bay because fecal coliform concentrations are greater than the water quality standards.

Numeric Water Quality Targets

The numeric water quality targets are set at the applicable water quality criteria or standard for each segment of Greenwich Bay, its coves, and its tributaries. In some areas, a waterbody segment with higher allowable fecal coliform bacteria limits discharges to a waterbody with more stringent criteria. In these places, the numeric water quality target must be set to the more strict criteria of the two standards at the point of discharge. These targets incorporate an implicit margin of safety (MOS) through conservative assumptions that ensure that the water quality standards are met.

The numeric water quality targets are set to the fecal coliform concentrations necessary to restore the designated uses to Greenwich Bay. For example, targets are set to what is necessary to reopen the shellfish waters during all weather conditions, in accordance with Rhode Island's Shellfish Program approved by the United States Food and Drug Administration (FDA). Targets are also set to the standards needed to keep the beaches open.

2.0 DESCRIPTION OF THE STUDY AREA

The waters of Greenwich Bay are home to three licensed bathing beaches, Goddard Park, Oakland Beach, and City Park, and over 4000 boats moored or docked primarily at marinas in three coves - Apponaug, Greenwich, and Warwick (Ganz, 2003). During the winter months when inclement weather makes harvesting shellfish more difficult in Narragansett Bay, local commercial shellfisherman rely on the Greenwich Bay shellfish resource to supplement their annual harvest.

The Greenwich Bay watershed includes parts of the City of Warwick and the Towns of East Greenwich and West Warwick in central Rhode Island. The watershed area is about 68 square kilometers (km^2) and can be characterized as urban/residential, with high to medium density residential land-use covering almost one-third of the total land area (RIGIS, 1999). The surface area of Greenwich Bay proper and its five coves is about 13 km^2.

2.1 Greenwich Bay Sub-Watersheds

The Class SA waters of Greenwich Bay proper extend from Chepiwanoxet Point on the western Greenwich Bay shoreline to a line that run between Warwick Point in Warwick Neck to Sandy Point in Potowomut along Narragansett Bay. Figure 2.1 shows the Greenwich Bay watershed divided into seven sub-watersheds. Characteristics and land uses within these sub-watersheds vary. Table 2.1 describes the land uses within both the entire Greenwich Bay watershed and the seven sub-watersheds. Land use is given both by total area in km^2 and by percentage. The surface area of Greenwich Bay and coves is not included. The sections following Table 2.1 detail land use, tributary streams, and other information about these sub-watersheds.

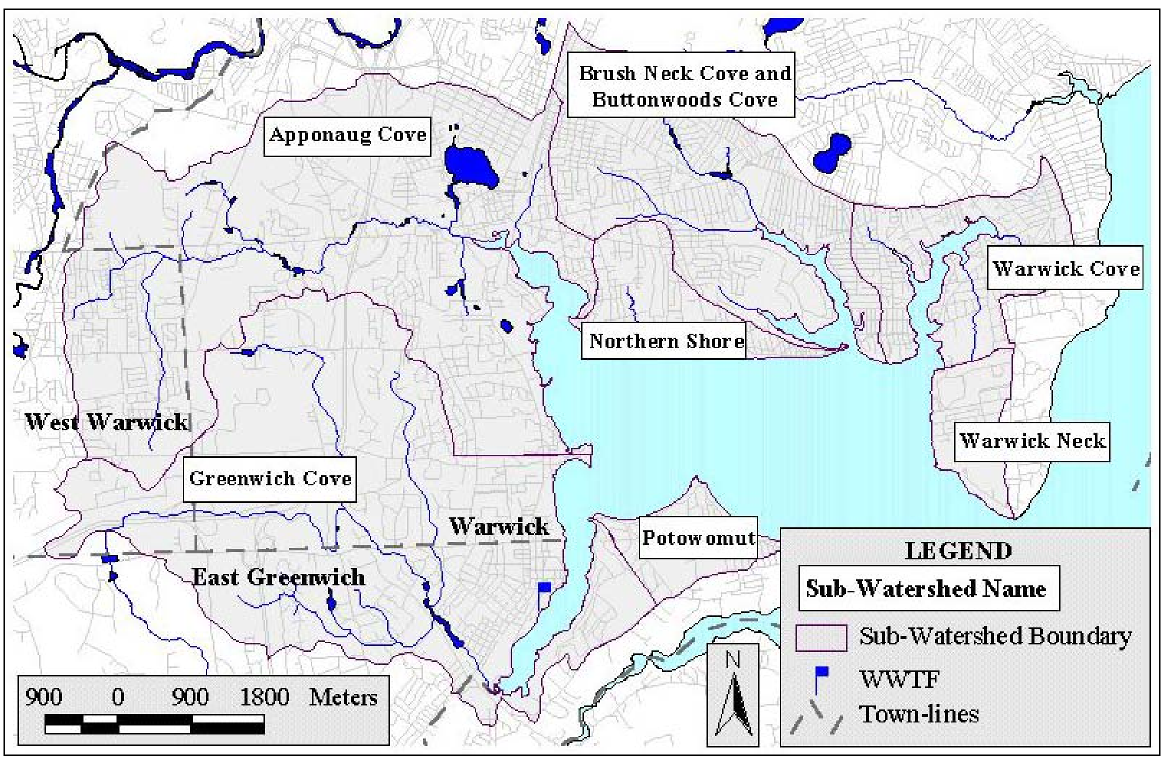

Figure 2.1 Greenwich Bay Sub-watersheds.

Table 2.1 Greenwich Bay and Sub-watershed Land Use by Area (km^2)[1] and Percentage (RIGIS, 1999).

	Greenwich Bay[2]	Potowomut	Greenwich Cove	Apponaug Cove	Northern Shore	BNC BWC[3]	Warwick Cove	Warwick Neck
Medium to High Density Residential	17.0 30.9 %	0.4 26.9 %	2.3 12.2 %	6.5 33.5 %	1.2 57.4 %	4.8 61.2 %	1.7 44.0 %	NA
Low to Medium Density Residential	8.4 15.3 %	0 <1 %	4.8 25.5 %	2.2 11.4 %	0 0.7 %	0.10 1.2 %	0.7 18.3 %	0.6 42.9 %
Commercial and Industrial	6.6 12.0 %	NA	1.9 10.2 %	3.4 17.7 %	0 2.0 %	0.9 11.2 %	0.3 7.7 %	0.2 11.0 %
Roads, Airports, Utilities, etc.	2.9 5.2 %	NA	1.2 6.6 %	1.0 5.2 %	NA	0.6 7.9 %	NA	NA
Recreation and Cemeteries	3.9 7.2 %	0.7 41.3 %	1.2 6.4 %	0.8 4.0 %	0.2 11.1 %	0.2 2.9 %	0.4 11.4 %	0.4 27.2 %
Agriculture	1.1 1.9 %	0 0.1 %	0.3 1.8 %	4.9 2.5 %	0.2 8.2 %	0.1 0.6 %	0 <1 %	0 0.7 %
Forests	10.1 18.4 %	0.4 26.0 %	4.9 26.1 %	3.2 16.7 %	0.2 10.7 %	0.9 11.7 %	0.3 8.4 %	0.1 8.7 %
Water, Wetlands, Sandy Areas	4.9 9.0 %	0.1 5.7 %	2.1 11.2 %	1.7 8.9 %	0.2 9.9 %	0.3 3.3 %	0.4 10.2 %	0.1 9.4 %
Total Area (km^2)	54.8 km^2	1.6 km^2	17.7 km^2	17.5 km^2	2.1 km^2	7.9 km^2	3.8 km^2	1.4 km^2

[1]The conversion from km^2 to acres is 1 km^2 is 247 acres.
[2]Entire Greenwich Bay watershed, excluding the surface area of the Bay and Coves.
[3]Brush Neck Cove and Buttonwoods Cove

Potowomut

The Potowomut sub-watershed covers an area of 1.6 km^2 along the southern shoreline of Greenwich Bay as shown in Figure 2.1. It extends from Greenwich Cove to Sandy Point, the boundary between Greenwich Bay and Narragansett Bay. There are few freshwater sources that drain from the Potowomut area to Greenwich Bay. Goddard Park comprises about half of the Potowomut sub-watershed, from the mouth of Greenwich Cove to Sally Rock.

Goddard Park is a state-owned park that contains a beach, golf course, and forested land. Land use in the remainder of the Potowomut sub-watershed from Sally Rock to Sandy Point is high to medium density residential (RIGIS, 1999). Sewers are not available and are not planned for this area.

Greenwich Cove

Greenwich Cove empties into the southeastern corner of Greenwich Bay proper. As shown in Figure 2.1, the Greenwich Cove sub-watershed includes all land that drains south of Chepiwanoxet Point. The cove has a surface area of 1.1 km^2 (FDA, 1993) and a total watershed area of 17.7 km^2. The Greenwich Cove sub-watershed includes land from East Greenwich and Warwick as shown in Figure 1.1 and Figure 2.1. Goddard Park is located along the undeveloped Warwick shoreline. The East Greenwich Shoreline is developed and contains the East Greenwich Wastewater Treatment Facility. This secondary treatment plant discharges treated effluent at a point midway between the two shorelines. The Maskerchugg

River, the second largest freshwater tributary to Greenwich Bay, discharges to the head of Greenwich Cove. Its headwaters extend west of Interstate 95 (I-95) in East Greenwich and into the Cowesett section of Warwick. Greenwich Cove contains major mooring and docking space for boats in Greenwich Bay along the East Greenwich shoreline.

A variety of land uses occur throughout the Greenwich Cove watershed. The portion of Goddard Park along the eastern shoreline of Greenwich Cove includes both forested land and a golf course. On the western shoreline of the cove, US Route 1 (US-1), also known as Main Street, and train tracks run parallel to Greenwich Cove. Commercial properties line this two-lane road. This commercial area is surrounded by high to medium density residential development. A steep hill runs from Main Street down to the Cove. Extending to the west of Main Street, the Maskerchugg River watershed consists of medium to low residential development in both East Greenwich and Warwick. I-95 is located in the upper reaches of this sub-watershed. Land use west of I-95 includes forested area and power lines (RIGIS, 1999). Though sewers are available along US-1, they are not available for the majority of this sub-watershed.

Apponaug Cove

Apponaug Cove is located in northeastern Greenwich Bay. As shown in Figure 2.1, the Apponaug Cove sub-watershed includes all land that drains north of Chepiwanoxet Point. The Cove has a surface area of 0.48 km^2 (FDA, 1993) and a total watershed area of 17.5 km^2. Hardig Brook is the largest freshwater tributary in the Greenwich Bay watershed. Its headwaters are located in Warwick north of Route 117 between a farm and golf course. Hardig Brook travels along Route 117 before it reaches the head of Apponaug Cove. Before reaching the Cove, Hardig Brook merges with Mill Brook and Gorton Pond Tributary. Another tributary, Greenwood Creek, flows into the cove east of Hardig Brook. Apponaug Cove contains significant mooring and docking space for boats in Greenwich Bay.

High to medium density residential development accounts for just over one-third of the land use in the Apponaug Cove sub-watershed. An additional eighteen percent of the land is used for commercial and industrial uses, mainly along high-traffic roads, such as Route 2 and Route 117. US-1 runs parallel to the western shoreline of Apponaug Cove. Land uses in the area directly surrounding US-1 include commercial, industrial, and high density residential. Much of the high density residential development is condominiums and apartments located on Greenwich Bay. Sewers are planned for the condominiums and apartments along US-1. Isolated pockets of forested land are present throughout the sub-watershed and along I-95 (RIGIS, 1999).

Northern Shoreline

The Greenwich Bay northern shoreline extends from Apponaug Cove to the combined opening of Brush Neck Cove and Buttonwoods Cove. Located in Warwick, the northern shoreline sub-watershed is 2.1 km^2 in size. Baker Creek, in the Nausauket area of Warwick discharges along the northern shoreline. Baker Creek is mostly tidal and surrounded by wetlands. Other freshwater sources are small and have never been sampled extensively. Most houses in this area have sewers available, though there are still some areas where sewer lines have yet to be installed.

High to medium density residential development accounts for the majority of the land uses in this area. Other land uses include forested land, the wetlands surrounding Baker Creek, and the open space of the Masonic Youth Center (RIGIS, 1999).

Brush Neck Cove and Buttonwoods Cove

Brush Neck Cove and Buttonwoods Cove are located in the northern Greenwich Bay, directly east of Warwick Cove. Brush Neck Cove has a surface area 0.35 km^2, while Buttonwoods Cove covers 0.22 km^2 (FDA, 1993). Both coves are shallow, with low tide depths of approximately one to four feet.

The area of the sub-watershed for both coves is 7.9 km^2. The two coves merge at City Park before entering Greenwich Bay. Oakland Beach abuts Brush Neck Cove on its eastern edge. Two freshwater streams discharge to the head of Brush Neck Cove. Tuscatucket Brook rises at TF Green Airport and flows to the southeast to the head of Brush Neck Cove south of Route 117. Southern Creek, also known as Carpenter Brook, rises near the intersection of Route 117 and Buttonwoods Road west of Tuscatucket Brook. The Creek flows southeast to the head of Brush Neck Cove. An unnamed stream discharges to the head of Buttonwoods Cove. This stream is dry during the summer months.

Land use in over half of the sub-watershed is high to medium density residential. This high to medium density residential land use can be found throughout the watershed (RIGIS, 1999). Part of TF Green Airport is located in the northern reaches of the watershed, furthest away from Brush Neck Cove. City Park is located along the western edge of Brush Neck Cove and the northern edge of Buttonwoods Cove at the intersection of Brush Neck and Buttonwoods Cove. Sewer construction and tie-ins are ongoing in the area.

Warwick Cove

Warwick Cove is located at the northeastern corner of Greenwich Bay proper. The Cove has a surface area of 0.48 km^2 (FDA, 1993) and a total watershed area of 3.8 km^2. The Cove is separated from the western edge of upper Narragansett Bay by a neck of land, approximately 2.5 kilometers wide, known as Warwick Neck. Oakland Beach abuts the western edge of the mouth Warwick Cove. Two freshwater streams discharge into the northeastern reaches of Warwick Cove. Fosters Brook rises south of the Seaview Country Club. The brook runs through the Country Club and makes its way north to Warwick Cove in the vicinity of Meadow View Avenue. The Oakside Street Brook discharges north of Fosters Brook near Warwick Neck Avenue. Another small stream discharges to the upper-western reaches of Warwick Cove in the vicinity of Peqout Street. Warwick Cove contains major mooring and docking space for boats in Greenwich Bay. The cove has a dredged channel with reported depths of 6 feet extending to the upper cove at mean low tide.

High to medium density residential land use can be found in almost half of the Warwick Cove sub-watershed, primarily in the western and northern areas. Land uses in the southeastern half include low to medium density residential and a golf course on Warwick Neck near Fosters Brook. Some forested area exists near the headwaters of the Oakside Street Brook in Warwick Cove, though the stream's watershed is predominately high to medium density residential development (RIGIS, 1999). Sewers are available in Oakland Beach, the eastern half of the watershed.

Warwick Neck

The Warwick Neck sub-watershed is 1.44 km^2 in size. The shoreline of Warwick Neck extends from Warwick Cove southeast until it reaches Warwick Point, the boundary between Greenwich Bay and Narragansett Bay. Land uses on Warwick Neck are primarily medium to low density residential and golf courses (RIGIS, 1999).

2.2 Water Quality History in Greenwich Bay

Prior to 1992, harvesting shellfish from Greenwich Bay was approved, allowed regardless of precipitation with some resource management restrictions. In December 1992, almost 4 inches of rain and 3.5 inches of snow fell at TF Green Airport in Warwick, Rhode Island in three days. The heavy precipitation resulted in sustained violations in the fecal coliform standard in Greenwich Bay. After weeks of temporary closures, Greenwich Bay was permanently closed for shellfish harvesting on January 5, 1993 until a reclassification study could be conducted (RIDEM, 1993).

DEM and FDA jointly conducted the Greenwich Bay reclassification study. Primary study objectives included assessing the relative importance of pollution sources impacting bay water quality and developing recommendations for the classification and management of the bay. The reclassification study was conducted in the spring (April 5 to 19) and early summer (June 21 to July 2) of 1993. Twenty-seven stations throughout Greenwich Bay were sampled during the two studies. Twenty-five streams, tributaries, and direct storm water discharges were also sampled throughout the survey (FDA, 1993).

The reclassification study concluded that the Greenwich Bay Growing Area should be classified as Conditionally Approved. While dry weather water quality is acceptable for the direct harvesting of shellfish, the area is impacted following rainfall that exceeds 0.5 inches in a 24 hour period. The minimum closure time should be 6 days; including four days for the effects of the event to pass and two days for the shellfish to depurate. Harvesting shellfish should be halted within twelve hours following a qualifying rain event, due to the rapid degradation of Greenwich Bay following rainfall (FDA, 1993). Greenwich Bay was reopened as a Conditional Area on June 27, 1994 (RIDEM, 1994).

FDA identified Hardig Brook in Apponaug Cove as the largest dry and wet weather bacteria source to the watershed. Apponaug Cove had the highest fecal coliform levels in the entire watershed during wet weather. As estimated by the FDA report, 95% of the overall daily and 99% of the wet weather fecal coliform inputs to Greenwich Bay came from eight sources. (FDA, 1993). These sources included Hardig Brook, Southern Creek, and the Maskerchugg River.

The 1992 storm event and the resulting shellfish closure and reclassification study drew attention to pollution sources within Greenwich Bay. The Greenwich Bay Initiative (GBI) was a multi-faceted program organized in 1993 that incorporated many agencies and organizations from throughout Rhode Island. The GBI aimed to assess the physical conditions within the watershed while evaluating the impacts of these conditions on Greenwich Bay. The GBI also aimed to determine the approximate location of key *hot spots* or areas of concern that contributed most to the watershed's pollutant loading.

Researchers from the University of Rhode Island's Department of Civil and Environmental Engineering (URI-CVE) studied pollutant sources identified by the FDA report throughout the 1990s. URI-CVE sampled seven Greenwich tributaries and several storm water discharges. URI-CVE also identified over 100 storm water discharges. Mitigation activities resulting from these studies included implementing best management practices at a dairy farm and eliminating three raw sewage pipes at a mill complex (DEM Complaint 94-241) (DeMelo, Viator, and Wright, 1997).

Greenwich Bay contains three licensed beaches. These beaches are periodically closed throughout the summer months. In 2002, HEALTH completed surveys that evaluated the Greenwich Bay Beaches according to past and present conditions, known or likely sources of pollution, and user characteristics.

Graded point classifications used to evaluate beach risk are based on numbers of days the beaches were closed, confirmed illnesses, point discharge proximity, bacteria monitoring, storm water, birds, number of users, and other relevant parameters. All Greenwich Bay beaches were classified as high risk and are sampled at least three times per week (HEALTH, 2002).

Table 2.2 Closure Days at Greenwich Bay Beaches and Shellfish Grounds[1].

Location	Number of Closure Days					
	1998	1999	2000	2001	2002	2003
City Park Beach	27	0	0	19	15	23
Oakland Beach	31	7	10	12	12	66
Goddard Park Beach	14	0	16	28	7	21
Shellfish Growing Area[2]			58	67	41	73
Rain (Inches) TF Green[2]			13.0	17.3	8.8	19.4

[1](HEALTH, 2000, 2001, 2002, and 2003) (RIDEM, 2000, 2001, 2002, 2003)
[2]Between May 15 and September 7

2.3 Supporting Documentation

Recent water quality studies are presented in Table 2.3. Most studies included in the table were generated as a result of the Greenwich Bay Initiative. These references were used to characterize present water quality conditions and to identify water quality trends.

Table 2.3 Supporting Documentation.

Primary Organization	Title	Date of Report	Approximate Date of Study
Rhode Island Department of Environment Management Shellfish Surface Water Monitoring Program	Review: Shellfish Surface Water Monitoring Program	Ongoing	Ongoing
Rhode Island Department of Environment Management TMDL Program	Hardig Brook Watershed Final Data Report Bacteria Sampling 2001-2003	2004	2001-2003
Rhode Island Department of Environment Management TMDL Program	Greenwich Bay Watershed Final Data Report Bacteria Sampling 2000-2002	2002	2000-2002
Rhode Island Department of Environment Management Shellfish Surface Water Monitoring Program	Greenwich Bay Growing Area 8 Shoreline Survey, 2001 Report	2001	2001
Department of Civil and Environmental Engineering, University of Rhode Island	Baseline Monitoring Project	2000	Ongoing
Department of Civil and Environmental Engineering, University of Rhode Island	Greenwich Bay Initiative – Northern Watersheds Loading Estimates to Greenwich Bay	1999	Spring, Fall 1995
Cooperative Extension, University of Rhode Island	Maskerchugg River Watershed – Warwick, West Warwick, and East Greenwich, RI	1998	Summer 1996, Summer 1997
Department of Civil and Environmental Engineering, University of Rhode Island	Characterization of Nonpoint Source Pollutant Sources to an Estuary under Wet Weather Conditions – Direct Stormwater Discharges	1998	Spring, Fall 1995
Rhode Island Department of Environment Management Shellfish Surface Water Monitoring Program	Greenwich Bay Growing Area 8 Shoreline Survey, 1998 Report	2001	1998
Department of Civil and Environmental Engineering, University of Rhode Island	Greenwich Bay Initiative – Water Quality Evaluation of Hardig Brook	1997	Fall 1994, Spring 1995
Food and Drug Administration (FDA)	Greenwich Bay, RI Shellfish Growing Area Survey and Classification Considerations	1993	Spring 1993

3.0 PRESENT CONDITION OF THE WATERBODY

The impacts of elevated bacteria concentrations in Greenwich Bay can be seen in closures of the shellfish harvesting grounds and at the beaches. Harvesting shellfish is prohibited in Greenwich Bay for seven days following a rain event that exceeds 0.5 inches. Dry weather closures in the Class SA areas of Greenwich Bay include Brush Neck Cove, Buttonwoods Cove, and an area of Greenwich Bay directly adjacent to Apponaug Cove.

The Rhode Island Department of Health (HEALTH) administers the beach program for Rhode Island. Beach closures are common at the Greenwich Bay beaches throughout the summer. The three beaches in Greenwich Bay were closed for a combined total of 26 days in 2000 and 59 days in 2001. As shown in Appendix F, most beach closures occur under wet weather conditions when the shellfish grounds are also closed.

The current water quality conditions throughout the entire Greenwich Bay watershed are detailed in the following sections. Data collected at stations within the Bay and at the beaches are discussed in the first section. Other sections detail current water quality conditions in freshwater tributaries to Greenwich Bay, in sampled direct storm water discharges, from the East Greenwich Wastewater Treatment Facility, and from other sources, including wildlife and boats.

3.1 Instream Water Quality – Greenwich Bay and Coves

Shellfish Stations

The Shellfish Growing Area Water Quality Monitoring Program is part of the State of Rhode Island's agreement with the FDA NSSP. NSSP requires Rhode Island to conduct routine bacteriological monitoring and conduct shoreline surveys of the State's waters where shellfish is intended for direct human consumption. With the exceptions of Brush Neck Cove, Buttonwoods Cove, and the area of Greenwich Bay adjacent to Apponaug Cove extending past Baker Creek, the Class SA waters of Greenwich Bay and its coves are Conditionally Approved for the direct harvesting of shellfish. Figure 3.1 shows the shellfish harvesting closure lines for May 2002 to May 2003. Data collected between October 2000 and December 2001 were used to set the closures lines for this time period. In the Greenwich Bay Conditional Area, harvesting shellfish is prohibited for seven days directly following rain and/or snowmelt of 0.5 inches or more in a twenty-four hour period.

The Rhode Island Shellfish Program samples Greenwich Bay monthly when the Greenwich Bay Conditional Area is open. The FDA has approved the locations of the nineteen Greenwich Bay monitoring stations as representative of all the waters of Greenwich Bay. Figure 3.1 shows the shellfish stations. Twelve stations are in Class SA waters, with four of these stations in waters that are presently closed to shellfish harvesting. Seven stations are located in Class SB/SB1 waters. Sampling by the Shellfish Program in waters permanently closed for shellfish harvesting may be limited. For the TMDL, additional stations sampled by the TMDL Program in these areas were used to further localize and characterize pollutant sources.

The twelve stations located in Class SA waters will be used in this TMDL to set the percent reductions needed to attain compliance with the water quality standards for harvesting shellfish. In addition, the swimming use at licensed beaches within these areas was evaluated utilizing HEALTH data as presented in the next section. Dry weather conditions are characterized by fifteen surveys taken by the RI Shellfish Program between October 2000 and December 2001. Samples taken by the RI TMDL and Shellfish

Programs six times immediately following three storm events are used to define the wet weather condition. Before Greenwich Bay is permitted to remain open after wet weather events, these twelve shellfish stations must meet the Class SA water quality standards. Appendix A includes the dry and wet weather shellfish station data.

Table 3.1 summarizes water quality data for Greenwich Bay and its coves based on data from Appendix A. Numbers shown in bold in Table 3.1 exceed the applicable criterion. In dry weather, all stations meet the geometric mean criterion, and five stations exceed the 90^{th} percentile standard. In 2002, the shellfish areas surrounding these stations, Buttonwoods Cove, Brush Neck Cove, and the area outside of Apponaug Cove were closed in dry weather. In Greenwich Bay, only Station GA8-17 meets both parts of the water quality standard following rain events. This station is located in the outer Bay, near Narragansett Bay. With the exception of one station in Greenwich Cove, bacteria concentrations at all other stations exceed the 90^{th} percentile criterion. Most stations also exceed the geometric mean standard in wet weather.

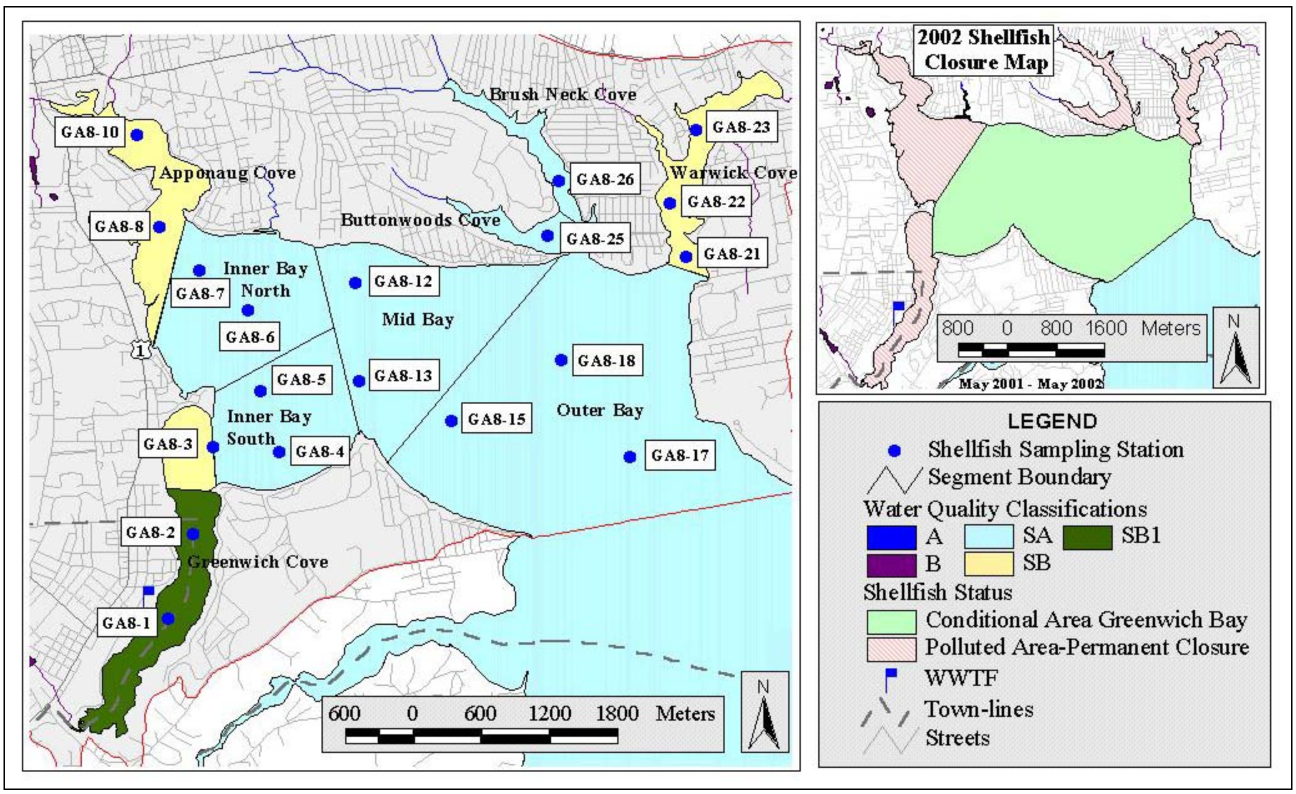

Figure 3.1 Greenwich Bay Shellfish Stations, Segments, and Closure Lines.

Table 3.1 Greenwich Bay Water Quality.[1, 2]

Station	Location		Number of Samples Dry	Number of Samples Wet	Geometric Mean (fc/100 ml) Target	Observed Dry	Observed Wet	90th Percentile (fc/100 ml) Target	Observed Dry	Observed Wet
1	Greenwich Cove	SB1	15	3	50	9	**58**	500	73	169
2			15	6		9	**202**		43	**930**
3		SB[3]	15	6	14	3	**49**	49	8	**680**
4	Inner Bay South	SA	15	6	14	3	**16**	49	7	**210**
5			15	6		4	**34**		9	**330**
6	Inner Bay North	SA	15	6	14	8	**33**	49	**93**	**230**
7			15	5		8	**71**		**65**	**430**
8	Apponaug Cove	SB[3]	15	6	14	9	**97**	49	**73**	**2615**
10		SB	15	6	50	22	**423**	500	93	**12650**
12	Mid Bay	SA	15	6	14	4	**17**	49	9	**387**
13			15	6		4	10		17	**127**
15	Outer Greenwich Bay	SA	15	6	14	3	**25**	49	4	**162**
17			15	6		3	4		19	26
18			15	6		4	11		20	**137**
21	Warwick Cove	SA	15	6	14	5	**57**	49	19	**535**
22		SB[3]	15	6	14	12	**148**	49	43	**1615**
23		SB	15	3	50	11	**373**	500	62	**3496**
25	Buttonwoods Cove	SA	15	5	14	8	**116**	49	**93**	**354**
26	Brush Neck Cove	SA	15	6	14	14	**228**	49	**73**	**8758**

[1]Dry weather samples were taken between October 2000 and December 2001. Wet weather samples were taken following storm events in 2001 and 2002.
[2]Shellfish use support has been evaluated consistent with NSSP protocol.
[3]These stations are on or close to the Class SA line and must meet Class SA standards.

Beach Stations

In addition to the shellfish use evaluation discussed in the previous section, swimming use at licensed beaches was evaluated utilizing HEALTH data. In a program administered by HEALTH during the bathing beach season, water samples are collected for bacteria analysis at three licensed beaches along Greenwich Bay. Sampling generally occurs between Memorial Day and Labor Day. Data for the 2000 and 2001 season are summarized in Table 3.2. To complete Table 3.2, DEM separated the HEALTH Beach data into dry and wet weather categories. Wet weather samples consisted of all samples taken when the Greenwich Bay shellfish areas were closed, within seven days of 0.5 inches of rain. It should be noted that while DEM separated the beach data into wet and dry categories using the shellfish definition of wet weather, HEALTH uses a different definition of wet weather. HEALTH considers the beaches to be influenced by wet weather conditions for three days following a rain event of 0.5 inches or more. DEM used the longer duration of wet weather to be consistent throughout the TMDL document.

In 2000, samples were analyzed using the MPN test, while in 2001 samples were analyzed using the A-1 test. Goddard Park is sampled four times per week while Oakland Beach and City Park are sampled three times per week. There are no violations of the swimming standard when data is analyzed over a seasonal basis. Closures occur because they are based on evaluating each individual sample result, the water quality history at the sampled location, and other environmental conditions.

Table 3.2 Beach Water Quality.

			Number of Samples		Geometric Mean (fc/100 ml)			90th Percentile (fc/100 ml)		
						Observed			Observed	
Station	**Location**		**Dry**	**Wet**	**Target**	**Dry**	**Wet**	**Target**	**Dry**	**Wet**
East	Goddard Park	SA[3]	65	43	50	25	22	500	288	212
Center[1]	Goddard Park	SA[3]	41	23	50	22	37	500	202	300
West	Goddard Park	SA[3]	64	43	50	45	45	500	492	488
East	Oakland Beach	SA[3]	33	23	50	34	44	500	460	240
Middle[2]	Oakland Beach	SA[3]	23	19	50	34	42	500	232	440
West	Oakland Beach	SA[3]	33	20	50	17	31	500	262	155
	City Park	SA[3]	35	22	50	28	29	500	444	240

[1]The Goddard Park Center Station was only sampled in 2001.
[2]The Oakland Beach Middle Station was only sampled in 2000.
[3] Swimming use was evaluated utilizing data collected by HEALTH;

3.2 Pollution Sources

Every twelve years, the DEM Shellfish Program conducts shoreline surveys to identify and quantify all actual and potential pollution sources which may directly or indirectly affect a growing area and, as a result, render shellfish harvested from that area as unsafe for human consumption. DEM documents any evidence of human waste contamination and takes samples from all creeks, streams, ground water seeps, and discharging pipes and/or culverts. An annual analysis of the data is used to determine whether water quality within the growing area meets water quality standards and complies with NSSP requirements. Every three years, NSSP requires that any actual sources be revisited. The most recent Greenwich Bay shoreline surveys were conducted in 1991, 1998, and 2001. Data from these surveys have been used in this report to identify potential and actual bacteria sources to Greenwich Bay.

The 1993 FDA Reclassification Study identified the major tributary and direct storm water bacteria sources to Greenwich Bay. Each source was sampled directly upstream of its discharge point to Greenwich Bay or its coves. No upstream sampling of the Greenwich Bay tributaries was completed as part of the study. Following the FDA study, URI-CVE conducted three studies examining bacteria sources to Greenwich Bay. Two studies focused on sampling tributaries. In the third study, URI-CVE sampled twenty storm water discharges. This Direct Storm Water Study identified the locations of over 100 direct storm water discharges to the watershed.

Other organizations that have sampled the Greenwich Bay sources include the DEM TMDL Program and University of Rhode Island's Watershed Watch volunteers. All collected data has been analyzed and used to evaluate water quality conditions in the Greenwich Bay watershed and to aid in source identification and prioritization for abatement, as discussed in the following section and in the Implementation Section of this report.

Tributary Streams

URI-CVE conducted extensive sampling of the Greenwich Bay tributaries in both the Hardig Brook Study and the Northern Watersheds Study. In addition, URI-CVE sampled two streams extensively in wet weather as part of its Direct Storm Water Discharges Study. For the most part, DEM used the URI-CVE data to characterize water quality conditions in the Greenwich Bay tributaries.

Hardig Brook, the largest freshwater source to Greenwich Bay, enters Apponaug Cove after merging with two other streams just upstream of its point of discharge to Apponaug Cove. Gorton Pond Tributary discharges into Hardig Brook at Route 117, while Mill Brook enters just upstream of Route 1. Hardig Brook and Gorton Pond Tributary were sampled as part of the Hardig Brook Study. This study identified direct sewage pipes to the Gorton Pond Tributary and a farm in the Hardig Brook headwaters as significant bacteria sources (DeMelo, Viator, and Wright, 1997). With the removal of the sewage pipes and the end of farming practices at the farm, DEM decided that further sampling was needed to characterize the current water quality condition in these two streams.

DEM completed its sampling of Hardig Brook in late 2003. Results are included in Table 3.3. Dry weather geometric mean concentrations and bacteria loads have dropped in half at station HB01, the first regularly sampled station downstream of the farm. Wet weather concentrations at HB01 also appear to be lower. Even with these improvements, bacteria concentrations in the Hardig Brook headwaters remain among the highest in the watershed in both dry and wet weather (Table 3.3). The DEM study also confirmed the elimination of the sewage pipes along Gorton Pond Tributary. Dry weather bacteria concentrations were significantly reduced, resulting in a 94% reduction in bacteria loads to Apponaug Cove between 1995 and 2003. Gorton Pond Tributary occasionally exhibits elevated bacteria concentrations, most likely due to wildlife. With the exception of some reduction in Gorton Pond Tributary, Hardig Brook wet weather bacteria concentrations in the vicinity of Apponaug Cove showed no improvement since the Hardig Brook Study. This reflects the lack of any significant mitigation activities in this area to address wet weather bacteria sources (RIDEM, 2004). The information presented in Table 3.3 does not include any URI-CVE data where mitigation activities would have changed the water quality.

URI-CVE sampled Greenwood Creek, Mill Brook, Tuscatucket Brook, Southern Creek, and Baker Creek during its Northern Watershed Study. Southern Creek was found to contribute the highest observed fecal coliform load during the Northern Watershed Study. Its fecal coliform load was greater than the summed loads from Hardig Brook and Gorton Pond Tributary, each of which has a higher discharge. After examining their results for Tuscatucket Brook, also in Brush Neck Cove, URI-CVE hypothesized that there may be a fecal coliform source between stations TB01/TB01A and TB02, shown in Figure 3.2 (Wright and Viator, 1999).

Prior to the URI-CVE study of Southern Creek and Tuscatucket Brook, the DEM Groundwater and ISDS Section conducted a single dry weather sampling survey on these streams. This sampling demonstrated the localized impacts of a failing septic system in the vicinity of Southern Creek. A failing septic system at a 126-unit condominium complex resulted in bacteria concentrations of 3000 fc/100 ml. Three hundred meters downstream, concentrations dropped to under 9 fc/100 ml (O'Rourke, 1995). Data from this survey was not used in TMDL calculation given the availability of more recent data in 1994, 1995, and 2000. The more recent sampling data did not show elevated dry weather concentrations in Southern Creek.

Baker Creek is located in the Nausauket area of Warwick east of Apponaug Cove. Though five of six dry weather samples collected by URI-CVE met standards, the sixth sample was sufficiently elevated to indicate an impairment. All stations sampled as part of the Northern Watersheds study follow the same trend as stations in Greenwich Bay. For the most part, dry weather criteria are met, while wet weather criteria are exceeded (Wright and Viator, 1999).

The University of Rhode Island's Watershed Watch Program organized volunteers to sample the Maskerchugg River in 1996 and 1997. Volunteers collected about six samples from eleven locations over the two-year study (Herron et. al., 1998b). Additionally, URI-CVE samples the Maskerchugg River at US-1 four times per year as part of a Baseline Monitoring Program throughout Rhode Island (Wright, 2000). Water quality data shown in Table 3.3 shows some violations in water quality standards in the Maskerchugg River.

Table 3.3 summarizes the water quality data from the Greenwich Bay tributaries. Numbers shown in bold in Table 3.3 exceed the applicable criterion. Table 3.3 includes a column that gives information concerning which Studies were used to quantify current water quality conditions. In general, all available data collected since the 1993 FDA study were used when characterizing current water quality conditions. Exceptions were in Hardig Brook and station GP03 in Gorton Pond Tributary. At these stations, mitigation activities since the URI-CVE study have resulted in changes in water quality conditions, making the URI-CVE data obsolete. Appendix B lists all the data used in this table. Water quality stations are shown in Figure 3.2.

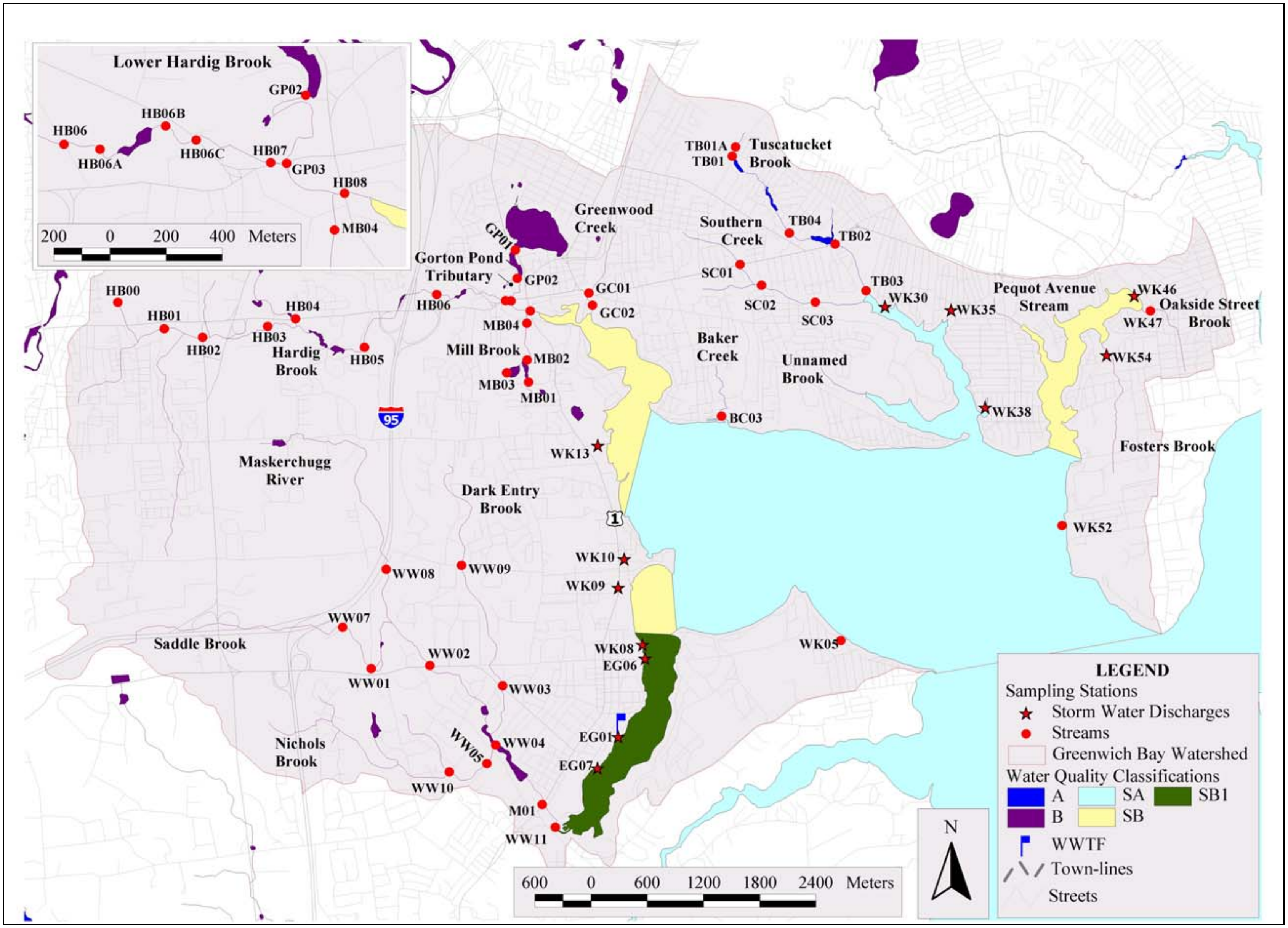

Figure 3.2 Tributary and Direct Storm Water Sample Stations.

Table 3.3 Tributary Water Quality

Station	Location	Water Quality Class	Study / Data used for Assessment[1]	Number of Samples		Geometric Mean (fc/100 ml)			90th Percentile (fc/100 ml)		
				Dry	Wet	Target	Observed Dry	Observed Wet	Target	Observed Dry	Observed Wet
Apponaug Cove											
HB00	Hardig Brook	B	HB-D	7	0	200	**458**	NA	500	**1290**[4]	NA
HB01	Hardig Brook	B	GB, HB-D	13	14	200	**400**	**6859**	500	**748**[4]	**22700**[4]
HB02	Hardig Brook	B	GB, HB-D	12	12	200	**418**	**6436**	500	**884**[4]	**16800**[4]
HB03	Hardig Brook	B	HB-D	11	12	200	**344**	**7706**	500	**540**[4]	**15700**[4]
HB04	Hardig Brook Tributary	B	HB-D	6	12	200	114	**3165**	500	**1100**[4]	**10460**[4]
HB05	Hardig Brook	B	HB-D	12	11	200	161	**2835**	500	360[4]	**14000**[4]
HB06	Hardig Brook	B	GB, HB-D	14	14	200	109	**5019**	500	220[4]	**14000**[4]
HB06A	Hardig Brook	B	HB-D	4	3	200	163	**7882**	500	246[4]	**12840**[4]
HB06B	Hardig Brook	B	HB-D	12	12	200	82	**5742**	500	156[4]	**11000**[4]
HB06C	Hardig Brook	B	HB-D	12	12	200	116	**6117**	500	190[4]	**11800**[4]
HB07	Hardig Brook	B[3]	GB, HB-D	18	21	50	**120**	**4225**	500	389	**12000**
HB08	Hardig Brook	B[3]	GB, HB-D	6	7	50	**291**	**3796**	500	**647**	**13460**
GP01	Gorton Pond Tributary	B	HB, HB-D	8	17	200	135	**465**	500	194[4]	**1000**[4]
GP02	Gorton Pond Tributary	B	HB, HB-D	12	28	200	16	**320**	500	40[4]	**4080**[4]
GP03	Gorton Pond Tributary	B[3]	GB, HB-D	16	17	50	**210**	**3780**	500	**705**	**10480**
MB01	Mill Brook	B	NW, GB	8	30	200	177	**3993**	500	**542**[4]	**10000**[4]
MB02	Mill Brook	B	NW	8	28	200	18	**655**	500	91[4]	**5720**[4]
MB03	Mill Brook	B	NW	8	28	200	16	**1787**	500	42[4]	**10600**[4]
MB04	Mill Brook	B[3]	NW, GB, HB-D	25	48	50	**158**	**1952**	500	**550**	**19600**
GC01	Greenwood Creek	B[3]	NW	8	30	50	7	**1138**	500	126	**20600**
GC02	Greenwood Creek	B[3]	NW, GB	7	8	50	6	**360**	500	188	**2400**
Northern Shoreline											
BC03	Baker Creek	A[2]	NW, S98, S01	7	10	14	**44**	**607**	49	**1432**	**3090**
Brush Neck Cove											
SC01	Southern Creek	A	NW	8	28	20	3	**1875**	200	166	**25000**
SC02	Southern Creek	A	NW, GB	8	30	20	2	**876**	200	148	**17100**
SC03	Southern Creek	A[2]	NW, GB	10	30	14	11	**1928**	49	**471**	**19200**
TB01	Tuscatucket Brook	A	NW	8	28	20	9	**157**	200	41	**6240**
TB01A	Tuscatucket Brook	A	NW	8	28	20	6	**723**	200	87	**4860**
TB04	Tuscatucket Brook	A	GB		2	20		**1406**	200		**3472**
TB02	Tuscatucket Brook	A[2]	NW, GB	10	30	14	**19**	**1881**	49	**84**	**14200**
TB03	Tuscatucket Brook	A[2]	NW	7	8	14	**39**	**448**	49	**257**	**1470**
Greenwich Cove											
WW08	Maskerchugg River	B	WW	4	3	200	8	44	500	24[4]	423[4]
WW02	Maskerchugg River	B	WW	4	3	200	29	**443**	500	84[4]	**2814**[4]
WW04	Maskerchugg River	B	WW	4	2	200	104	**362**	500	163[4]	**1534**[4]
M01	Maskerchugg River	B[3]	WW, BL, GB	10	5	50	**39**	**336**	500	176	**1440**
WW11	Maskerchugg River	B[3]	WW	2	1	50	32	**75**	500	82	75
WW07	Saddle Brook	B	WW	3	2	200	31	79	500	287[4]	**713**[4]
WW01	Saddle Brook	B	WW	5	3	200	95	85	500	424[4]	**858**[4]
WW09	Dark Entry Brook	B	WW	3	3	200	99	50	500	184[4]	78[4]
WW03	Dark Entry Brook	B	WW	3	3	200	42	**270**	500	65[4]	**1092**[4]
WW10	Nichols Brook	B	WW	3	1	200	43	36	500	214[4]	36[4]
WW05	Nichols Brook	B	WW	5	1	200	106	32	500	**710**[4]	32[4]

[1]HB: URI-CVE Hardig Brook, NW: URI-CVE Northern Watershed, WW: URI-CE Watershed Watch, BL: URI-CVE Baseline, S98: DEM SP98, S01: DEM SP01, GB: DEM Greenwich Bay, HB-D: DEM Hardig Brook.

[2]These stations are on or close to the Class SA line and must meet the Class SA standard.

[3]These stations are on or close to the Class SB line and must meet the Class SB standard.

[4]Value is an 80th percentile concentration.

Direct Storm Water Discharge and other Sources

More than 150 storm water discharges have been identified along Greenwich Bay, its coves, and along tributaries in Brush Neck Cove, Buttonwoods Cove, and Warwick Cove. Figure 3.3 shows all the known outfalls in Greenwich Bay watershed. While most outfalls that discharge directly to Greenwich Bay have been identified, storm water discharges along streams such as Hardig Brook and the Maskerchugg River have not been identified. Appendix C lists all known direct storm water discharges organized by sub-watershed.

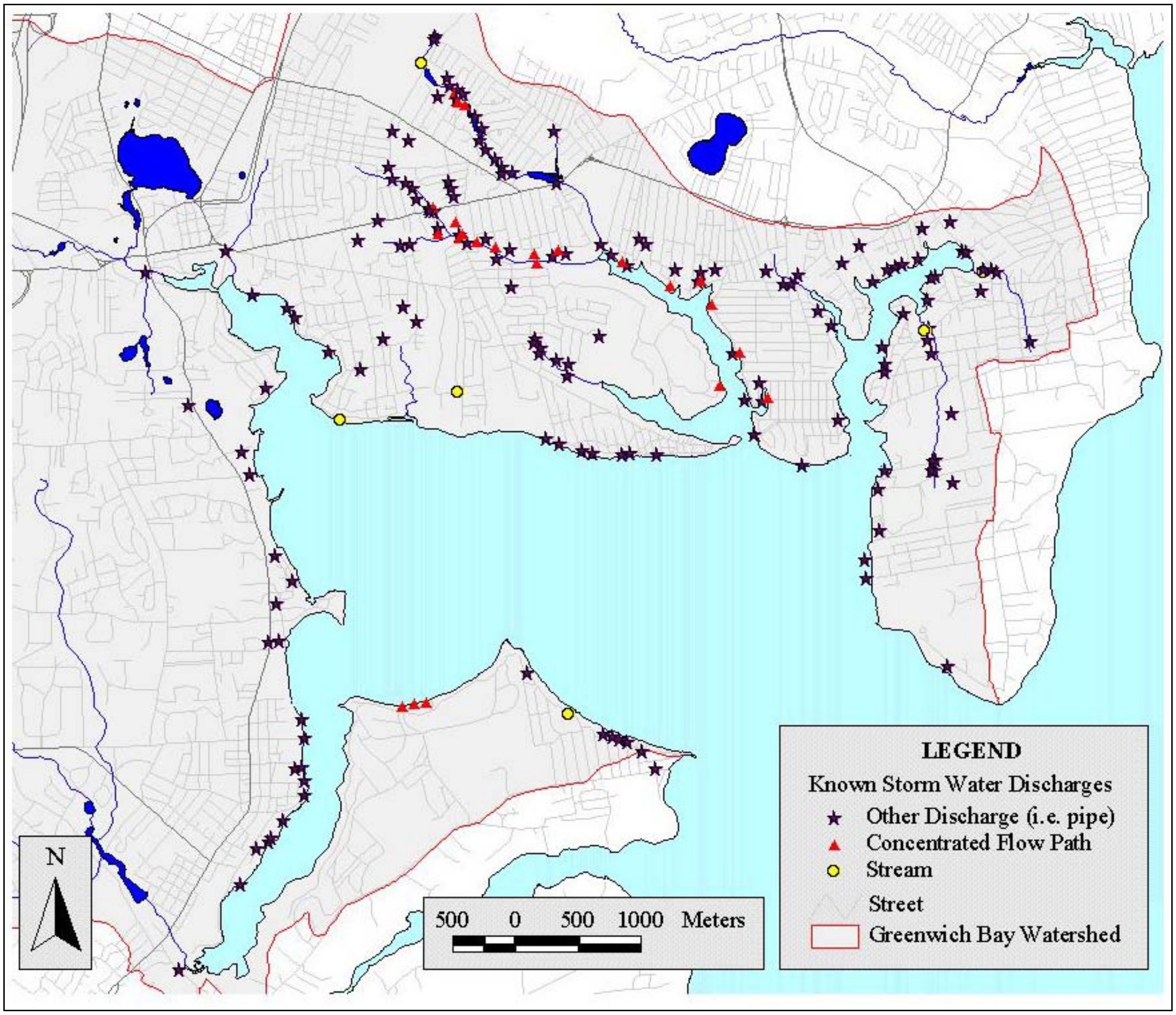

Figure 3.3 Approximate Locations of Known Direct Storm Water Discharges.

URI-CVE sampled a limited number of direct storm water sources and two streams during its Direct Storm Water Study. A single grab sample was taken during dry weather and between 16 and 27 samples were taken during wet weather at twenty storm water and two stream locations throughout the watershed. Available data for the direct storm water sources, which includes the Wright, Fanning, and Viator (1999) study, Shellfish Program Shoreline Survey data, and TMDL data, are summarized in Table 3.4. Stream data are included in this section because of the limited dry weather data available. These streams will be treated as other storm water sources for remediation activities. Sample locations are shown in Figure 3.2. Data are listed in Appendix D.

Table 3.4 Direct Storm Water Discharge and Other Source Water Quality.

Station	Location	Number of Samples		Geometric Mean (fc/100 ml) Observed		90th Percentile[1] (fc/100 ml) Observed		80th Percentile[1] (fc/100 ml) Observed	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Potowomut									
WK5A	Beachwood Pond	2	23	12	560	135	24000		
WK5B	Beachwood Pond	0	24		430		7890		
WK5C	Beachwood Pond	0	25		1034		8840		
WK5D	Beachwood Pond	0	25		1532		20800		
Apponaug Cove									
WK09	Post Rd and Ocean Point Ave South	1	16	1	5668			1	14000
WK10	Chepiwanoxet Way and Oak Grove	1	16	44	4949	44	11000		
WK13	Masthead Dr and Fred Humlak Way	1	16	22	11894			22	21000
Brush Neck Cove									
WK30	Shand Avenue	2	17	4	3310	4.9	17800		
WK35	Gordon, Hawksley, Seaview	1	17	1	8000	1	13000		
WK38	Mohawk Avenue	1	17	360	35656	360	270000		
Warwick Cove									
WK46	Samuel Gorton Avenue	1	17	17	3580			17	6880
WK47	Oakside Street Brook	1	2	590	5683			590	15540
WK54	Fosters Brook	1	18	33	6105			33	13600
Warwick Neck									
WK52	Kirby Avenue	1	18	1	484	1	3100		
Greenwich Cove									
EG01	East Greenwich Transfer Station	1	27	400	9665			400	23000
EG06	Division Street	1	27	19	9910			19	31600
EG07	Crompton Ave at Rocky Hollow	1	27	5	4234			5	8660
WK08	Ladd Street at Norton's Marina	1	27	4600	6444			4600	14600

[1]Stations that discharge to Class SA waters must meet a 90th percentile criterion while stations that discharge to Class SB/SB1 waters must meet an 80th percentile criterion.

RIPDES (Rhode Island Pollutant Discharge Elimination System) Sources

The East Greenwich WWTF, RIPDES permit number RI0100030, discharges to Greenwich Cove. The observed discharge and fecal coliform concentrations at the WWTF for 2000 and 2001 are listed in Table 3.5.

Table 3.5 East Greenwich WWTF Water Quality.

Point Source	Observed Discharge[1] (MGD)	Observed Concentration[1] (fc/100 ml)
East Greenwich WWTF	1.04	4

[1]Discharge is the average of all daily 2000-2001 flows. Concentration is the geometric mean of 299 samples from 2000-2001.

Septic Systems

Beginning in late 1993, DEM inspected over 1500 septic systems in Warwick, East Greenwich, South Kingstown, and Charlestown. The vast majority of the inspected systems were in the Greenwich Bay watershed. Visual outside inspections resulted in reported violations primarily for water pooling at ground level and for illegal gray water or laundry discharges. At the time the report was written, 55 repairs of 171 violating systems (in areas including South Kingstown and Charlestown) had been completed. The remaining violating systems may have been repaired after the report was completed or in systems with illegal gray water discharges, the gray water lines may have been connected into the existing septic system eliminating the violation. Results of the study are shown in Table 3.6. The East Greenwich sub-area exhibited the lowest violation rate. Sewers were available to some homeowners in East Greenwich, possibly accounting for the lower violation rate. The highest violation rates were in Potowomut and Brush Neck Cove (O'Rourke, 1995). Although, sewers are now available in Brush Neck Cove, sewers will not be extended into Potowomut.

Table 3.6 Septic System Violation Rates (O'Rourke, 1995).

Sub-Area	Total Inspections	Violations	Percent Violations
East Greenwich[1]	157	3	1.9 %
East of Post Road (East Greenwich Line to Arnold's Neck)	210	15	7.1 %
Arnold's Neck	142	10	7.9 %
Brush Neck Cove	598	97	16.2 %
Potowomut	142	26	18.3 %
TOTALS	1249	151	12.1 %

[1]Sewers were available in some of this area.

Other Bacteria Sources

Other bacteria sources to Greenwich Bay include waterfowl, wildlife, and domestic pets. Waterfowl are known to gather at beaches and in the Greenwich Bay coves.

On August 18, 1998 EPA designated Rhode Island's marine waters as a *Federal No Discharge Area*. Boats with installed toilets must have an operable Coast Guard approved marine sanitation device (MSD) designed to hold sewage for pump-out or for discharge in the ocean beyond the three mile limit. There are ten pump-out facilities and one pump-out boat in Greenwich Bay. DEM oversees the operation and maintenance of the pump-out infrastructure by participating in the Clean Vessel Act (CVA) program which provides money for the construction, repair, and replacement of pump-out facilities and by coordinating outreach and education programs.

The Narragansett Bay Commission's (NBC) Combined Sewer Overflows (CSO) to the Providence and Seekonk Rivers are *not* a wet weather source of bacteria to Greenwich Bay. Greenwich Bay sampling data shows the lowest bacteria concentrations occur in the Greenwich Bay stations closest to Narragansett Bay. An analysis of wet weather data collected from two shellfish stations in just outside Greenwich Bay shows no wet weather impairment. This data can be found in Appendix E.

3.3 Natural Background Conditions

Natural background concentrations are those that would exist in the area in the absence of human-induced sources. The natural background concentrations could not be resolved independently for this TMDL.

3.4 Water Quality Impairments

Consistent with the current prohibited and conditionally approved shellfish harvesting restrictions established by Rhode Island's Shellfish Program, data analyses for this TMDL found every segment of Greenwich Bay and its five coves violate one or both parts of the water quality standard during wet weather. In dry weather, variability standards are exceeded at stations in Brush Neck Cove, Buttonwoods Cove, and Apponaug Cove. The variability violations are also seen in the Greenwich Bay waters adjacent to Apponaug Cove. Table 3.1 shows that the highest bacteria concentrations can be seen in the five Greenwich Bay coves and that the lowest concentrations are in the parts of Greenwich Bay furthest from the coves. This trend of high bacteria concentrations following rain events can also be seen in the Greenwich Bay tributary streams as shown in Table 3.3. While most tributaries meet fecal coliform standards under dry weather conditions, wet weather bacteria concentrations far exceed the water quality standards.

4.0 TMDL ANALYSIS

4.1 Establishing a Numeric Water Quality Target

MOS (Margin of Safety) / Allocation for Future Growth

The MOS may be incorporated into the TMDL in two ways. One can implicitly incorporate the MOS using conservative assumptions to develop the allocations or explicitly allocate a portion of the TMDL as the MOS. This TMDL uses the former approach of conservative assumptions to ensure an adequate MOS. The primary source of fecal coliform in the Greenwich Bay watershed is storm water, which enters the Bay through culverts or channeled flows. Under the EPA's Phase II Storm Water Program these are considered point sources. Because bacteria loads are inherently difficult to quantify with any certainty, this TMDL uses the following assumptions:

- Three out of six wet weather samples from Greenwich Bay and coves were taken directly after a rain event of greater than 3 inches. All tributaries except the Maskerchugg River system were sampled intensively during and directly following rain events of at least 1.5 inches of rain.
- The Greenwich Bay watershed is developed and any future growth will be limited.
- In this TMDL, wet weather conditions are considered to occur in Greenwich Bay for seven days following a rain event consistent with the findings of the Greenwich Bay Reclassification Study (FDA, 1993).
- In some areas, a waterbody segment with higher allowable fecal coliform bacteria limits discharges to a waterbody with more stringent criteria. In these places, the numeric water quality target is set to the more strict criteria of the two standards at the point of discharge.

Critical Conditions / Seasonal Variations

Critical conditions in the Greenwich Bay watershed occur after wet weather events. High values occur in all seasons, so seasonal variation is not an issue. This TMDL uses data from three rain events, which adequately characterizes for wet weather conditions.

Numeric Water Quality Targets

The numeric water quality targets will be set to the applicable water quality criteria or standard for each segment of Greenwich Bay, its coves, and its tributaries. Segment boundaries for Greenwich Bay and its coves are shown in Figure 3.1. In some areas, a waterbody segment with higher allowable limits of fecal coliform bacteria discharges to a waterbody with more stringent criteria. In these places, the numeric water quality target must be the more strict criteria at the station nearest the boundary with the higher water quality standard. Targets are set such that Greenwich Bay can meet its designated uses.

4.2 Establishing the Allowable Loading (TMDL)

EPA guidelines specify that a TMDL identify the pollutant loading that a waterbody can assimilate per unit time without violating water quality standards, with loads expressed as mass per time, toxicity, or any other appropriate measure (40 CFR§130.2). EPA Region 1 has determined that for bacteria TMDL plans it is appropriate to use concentration units. The loading capacity for this TMDL will be expressed as concentration units set equal to the state water quality standard.

Extensive field surveys, water quality monitoring, and a review of aerial and topographic maps were used to establish the link between pollutant sources and instream concentrations.

Before determining allowable loads and percent reductions, DEM separated surface waters in the Greenwich Bay watershed into segments. Tributary streams were divided into segments centered on each individual station. The estuarine waters of Greenwich Bay were divided into its five coves and four segments each with distinct water quality goals and sources. Table 4.1 lists stations grouped in each segment. Figure 3.1 shows the location of the segments and stations for Greenwich Bay and its coves. The reduction goal for each segment was determined by comparing current fecal coliform concentrations to the applicable water quality target, then calculating the percent reduction required to reach that target. Since the water quality regulations specify both geometric mean and 90th percentile criteria, the higher percent reduction resulting from evaluation of the shellfish and beach data against their respective water quality standards was used to set each segment's necessary reduction. The ***three-step*** process is outlined below.

Table 4.1 Stations within Each Greenwich Bay Segment.

Greenwich Bay Segment / Cove	Stations Used to Characterize Water Quality Conditions
Outer Bay	GA8-15, 17, 18
Mid Bay	GA8-12, 13
Inner Bay North	GA8-6, 7
Inner Bay South	GA8-4, 5
Buttonwoods Cove	GA8-25
Brush Neck Cove	GA8-26
Apponaug Cove	GA8-8, 10
Greenwich Cove	GA8-1, 2, 3
Warwick Cove	GA8-21, 22, 23

Comparison of the weighted geometric mean to the geometric mean standard

The goal of this TMDL is to fully restore the shellfishing use to Greenwich Bay Class SA waters, meaning that these waters would need to meet the approved shellfishing criteria at all times (i.e. open during wet and dry weather conditions). For this reason, both wet and dry weather sampling data were assessed to determine the required percent reductions needed for Greenwich Bay. In contrast, consistent with NSSP requirements that a conditional area meet the requirements of an approved area when that conditional area is in the open status, only sampling data collected in dry weather (when Greenwich Bay is open to shellfish harvesting) are currently considered in the DEM annual shellfish classification review of Greenwich Bay waters.

Current bacteria conditions in Greenwich Bay waters were compared to the geometric mean by first calculating a "weighted geometric mean" value. The "weighted geometric mean" combines the wet and dry weather geometric means to a single value, weighted by their frequency of occurrence. When a segment contained multiple stations, the highest dry weather and the highest wet weather value at any station for the entire segment was selected as representative of water quality conditions for the segment. As described above, each tributary station represented one segment.

The 1993 FDA study of Greenwich Bay found that the highest fecal coliform concentrations could occur up to three days following a rain event in some areas of the Bay. Today, the RIDEM Shellfish Program manages Greenwich Bay as a Conditional Area where the bay closes for seven days after a rain event or snowmelt of at least 0.5 inches in twenty-four hours or less. To calculate the percent of wet days in a year, RIDEM examined the conditional closure history of Greenwich Bay since 1996. On average, the area has been closed due to wet weather events for just under half the days in a year. The "weighted geometric mean" will therefore assume that Greenwich Bay experiences dry weather conditions for 50% of the year and wet weather conditions for 50% of the year. Since weather conditions are evenly split into dry and wet weather, the "weighted geometric mean" is the average of the individual dry and wet weather geometric means.

Comparison of the weighted 90th percentile value to the percent exceeding standard

Current bacteria conditions in Greenwich Bay were compared to percent exceeding standard as a "weighted 90th percentile" value. The "weighted 90th percentile" value combines the wet and dry weather 90th percentile values, weighted by their frequency of occurrence, in the same manner as the "weighted geometric mean" was calculated. The 90th percentile value at each station was calculated using the PERCENTILE function in Microsoft Excel. This value was then compared to the applicable target to determine if a violation had occurred. Since weather conditions are evenly split into dry and wet weather, the "weighted 90th percentile" value is the average of the individual dry and wet weather 90th percentile values.

4.3 Required Reductions

EPA guidance requires that load allocations be assigned to either point (wasteload) or nonpoint (load) sources. As is the case for most bacteria impairments, insufficient data existed to accurately differentiate between point and nonpoint sources of bacteria. Therefore, as recommended by EPA Region 1, all bacteria source reductions for this TMDL are combined into the wasteload allocation.

However, in implementing this TMDL both point and nonpoint controls are necessary to meet the TMDL plan's water quality targets. To guide TMDL implementation, DEM evaluated Greenwich Bay watershed land use and pollution source data. Using the assumption that storm water generated on developed land is a point source and storm water generated on undeveloped land is a nonpoint source, two-thirds of the required reductions are estimated to be from point sources and one-third is estimated to be from nonpoint sources. These estimates do not alter the determination of point sources regulated under the RIPDES Storm Water Phase II Program. Channelized storm water associated with activities that are subject to phases I and II of EPA's regulations for storm water discharges (whether on developed or undeveloped land) are regulated under the RIPDES program as a point source, while unchannelized storm water is considered a nonpoint source.

Greenwich Bay and Coves

The required fecal coliform reductions for Greenwich Bay and its coves are presented in Table 4.2. They are calculated from observed concentrations at instream shellfish stations. The "weighted geometric mean" and the "weighted 90th percentile value" were calculated as described above for each Greenwich Bay segment and cove. These values were then compared to the applicable portion of the water quality standard. The station having the largest violation relative to the state's fecal coliform standard was used to calculate the percent reduction for the segment containing that station and is shown in bold in Table 4.2. The required reduction for each segment is the higher of the two reductions ("weighted geometric mean" versus the "weighted 90th percentile value").

For the Class SB waters of Greenwich Cove and Apponaug Cove, the water quality standard for the station closest to the Class SA boundary was set to the Class SA standard. This generated two additional reduction criteria goals for these coves. The final percent reduction is most protective of the four reduction goals. The required percent reduction for Warwick Cove was determined in a way similar to the method for Greenwich Cove and Apponaug Cove. One station in Warwick Cove is in Class SA waters. It and the adjacent station in Class SB waters must meet the Class SA fecal coliform standard.

Violations of bacteria standards in Greenwich Bay generally occur in wet weather conditions. Required percent reductions are highest for Apponaug Cove, Brush Neck Cove, and Warwick Cove.

Table 4.2 Greenwich Bay Segment Weighted Geometric Mean and 90th Percentile Values.

			Number of Samples		Geometric Mean (fc/100 ml)				90th Percentile (fc/100 ml)				Required Percent Reduction
					Observed			Segment	Observed			Segment	
Station	Location		Dry	Wet	Dry[2]	Wet[2]	Target	Weighted[1]	Dry[2]	Wet[2]	Target	Weighted[1]	
1	Greenwich Cove	SB1	15	3	9	58	50	105.3	**73**	169	500	501.5	85.8
2			15	6	**9**	**202**			43	**930**			
3		SB[3]	15	6	**3**	**49**	14	25.8	**8**	**680**	49	344	
4	Inner Bay South	SA	15	6	3	16	14	19.0	7	210	49	169.5	71.1
5			15	6	**4**	**34**			**9**	**330**			
6	Inner Bay North	SA	15	6	8	33	14	39.7	**93**	230	49	261.5	81.3
7			15	5	**8**	**71**			65	**430**			
8	Apponaug Cove	SB[3]	15	6	**9**	**97**	14	53.1	**73**	**2615**	49	1344	96.4
10		SB	15	6	**22**	**423**	50	222.4	**93**	**12650**	500	6371.5	
12	Mid Bay	SA	15	6	**4**	**17**	14	10.3	9	**387**	49	201.75	75.7
13			15	6	4	10			**17**	127			
15	Outer Greenwich Bay	SA	15	6	3	**25**	14	14.6	4	**162**	49	90.75	46.2
17			15	6	3	4			19	26			
18			15	6	**4**	11			**20**	137			
21	Warwick Cove	SA	15	6	**5**	**57**	14	30.9	**19**	**535**	49	277	94.1
22		SB[3]	15	6	**12**	**148**	14	80.1	**43**	**1615**	49	829	
23		SB	15	3	**11**	**373**	50	191.9	**62**	**3496**	500	1779	
25	Buttonwoods Cove	SA	15	5	**8**	**116**	14	62.2	**93**	**354**	49	223.5	78.1
26	Brush Neck Cove	SA	15	6	**14**	**228**	14	121.0	**73**	**8758**	49	4415.5	98.9

[1]Using 50% wet weather and 50% dry weather.
[2]Bold font indicates stations used to calculate geometric mean and 90th percentile value for each segment.
[3]These stations are on or close to the Class SA line. They need to meet Class SA standards.

Evaluating Swimming Use

The "weighted geometric mean" and the "weighted 90th percentile value" were calculated as described above for each beach in Greenwich Bay and compared to the applicable portion of the swimming standard. The HEALTH Beach data was divided in dry and wet weather categories by DEM. To make the shellfish and beach data consistent, wet weather was defined as seven days following a rain event of more than 0.5 inches. In Table 4.3, when the 2000 and 2001 swimming data is analyzed on a seasonal basis, there are no violations of the swimming standards, though beach closures occur every summer. When evaluating whether to recommend a swimming advisory at a designated bathing beach area, HEALTH evaluates concentrations over shorter periods of time. When evaluated in this manner, the data can exceed swimming standards. DEM will make recommendations for controlling sources discharging to each beach in the implementation section of the TMDL report.

As mentioned previously, HEALTH considers the Greenwich Bay beaches to be influenced by wet weather conditions for three days following a rain event of 0.5 inches or more. At the request of HEALTH, DEM conducted an analysis of the beach data using the HEALTH definition of wet and dry weather. This analysis, located in the DEM Response to Comments shows that while wet weather geometric means increase when using a three day wet weather closure, dry weather geometric means decrease. This results in only negligible changes in the weighted geometric mean values at each location. Based on these results DEM considers the seven day wet weather closure to be consistent with the HEALTH definition of wet and dry weather.

Table 4.3 Beach Weighted Geometric Mean and 90th Percentile Values.

		Number of Samples		Geometric Mean (fc/100 ml)				90th Percentile (fc/100 ml)				Required Percent Reduction
				Observed			Station	Observed			Station	
Station	**Location**	**Dry**	**Wet**	**Dry**	**Wet**	**Target**	**Weighted[1]**	**Dry**	**Wet**	**Target**	**Weighted[1]**	
East	Goddard Park	43	65	25	22	50	45.1	288	212	500	490	NA
Center[2]		23	41	22	37			202	300			
West		43	64	45	45			492	488			
East	Oakland Beach	23	33	34	44	50	39.1	460	240	500	450	NA
Middle[3]		19	23	34	42			232	440			
West		20	33	17	31			262	155			
	City Park Beach	22	35	28	29	50	28.5	444	240	500	342	NA

[1]Using 50% wet weather and 50% dry weather.
[2]The Goddard Park Center Station was only sampled in 2001.
[3]The Oakland Beach Middle Station was only sampled in 2000.

Tributary Streams

Tributary reductions were calculated using the "weighted geometric mean" and the "weighted 90th percentile value" approach used at the shellfish stations and at the beaches. Dry and wet weather geometric mean and 90th percentile values for each tributary are shown in Table 4.4. The table groups the tributaries by their entry point to Greenwich Bay and the coves. As in Table 4.2, violations in water quality criteria are predominately seen under wet weather conditions. Water quality targets at stations adjacent to areas with lower required bacteria standards are set to the more protective target. For example, Southern Creek enters Brush Neck Cove just downstream of station SC03. The water quality goal at SC03 was set to the more stringent Class SA standard.

Required reductions vary throughout the watershed. Tributaries, such as Hardig Brook and Southern Creek that require the highest reductions are located in Brush Neck Cove and Apponaug Cove, while reductions are lowest in the Maskerchugg River. This trend is reflected in Table 4.2, which shows that the highest bacteria reductions are needed in Apponaug Cove and Brush Neck Cove. Land use densities along the Maskerchugg River are much lower than that along Hardig Brook, Southern Creek, and Tuscatucket Brook, which may explain the difference in required percent reductions. The Maskerchugg River has also not been sampled as intensively as other tributaries.

It should be noted that the variability standard for Class B tributaries is an 80th, not a 90th percentile value. Table 4.4 shows in a footnote which stations require 80th percentile values.

Table 4.4 Tributary Weighted Geometric Mean and 90^{th} Percentile Values.

			Number of Samples		Geometric Mean (fc/100 ml)				90^{th} Percentile (fc/100 ml)				Required
					Observed			Segment	Observed			Segment	Percent
Station	Location		Dry	Wet	Dry	Wet	Target	Weighted[1]	Dry	Wet	Target	Weighted[1]	Reduction
Apponaug Cove													
HB00	Hardig Brook	B	7	0	458	NA	200	NA	1290[4]	NA	500	NA	NA[5]
HB01	Hardig Brook	B	13	14	400	6859	200	3630	748[4]	22700[4]	500	11724	96
HB02	Hardig Brook	B	12	12	418	6436	200	3427	884[4]	16800[4]	500	8842	94
HB03	Hardig Brook	B	11	12	344	7706	200	4025	540[4]	15700[4]	500	8120	95
HB04	Hardig Brook Trib.	B	6	12	114	3165	200	1640	1100[4]	10460[4]	500	5780	91
HB05	Hardig Brook	B	12	11	161	2835	200	1498	360[4]	14000[4]	500	7180	93
HB06	Hardig Brook	B	14	14	109	5019	200	2564	220[4]	14000[4]	500	7110	93
HB06A	Hardig Brook	B	4	3	163	7882	200	4022	246[4]	12840[4]	500	6543	95
HB06B	Hardig Brook	B	12	12	82	5742	200	2912	156[4]	11000[4]	500	5578	93
HB06C	Hardig Brook	B	12	12	116	6117	200	3116	190[4]	11800[4]	500	5995	94
HB07	Hardig Brook	B[3]	18	21	120	4225	50	2172	389	12000	500	6195	98
HB08	Hardig Brook	B[3]	6	7	291	3796	50	2044	647	13460	500	7053	98
GP01	Gorton Pond Trib.	B	8	17	135	465	200	261	194[4]	1000[4]	500	528	33
GP02	Gorton Pond Trib.	B	12	28	16	320	200	177	40[4]	4080[4]	500	2069	76
GP03	Gorton Pond Trib.	B[3]	16	17	210	3780	50	1995	705	10480	500	5593	97
MB01	Mill Brook	B	8	30	177	3993	200	2085	542[4]	10000[4]	500	5271	91
MB02	Mill Brook	B	8	28	18	655	200	336	91[4]	5720[4]	500	2905	83
MB03	Mill Brook	B	8	28	16	1787	200	901	42[4]	10600[4]	500	5321	91
MB04	Mill Brook	B[3]	25	48	158	1952	50	1404	550	19600	500	7176	95
GC01	Greenwood Creek	B[3]	8	30	7	1138	50	573	126	20600	500	10363	95
GC02	Greenwood Creek	B[3]	7	8	6	360	50	183	188	2400	500	1294	73
Northern Shoreline													
BC03	Baker Creek	A[2]	7	10	44	607	14	326	1432	3090	49	2261	98
Brush Neck Cove													
SC01	Southern Creek	A	8	28	3	1875	20	939	166	25000	200	12583	98
SC02	Southern Creek	A	8	30	2	876	20	439	148	17100	200	8624	98
SC03	Southern Creek	A[2]	10	30	11	1928	14	969	471	19200	49	9836	100
TB01	Tuscatucket Brook	A	8	28	9	157	20	83	41	6240	200	3141	94
TB01A	Tuscatucket Brook	A	8	28	6	723	20	365	87	4860	200	2473	95
TB04	Tuscatucket Brook	A	0	2	NA	1406	20	NA	NA	3472	200	NA	NA[5]
TB02	Tuscatucket Brook	A[2]	10	30	19	1881	14	950	84	14200	49	7142	99
TB03	Tuscatucket Brook	A[2]	7	8	39	448	14	244	257	1470	49	864	94
Greenwich Cove													
WW08	Maskerchugg River	B	4	3	8	44	200	26	24[4]	423[4]	500	223	0
WW02	Maskerchugg River	B	4	3	29	443	200	236	84[4]	2814[4]	500	1449	65
WW04	Maskerchugg River	B	4	2	104	362	200	233	163[4]	1534[4]	500	848	41
M01	Maskerchugg River	B[3]	10	5	39	336	50	188	581	1920	500	1101	73
WW11	Maskerchugg River	B[3]	2	1	32	75	50	53	91	75	500	83	6
WW07	Saddle Brook	B	3	2	31	79	200	55	287[4]	713[4]	500	500.1	0.02
WW01	Saddle Brook	B	5	3	95	85	200	90	424[4]	858[4]	500	641	22
WW09	Dark Entry Brook	B	3	3	99	50	200	74	184[4]	78[4]	500	131	0
WW03	Dark Entry Brook	B	3	3	42	270	200	156	65[4]	1092[4]	500	578	14
WW10	Nichols Brook	B	3	1	43	36	200	40	214[4]	36[4]	500	125	0
WW05	Nichols Brook	B	5	1	106	32	200	69	710[4]	32[4]	500	371	0

[1]Using 50% wet weather and 50% dry weather.
[2]These stations are on or close to the Class SA line. They need to meet Class SA standards.
[3]These stations are on or close to the Class SB line. They need to meet Class SB standards.
[4]These values are 80^{th} percentile concentrations.
[5]Surrounding stations adequately characterize the water quality conditions and required reductions at these locations.

RIPDES (Rhode Island Pollutant Discharge Elimination System) Sources

The allocations for the East Greenwich WWTF are the same in dry and wet weather and are set to its current permit limit, as listed in Table 4.5. Also listed in the table is the current fecal coliform geometric mean and the average discharge for 2000 and 2001.

Table 4.5 RIPDES Permit Limits.

Point Source	Permitted Discharge[1] (MGD)	Permitted Concentration[1] (fc/100 ml)	Observed Discharge[2] (MGD)	Observed Concentration[2] (fc/100 ml)
East Greenwich WWTF	1.7	200	1.04	4

[1]The permitted discharge and concentration values are the average monthly limits.
[2]Discharge is the average of all daily 2000-2001 values. Concentration is the geometric mean of 299 2000-2001 values.

Dye dilution studies have been used to establish mixing zones and water quality- based discharge limits for the East Greenwich WWTF. EPA guidance (EPA, 1991) and an East Greenwich WWTF dye study (Rines, 1997) established the size of the acute mixing zone as a circle with a radius of 11 meters centered on the outfall. The minimum observed dilution within 11 meters of the outfall was 20:1 (i.e. minimum of observed raw values in the top two meters of the water column at the boil). The chronic mixing zone is a circle with a radius of 88 meters and a minimum dilution factor of 40:1. The permit includes an average monthly fecal coliform limit of 200 MPN/100 ml, with a daily maximum and weekly average of 400 MPN/100 ml. The elevation in fecal coliform concentrations in the receiving waters would be 20 fc/100 ml when the plant discharges at its maximum permitted concentration. Assuming a dry weather ambient concentration of 9 fc/100ml for the Greenwich Cove, the maximum local concentration in the vicinity of the outfall would be 29 fc/100 ml at the WWTF where the standard is 50 fc/100 ml. This is a conservative estimate because the observed dry weather ambient concentration already includes any impact from the plant.

Additional dilution would occur between the boundary of the mixing zone and the Class SA portions of Greenwich Cove, a distance of 1500 meters. Effluent from the East Greenwich WWTF is diluted to a sufficient degree that its contribution to fecal coliform concentrations in Greenwich Bay may be neglected. From examining the dye study data, DEM has concluded that this source has very little impact on fecal coliform concentrations in Greenwich Cove or Greenwich Bay.

4.4 Strengths and Weaknesses in the Analytical Approach

Strengths

- The TMDL is based on extensive data and knowledge of the area;
- The TMDL incorporates the findings of several studies and utilizes data collected over several years;
- The phased approach allows an emphasis on mitigation strategies rather than on modeling and more complex monitoring to keep the focus on mitigating sources; and
- The TMDL is based on actual data collected in the watershed.

Weaknesses

- Sources could not be measured on a mass basis due to lack of required resources and complexity of the area.

5.0 IMPLEMENTATION

Eliminating the bacterial impairments of Greenwich Bay and its watershed requires a reduction in both wet and dry weather inputs. All segments of Greenwich Bay, its coves, and its tributaries violate water quality standards after rain events. High bacteria concentrations originate from within the Greenwich Bay watershed and can be traced from tributaries to the Greenwich Bay coves to Greenwich Bay proper. The data shows that the major bacteria sources, such as storm water discharges and tributary streams, transmit to Greenwich Bay proper through the coves and that these sources cause the impairment to the Bay. Restoring the designated uses to Greenwich Bay will require that these sources be addressed. For example, high bacteria concentrations in Hardig Brook enter Apponaug Cove, causing impairments to both the cove and to adjacent areas of Greenwich Bay. The same trend can be seen in Brush Neck Cove with Southern Creek and Tuscatucket Brook. The stations with the lowest bacteria concentrations are located near the Greenwich Bay border with upper West Passage of Narragansett Bay.

In dry weather, harvesting shellfish is prohibited from Brush Neck Cove, Buttonwoods Cove, and in the northwestern corner of Greenwich Bay, adjacent to Apponaug Cove. While not approved for the direct harvesting of shellfish, Apponaug Cove violates its water quality standards. Bacteria concentrations at these locations are highly variable with bacteria concentrations meeting standards on one sampling day, but not the next. Although most beach closures occur as a result of wet weather conditions, dry weather closures do occur at Greenwich Bay beaches during the summer. As with wet weather, the stations with the lowest bacteria concentrations are located near the Greenwich Bay border with upper West Passage of Narragansett Bay indicating that bacteria sources from within the watershed cause the impairments.

Recommended implementation activities for Greenwich Bay are detailed in the following sections. Implementation activities focus on storm water and wastewater management. During wet weather, storm water contains high bacteria concentrations that lead to violations in stream and bay water quality standards. It is believed that lingering remnants of wet weather events may also contribute to the dry weather problems. Achieving standards requires that both the amount of storm water and the bacteria concentrations in that storm water reaching Greenwich Bay are reduced. Wastewater management activities include continuing the extension of sewer lines, connecting homes to the sewer system, adopting wastewater management ordinances in areas without sewers to ensure that septic systems are properly maintained and operated, and ensuring that boaters fully utilize pump-out facilities. Other recommendations include minimizing fecal contamination from domestic animals and wildlife.

5.1 Storm Water Management

Phase II – Six Minimum Measures

Effective February 25, 2003, DEM amended the existing Rhode Island Pollutant Discharge Elimination System (RIPDES) regulations to include Phase II Storm Water regulations. On December 19, 2003, the DEM RIPDES Program issued the General Permit for Storm Water Discharge from Small Municipal Separate Storm Sewer Systems (MS4s) and from Industrial Activity at Eligible Facilities Operated by Regulated Small MS4s. This General Permit gives MS4 operators within regulated areas (i.e. designated municipalities) until March 18, 2004 to submit the Notice of Intent (NOI) and the Storm Water Management Program Plan (SWMPP). Since the Greenwich Bay watershed is located in a regulated area, all operators of MS4s in the watershed will need to comply with the new regulations. The MS4s that discharge directly to Greenwich Bay and its tributaries are owned and operated by the City of

Warwick, the Towns of East Greenwich and West Warwick, and the Rhode Island Department of Transportation (DOT).

Operators must describe Best Management Practices (BMPs) for each of the following six minimum control measures:

- A public education and outreach program to inform the public about the impacts of storm water on surface water bodies,
- A public involvement/participation program,
- An illicit discharge detection and elimination program,
- A construction site storm water runoff control program for sites disturbing 1 or more acres,
- A post construction storm water runoff control program for new development and redevelopment sites disturbing 1 or more acres, and
- A municipal pollution prevention/good housekeeping operation and maintenance program.

The SWMPP must include measurable goals for each control measure (narrative or numeric) that may be used to gauge the success of the program. It must also contain an implementation schedule that includes interim milestones, frequency of activities and reporting of results. The DEM Director can require additional permit requirements based on the recommendations of a TMDL.

Specific Storm Water Measures

To realize water quality improvements in Greenwich Bay, both bacteria concentrations in storm water *and* the volume of storm water discharged to the Bay, coves, and tributaries, must be reduced. The large amount of impervious areas within the Greenwich Bay watershed contributes substantial increases in the amount of water and bacteria entering the Greenwich Bay directly following rain events. As the amount of impervious area in a watershed increases, the peak runoff rates and runoff volumes generated by a storm increases because developed lands have lost much or all of their natural capacity to delay, store, and infiltrate water. As a result, bacteria from birds, domestic pets, and other animals quickly wash off during storm events and discharge into Greenwich Bay. Flow data from all of the tributaries leading to Greenwich Bay demonstrate this trend. For example, during a 1995 storm event, flow in Southern Creek quickly doubled after less than 0.5 inches of rain while bacteria concentrations increased by a factor of six when compared to dry weather concentrations (Wright and Viator).

Due to the substantially large bacteria load that needs to be reduced in order to meet water quality standards, as previously mentioned, both water quality and water quantity must be addressed. Thus, DEM recommends the use of BMPs that reduce both bacteria loads *and* volumes to the maximum extent feasible. There are many opportunities to address both water quality and water quantity and tailor efforts to the local concerns in the SWMPP as follows:

Public Education/Public Involvement

The public education program should focus on both water quality and water quantity concerns within the watershed. Public education material should target the particular audience being addressed. For example, the residential community should be educated about the water quality impacts from residential use and activities and the measures they can take to minimize and prevent these impacts. Examples include disposing pet waste properly, discouraging large waterfowl populations by eliminating human feeding of waterfowl and minimizing large tracts of open land for waterfowl to land and congregate (see Section 5.3), and informing residents about disposing wastes improperly (i.e. disposing yard waste into storm drains). Public involvement programs should actively involve the community in addressing these concerns. Involvement activities may include posting signs informing the public not to feed waterfowl, stenciling storm drains with *Do Not Dump* labels, and designating and maintaining areas with pet waste bags and containers.

The residential community should also be informed about water quantity impacts as a result of large areas of impervious surfaces and what measures they can take to minimize or help offset these impacts. Measures include the infiltration of roof runoff where feasible and landscaping choices that minimize runoff. Some examples of landscaping measures are grading the site to minimize runoff and to promote storm water attenuation and infiltration, reducing paved areas such as driveways, and to consider porous driveways (cost effective options may include crushed shells or stone). Runoff can also be slowed by buffer strips and swales that add filtering capacity through vegetation. These examples can also be targeted to residential land developers and landscapers.

Other potential audiences include commercial property owners, land developers, and landscapers. BMPs that minimize runoff and promote infiltration should be encouraged when redeveloping or re-paving a site. Examples include porous pavement, infiltrating catch basins, breaking up large tracts/areas of impervious surfaces, sloping surfaces towards vegetated areas, and incorporating buffer strips and swales where possible.

Illicit Discharge Detection and Elimination

Wastewater management within the Greenwich Bay watershed is discussed in Section 5.2. After sewer extension projects are completed, sewers will be available to most of the Greenwich Bay watershed. Communities may want to target illicit discharge detection and dry weather flow sampling in areas not slated for sewers.

Construction/Post Construction

Storm water volume reduction requirements for development and redevelopment of commercial and industrial properties should be considered in the development of ordinances to comply with the construction and post construction minimum measures (see General Permit Part IV.B.4.a.1 and Part IV.B.5.a.2 respectively). As mentioned previously, examples of acceptable reduction measures include reducing impervious surfaces, sloping impervious surfaces to drain towards vegetated areas, using porous pavement, and installing infiltration catch basins where feasible. Other reduction measures to consider are the establishment of buffer zones, vegetated drainage ways, cluster zoning or low impact development, transfer of development rights, and overlay districts for sensitive areas.

Good Housekeeping/Pollution Prevention

The Storm Water General Permit (see Part IV.B.6.a.2 and Part IV.B.6.b.1) extends storm water volume reduction requirements to operator-owned facilities and infrastructure (RIDEM, 2003a). Similarly, municipal and state facilities could incorporate measures such as reducing impervious surfaces, sloping impervious surfaces to drain towards vegetated areas, incorporating buffer strips and swales, using porous pavement and infiltration catch basins where feasible. In addition, any new municipal construction project or retrofit should incorporate BMPs that reduce storm water and promote infiltration such as the before-mentioned measures: buffer strips, swales, vegetated drainage ways, infiltrating catchbasins, porous roads etc.

Storm Water Priorities for Municipalities and DOT

Addressing bacteria sources throughout the watershed will take many years. Localized water quality improvements will be seen earlier if storm water retrofit activities are concentrated at the sub-watershed level. While the Storm Water Phase II minimum measures apply to the entire watershed, targeted retrofit activities should be phased in over time, focusing first in those sub-watersheds designated as high priorities. It is recommended that preliminary design studies should evaluate means of distributing treatment structures within the watershed in addition to end-of-pipe solutions at the water's edge. This concept is particularly important for areas along tributary streams, such as Hardig Brook where rain events increase the storm water flows and bacteria loads as a result of the large amount of impervious surfaces and there is a small amount of undeveloped land available for BMP construction. Areas prioritized for restoration are associated with recent shellfish closures, require the highest percent reductions in bacteria, and are described in the following sections.

Warwick

Brush Neck Cove and Apponaug Cove are identified as priority areas for the City of Warwick. Required percent reductions for Brush Neck Cove are the highest for all of Greenwich Bay. All storm water sources discharging to Brush Neck Cove and its two tributaries, Southern Creek and Tuscatucket Brook have been identified and mapped. The Southern Rhode Island Conservation District (SRICD) has mapped all drainage areas. SRICD is expected to complete construction plans for infiltration basins at two locations, White Avenue and Boyle Street, in the Spring of 2004. Warwick applied for and received 319 Grant funds to help fund the construction of this project. Table 5.1 lists priority locations identified by SRICD and direct storm water discharges identified by URI-CVE as large bacteria loads to Greenwich Bay. While physical constraints at these locations may exist, they should be considered first for BMP construction.

Table 5.1 Priority Direct Storm Water Discharges.

ID	Location	Existing or Planned BMP	Why Priority?
	Greenwich Cove		
EG01	North of EG Town Dock		High bacteria loads
EG06	Division Street		High bacteria loads
EG07	Rocky Hollow Road		High bacteria loads
WK08	Norton's Shipyard		High bacteria loads
WK09	Post Road / Ocean Point Avenue West		High bacteria loads
	Apponaug Cove		
WK10	Chepiwanoxet Way / Oak Grove Street		High bacteria loads
WK13	Masthead Drive / Fred Humlak Way		High bacteria loads
	Brush Neck Cove		
WK29	Cottage Grove Avenue	Vortechnic Installed[1]	Large drainage area
WK30	Shand Avenue	Vortechnic Installed[1]	Large drainage area; High bacteria loads
WK35	Gordon and Hawskley	Vortechnic Installed[1]	Large impervious drainage area; High bacteria loads
WK38	Mohawk / Powhatan		High bacteria loads
WK87	West Shore Road		Large impervious drainage area
SRICD114	Burbank Drive		Impervious drainage area
SRICD116	Burgess Drive	Vortechnic Installed[1]	Impervious drainage area
SRICD121	Burbank Drive	Vortechnic Installed[1]	Impervious drainage area
SRICD123	West Shore Road		Large drainage area
SRICD127	West Shore Road		Large drainage area
SRICD128	Weslyan Avenue		Large drainage area
SRICD131	White Avenue	Infiltration Basins Designed	Large drainage area
SRICD133	Boyle Avenue	Infiltration Basins Designed	Large impervious drainage area
SRICD145	Industrial Drive		Large drainage area

[1]Vortechnics are not expected to reduce bacteria concentrations and storm water volume.

Apponaug Cove contributes to the high bacteria concentrations found in adjacent areas of Greenwich Bay proper, and required reductions are among the highest for all of Greenwich Bay. Unlike Brush Neck Cove, outfalls to Apponaug Cove and its tributaries have neither been identified nor prioritized for BMP construction. While outfalls discharging directly to Apponaug Cove were identified by URI-CVE, outfalls along Hardig Brook, Mill Brook, Gorton Pond Tributary, and Greenwood Creek have not been identified. Warwick and DOT will be required to identify all outfalls, including channelized flows, to these tributaries as part of their Storm Water Phase II Requirements. Warwick should also conduct a BMP feasibility study to identify locations and technologies for installing BMPs for Hardig Brook and the Gorton Pond Tributary. These studies should evaluate the feasibility of distributing infiltration throughout the drainage area of significant outfalls or inflow. Any feasibility study should include outfalls with large impervious drainage areas and the outfalls in Table 5.1. These outfalls had high bacteria loads when sampled by URI-CVE.

Warwick should adopt storm water volume reduction requirements for development and redevelopment of commercial and industrial properties. As stated previously, the city is required to adopt these policies for city-owned facilities and infrastructure (Part IV.B.6.a.2 and Part IV.B.6.b.1 of the Storm Water General Permit). Given documented bacterial elevations in the vicinity of the Apponaug mill complex, any redevelopment of this property should address water quality concerns.

The SWMPP is required to include a schedule for implementing TMDL recommendations. Priority should be given to activities in Brush Neck Cove and Apponaug Cove. The SWMPP must also set a schedule for other areas not identified as priorities, areas that drain to Warwick Cove, Greenwich Cove, Buttonwoods Cove, and the Northern Shoreline, which includes Bakers Creek. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

For areas that drain to Warwick Neck, Potowomut, and the Maskerchugg River, Warwick only needs implement the Phase II six minimum measures. Available water quality data shows that either these areas do not represent a water quality concern, or that it is reasonable to expect that the minimum measures will protect water quality.

East Greenwich

In 2001, the Louis Berger Group developed a BMP feasibility study for the densely developed East Greenwich shoreline along Greenwich Cove. This report identified the drainage areas of all East Greenwich outfalls along Greenwich Cove and possible BMP selection. As a result of this report, an East Greenwich consultant is developing a plan for upland flow attenuation for one drainage area and designing a Vortechnic unit at the outfall. The 2001 report did not examine the feasibility of infiltration basins, nor did it evaluate distributing treatment in the watershed as an alternative to end-of-pipe technologies. In addition to the Phase II minimum requirements, East Greenwich should design and construct infiltration basins or equivalent BMPs for outfalls along Greenwich Cove, wherever feasible. For the Maskerchugg River watershed, East Greenwich only needs to comply with the six minimum measures of the Storm Water Phase II program. East Greenwich should also adopt storm water volume reduction requirements for development and redevelopment of commercial and industrial properties in its zoning regulations. As stated previously, the town is required to adopt these policies for city-owned facilities and infrastructure (Part IV.B.6.a.2 and Part IV.B.6.b.1 of the Storm Water General Permit).

West Warwick

Upstream of station HB01, the headwaters of Hardig Brook break into many flow paths, one of which flows through a residential neighborhood in West Warwick. Bacteria concentrations in the headwaters of Hardig Brook are among the highest in the Greenwich Bay watershed. The large amount of impervious surface in this area contributes to elevated wet weather bacteria concentrations and loads. In addition to its Phase II minimum requirements, West Warwick should conduct a feasibility study that identifies areas within this neighborhood where infiltration basins or equivalent BMPs would be possible to construct. This study should evaluate the feasibility of distributing infiltration throughout the drainage area of significant outfalls or inflow. West Warwick should also adopt storm water volume reduction requirements for development and redevelopment of commercial and industrial properties in its zoning regulations. As stated previously, the town is required to adopt these policies for city-owned facilities and infrastructure (Part IV.B.6.a.2 and Part IV.B.6.b.1 of the Storm Water General Permit).

DOT

DOT owns direct storm water discharges throughout the Greenwich Bay watershed. DOT must coordinate its efforts with the local municipalities in the priority areas of Brush Neck Cove, Apponaug Cove, and Greenwich Cove (Part IV.C of the General Permit). DOT should investigate areas for storm water treatment along Route 117. Suggestions for improvements to Hardig Brook include the mitigation of storm water from Route 117 and I-95 using the open areas of the interstate highway. DEM recommends that DOT work with Warwick to evaluate means of reducing storm water from Apponaug to lower Hardig Brook and Gorton Pond Tributary. DOT should conduct a BMP feasibility study to identify ways to mitigate storm water entering Lower Hardig Brook and Gorton Pond Tributary from

Route 115, Route 117, and US-1. This area is also the site of a fish restoration study for Hardig Brook and Gorton Pond Tributary. One option being studied is the feasibility of returning Hardig Brook to its original streambed in this undeveloped area. Storm water planning should accommodate this possibility. Roadway reconstruction anywhere in the watershed should include infiltration or equivalent BMPs, wherever feasible.

Inter-Governmental Agency Cooperation
East Greenwich, Warwick, West Warwick, and DOT own storm water discharges in the Greenwich Bay watershed. These entities must work together to address storm water problems. SWMPPs submitted by each agency must describe how they are cooperating with each other and what issues have arisen (see Part IV.C of the General Permit).

5.2 Wastewater Management

The Greenwich Bay watershed is evolving from a watershed that once relied upon individual sewage disposal systems (ISDS) to one where the majority of sewage is handled by municipal sewers and treatment facilities. As documented in previous sections, the Greenwich Bay watershed has a history of failing septic systems. Inadequately treated wastewater from substandard and failed septic systems adds bacteria and nutrients to Greenwich Bay, contributing to water quality impairments. It is important that these sources be mitigated through planned sewer extensions and tie-ins and, for those areas where sewers will not be extended, through replacement of sub-standard and/or failed systems.

Warwick is spending more than $50 million to expand sewer lines into the Greenwich Bay watershed. The Coastal Resource Management Council (CRMC) has required Warwick to adopt a mandatory tie-in schedule for residential and commercial areas that drain to Greenwich Bay. CRMC Assent Number A00-6-35 stipulates that the mandatory tie-in schedule begin within one year of the completion of improvements at the Warwick Wastewater Treatment Facility (WWTF). Since DEM requires that the plant improvements be completed by August 19, 2004, the schedule for mandatory tie-in should begin in mid-2005. Consultants for the Warwick Sewer Authority used parameters such as soil type, proximity to wetlands, and housing density to identify priority areas for mandatory connection. Proposed areas where mandatory tie-ins will first occur include Brush Neck Cove, Apponaug Cove, and areas surrounding Post Road (Lucht, 2003). Warwick plans to have a public meeting concerning the mandatory tie-in schedule in the Spring of 2004. It is anticipated that it will take between five and seven years for the mandatory tie-in schedule to be complete, and that at the end of this time period all residential and commercial properties where sewers are available will be connected to the sewer system. Warwick does not plan to extend sewer lines into Potowomut, most of Warwick Neck, and for all but a few streets in Cowesett.

The Town of East Greenwich is also extending its sewer lines. East Greenwich does not require homes to connect to the sewer system, however, when the extensions are complete, it appears that most areas of Town within the Greenwich Bay watershed will have sewers available.

A properly designed and operating septic system does prevent bacterial pollution from impacting the surrounding area. Consistent with the Rhode Island's Coastal Nonpoint Pollution Control Program (1995), DEM recommends that communities adopt ordinances for those areas where sewers are not planned to establish an enforceable mechanism to ensure that existing septic systems are properly operated and maintained. As part of the wastewater management planning efforts, communities should keep detailed records of which properties are not connected to the municipal sewer system, identify sub-standard systems, and adopt a schedule for replacement of those systems located along the shoreline.

While properly functioning septic systems can effectively treat bacteria, they are not as efficient at removing nitrogen. Other water quality concerns in the watershed include excessive algal growth and low dissolved oxygen, the result of excessive nitrogen loads. DEM is currently evaluating nitrogen load reductions for Greenwich Bay. It has not been determined whether nutrient loads from septic systems in the areas where sewers are not planned impact algal growth and low dissolved oxygen in Greenwich Bay. The Greenwich Bay Special Area Management Plan being developed by CRMC, in coordination with DEM and other state, federal and local partners, is expected to establish what reductions, if any are needed from these areas.

5.3 Waterfowl, Wildlife, and Domestic Pets

Past studies have shown that waterfowl, wildlife, and domestic pets contribute significantly to elevated bacteria concentrations in surface water (RIDEM, 2003b). DEM Fish and Wildlife Regulations prohibit feeding wild waterfowl except on elevated feeders (e.g. hanging bird feeders) within 100 feet of an occupied dwelling throughout the state (RIDEM, 2003d). Storm Water Phase II requirements include an educational program to educate the public about the impact of storm water. The Greenwich Bay communities should address the importance of picking up after pets and not feeding birds in their education and outreach programs. Pet wastes should be disposed of away from Greenwich Bay, its coves, its tributaries, and any storm water system that discharges to any of these locations. Educational programs should emphasize that not cleaning up after pets and feeding waterfowl, such as gulls and geese, contributes to beach and shellfish bed closures.

Towns and residents can take several measures to minimize bird-related impacts. They can allow tall, coarse vegetation to grow in areas along the shores of the Bay that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to the Bay. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. Residents should also stop feeding birds. Eliminating this practice will decrease summer bird populations and make the area less attractive to the year-round residence of migratory birds.

5.4 Marine Pump-out Facilities

Greenwich Bay is home to over 4000 boats during the summer months (Ganz, 2004). EPA has designated Rhode Island marine waters as a *Federal No Discharge Area*. Adequate pump-out facilities are available throughout the areas of Greenwich Bay where many of boats are docked or moored: Apponaug Cove, Warwick Cove, and Cowessett. Greenwich Cove, the other area in Greenwich Bay with a high-density of boats, currently has only one fixed site pump-out facility. The addition of a pumpout boat for Greenwich Cove is recommended to better service the large mooring fields (predominately municipally operated by Warwick and East Greenwich). The two pump-out boats operated by the Greenwich Bay Marina Club should be better utilized. The local communities, DEM, and CRMC should examine ways to optimize use of these boats. Broader advertisement of the availability of these services and perhaps implementation of a “pennant system’ would increase the utilization of these boats. All pump-out facilities should be maintained and operated to maximize boat usage.

DEM oversees the operation and maintenance of the pump-out infrastructure by participating in the Clean Vessel Act (CVA) program which provides money for the construction, repair, and replacement of pump-out facilities and by coordinating outreach and education programs. CRMC should make marine pump-out facilities a mandatory maintenance item as a condition of minimum standard for operation of a marine facility.

Enforcing Rhode Island's No Discharge designation is required by the Clean Water Act. State laws 46 – 1-2- 39, 46-12- 40, and 46-12-41 give authority to local harbormasters, local police, Coast Guard, and DEM conservation officers and employees to enforce *No Discharge* laws. Boarding boats and inspecting marine sanitation devices (MSD) by all empowered agencies are needed in Greenwich Bay as a follow-up to the last ten years of outreach and education. As announced in a July 29th press release, the DEM Division of Law Enforcement stepped up bay-wide inspections of MSDs in 2004. Thirty-one inspections conducted over the boating season yielded one written warning and six arrests for non-compliant MSDs. Boats were non-compliant with current state regulations by not installing equipment or by not properly securing existing MSDs to prevent discharges. Identification of problem boaters by state, local, and federal officials will be improved with the newly passed legislation requiring boaters to display a mandatory MSD inspection sticker (HEALTH et al, 2004).

DEM will continue to work with harbormasters to intensify the enforcement of the no-discharge law, particularly in the vicinity of Greenwich Bay's licensed beaches: City Park, Goddard Park, and Oakland Beach. DEM will also continue to work with appropriate agencies and organizations, including marinas to enhance public education and outreach efforts regarding the No Discharge law and availability of pump-out opportunities. In addition, all agencies should develop a policy regarding the boarding of boats to inspect compliance with *No Discharge*.

5.5 Future Development

Land use data from Greenwich Bay shows a watershed where most of the land is developed. Warwick has purchased Chepiwanoxet Island and Barton Farm to preserve these areas as open space. Preserving open space should remain a goal of the communities.

As described previously, municipal ordinances should be reviewed and revised, if necessary, to make sure that future development projects do not add to water quality problems and that redevelopment projects reduce contributions to the water quality problems in Greenwich Bay.

5.6 Beach Management

Increased monitoring of beaches over the last several years has resulted in an increase in the numbers of beach closures at the Greenwich Bay beaches. Monitoring data from the summers of 2000 and 2001 shows that with a few exceptions, the beach closures correspond with the wet weather shellfish closures of Greenwich Bay. At this time, the Greenwich Bay beaches are sampled at least three times per week, with Goddard Park being sampled four times per week. Decisions to close the beach are based on the results of this sampling, the water quality history at the sampled location, and other environmental conditions. DEM believes that HEALTH sampling program protects human health. Reducing wet weather bacteria sources from Greenwich Bay will reduce the bacteria concentrations at the beaches, allowing the beaches to remain open.

Beach closures that occur during dry weather may be the result of bather load, waterfowl, and other animals along the beach. DEM recommends that HEALTH work with beach managers to plan ways to discourage beach goers from feeding birds. Feeding birds encourages them to stay at the beaches and add to the bacteria load to the beaches. Signs should be posted prominently at the beach explaining that feeding the birds is illegal (RIDEM, 2003d) and contributes to beach closures. When a beach closure occurs, beach managers should continue to groom the beaches to remove wrack. This wrack is a potential source of fecal coliform bacteria. Beaches should also adopt any other practical measures to reduce resident bird populations.

At some beaches, the source of the bacteria is difficult to establish. HEALTH should work with DEM to set up a bacteria source tracking program that would link elevated fecal coliform concentrations at the beaches to host organisms, such as humans, birds, and rodents, to better identify abatement measures.

At Goddard Beach, three sets of two culverts convey storm water from the parking lot onto the beach. Some of these culverts have grates across them to stop garbage from entering the beach area. Grates should be placed on all culverts and garbage picked up regularly. While not related to the bacteria problems at the beach, this will prevent garbage from entering the beach and reduce the food source for birds and scavengers.

5.7 Summary

DEM will continue to work with DOT, HEALTH, CRMC, SRICD, and the local municipalities to identify funding sources and evaluate locations and designs for storm water control BMPs throughout the watershed. Table 5.2 summarizes the recommended implementation activities for all communities within Greenwich Bay.

Table 5.2 Implementation Measures Summary.

Abatement Measure	Jurisdiction / Location	Notes
Storm Water Phase II Minimum Measures	DOT East Greenwich Warwick West Warwick	Plans submitted to DEM as required.
Apponaug Cove, Brush Neck Cove, Greenwich Cove – Constructing Infiltration Basins	DOT East Greenwich Warwick West Warwick	Infiltration basins are being designed at White Avenue and Boyle Street in Warwick. These should be constructed. All entities should begin BMP feasibility studies to identify and design infiltration basins for other locations.
Storm Water Cooperation	DOT East Greenwich Warwick West Warwick	Warwick, East Greenwich, West Warwick, and DOT should document their cooperation.
Future Development and Redevelopment	East Greenwich Warwick West Warwick	Local Ordinances should institute storm water volume reduction requirements for redevelopment of commercial and industrial properties.
Wastewater Treatment	East Greenwich Warwick	Sewer extensions and mandatory tie-in should continue as planned. Ordinances should be adopted for areas without sewers that require septic system maintenance.
Educational Programs	DOT East Greenwich Warwick West Warwick Beach Managers	Do not feed birds, Clean up pet waste, plant buffers along the water, etc.
No Discharge – Optimize use of Greenwich Bay pump-out facilities	Marina Operators Local Harbormasters	Increase public awareness of *No Discharge* requirements and available facilities.
No Discharge – Require mandatory maintenance of pump-out facilities as a condition of marina operation	CRMC	
No Discharge – Develop and implement policies for inspecting boats to ensure compliance with *No Discharge*.	Local Harbormasters Local Police Coast Guard DEM	
No Discharge – Participate in CVA Program to maintain infrastructure	DEM Marina Owners	
Good Housekeeping Activities at the Beaches	City Park Goddard Park Oakland Beach	Post signs "feeding birds leads to water pollution and beach closures", groom beaches to remove wrack, other practical measure to reduce bird populations. At Goddard Park, place grates on parking lot culverts.
Bacterial source tracking – DNA	Goddard Park	Identify bacteria sources.

6.0 PUBLIC PARTICIPATION

A public meeting will be held following the EPA initial review when the draft Greenwich Bay TMDL is presented for public review and comment. Following the presentation, the public will have a 30-day period in which to submit comments on the study and its findings. An initial public meeting was held in December of 2000.

7.0 FOLLOW-UP MONITORING

Additional monitoring is required to ensure that water quality standards are met as remedial actions are accomplished. Monitoring by DEM will be the principle method of obtaining the data necessary to track water quality conditions in the watershed. Also, as proposed BMPs are installed in the watershed, post construction influent and effluent sampling may be required to assess the effectiveness of the selected technology.

In accordance with NSSP requirements, the DEM Shellfish Monitoring Program will monitor water quality and conduct shoreline surveys. DEM will ensure that ambient sampling stations are located adjacent to point sources and effectively evaluate all nonpoint sources of pollution, including the addition and/or modification of sampling locations, as necessary. Shoreline surveys entail the evaluation of the effect of each actual and potential source of pollution on shellfish waters including as necessary, the collection of ambient water quality samples. In addition, non-shellfish program data (such as information on potential sources, beach and volunteer monitoring) will be considered and followed up with confirmatory monitoring by DEM, following NSSP approved methods, as appropriate.

The continued water quality monitoring and future shoreline surveys will be used to help evaluate the effectiveness of the recommendations of the TMDL in restoring designated uses and attaining water quality standards. Ultimately, attainment of the designated shellfishing use requires compliance with the Rhode Island water quality standards including ambient water quality criteria and all NSSP requirements (including evaluation of non-shellfish program data/surveys, special sampling site data, beach and volunteer monitoring, as appropriate).

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Appendices

Appendix A Shellfish Station Locations and Data

Shellfish Station Locations

ID	Location
GA8-01	Greenwich Cove, from the East Greenwich W.W.T.F. plume
GA8-02	Greenwich Cove, mid-channel at the East Greenwich Yacht Club.
GA8-03	Greenwich Cove, mid-point between a line from the range marker at Long Point to the range marker at the southern tip of Chepiwanoxet.
GA8-04	Inner Greenwich Bay, just north of Goddard Park Beach, mid-point between a line from Sally Rock Point to Long Point.
GA8-05	Inner Greenwich Bay, the intersection of a line from Sally Rock Point to the northern tip of Chepiwanoxet, and a line from the range marker at Long Point through Nun Buoy #6.
GA8-06	Inner Greenwich Bay, at Can Buoy #1.
GA8-07	Inner Greenwich Bay, mid-point between a line from Can Buoy #1 to Can Buoy #3.
GA8-08	Apponaug Cove, at Can Buoy #3, at the entrance to Apponaug Cove.
GA8-10	Apponaug Cove, at Nun Buoy #8.
GA8-12	Mid Greenwich Bay, the intersection of a line from Cedar Tree Point to Warwick Point, and a line from Sally Rock Point through Can Buoy #5.
GA8-13	Mid Greenwich Bay, at Can Buoy #5, just north of Sally Rock.
GA8-15	Outer Greenwich Bay, the intersection of a line from Can Buoy #5 to Sandy Point, and a line from Sally Rock Point to Warwick.
GA8-17	Outer Greenwich Bay, the intersection of a line from Sally Rock Point to Warwick Point, and a line from the flagpole at the Warwick Country Club on Warwick Neck to Sandy Point.
GA8-18	Outer Greenwich Bay, the intersection of a line from Cedar Tree Point to Warwick Point, and a line from Sandy Point to the entrance to Brush Neck Cove.
GA8-21	Warwick Cove, at Can Buoy #5.
GA8-22	Warwick Cove, at Can Buoy #9.
GA8-23	Warwick Cove, at Nun Buoy #12.
GA8-25	Buttonwoods Cove, mid-channel just south of Buttonwoods Beach.
GA8-26	Brush Neck Cove, mid-channel approximately 100 yards north of the Little Rhody Boat Club.

Dry Weather

All samples were analyzed using MPN.

Date	Tide	Days Since / Rain Amount (inches)[1]	GA8-1	GA8-2	GA8-3	GA8-4	GA8-5	GA8-6	GA8-7	GA8-8	GA8-10	GA8-12	GA8-13	GA8-15	GA8-17	GA8-18	GA8-21	GA8-22	GA8-23	GA8-25	GA8-26
24-Jul-00	F	8 / 0.84	4																		9
09-Aug-00	L	9 / 0.75	3																15		23
23-Aug-00	F	5 / 0.12	4						2								2	2	75		2
12-Oct-00	E	6 / 0.2	9	9	2	2	3	4	21	9	2	9	9	2	2	2	4	23	2	4	15
04-Dec-00	F	8 /1.33	2	4	4	9	7	23	23	93	230	4	9	2	23	15	2	2	4	2	2
27-Dec-00	H	9 / 2.98		2	4	2	4	9	430	9	4	3	2	2	23	23				2	
17-Jan-01	F	2 / 0.47		9	4	2	2	93	23	4	93	4	3	2	2	2	7	2	4	2	
16-Feb-01	E	10 / 1		4	2	2	4	2	2	4	4	2	2	2	2	2	2	2	4	2	9
20-Apr-01	E	2 / 0.1	4	2	2	2	2	2	2	2	2	3	2	2	2	2	2	930	2	2	2
02-May-01	L	14 / 0.14	2	2	2	2	2	4	2	4	23	2	2	2	2	2	2	6	2	4	
11-Jun-01	F	9 / 1.45	9	21	2	2	2	2	2	2	2	2	2	2	2	2	2	4	23	2	4
27-Jun-01	F	3 / 0.38	9	43	7	4	4	9	4	6	93	4	2	2	2	2	21	43	23	4	43
20-Jul-01	E	8 / 1.11	14	9	4	7	9	9	14	93	93	7	4	2	4	2	93	23	43	93	230
27-Jul-01	F	0.5 / 0.25	43	43	2	7	9	93		43	93	2	2	2	2	2	14	23		21	15
05-Sep-01	H	8 / 0.52	93	230	9	7	9	4	2	2	23	4	3	4	2	2	9	15	9	230	23
03-Oct-01	H	2 / 0.2	93	9	2	2	4	2	9	43	93	9	23	23	2	2	4	9	93	23	9
29-Oct-01	L	12 / 0.42	2	4	23	4	2	4	2	4	23	2	2	2	4	4	15	9	11	4	93
10-Dec-01	L	1 / 0.42	15	4	2	4	4	93	93	23	75	93	93	4	14	75	4	43	43	93	43
		COUNT	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
		GEOMETRIC MEAN	9	9	3	3	4	8	8	9	22	4	4	3	3	4	5	12	11	8	14
		90th PERCENTILE	73	43	8	7	9	93	65	73	93	9	17	4	19	20	19	43	62	93	73

[1]Rain measured at DEM in Providence.

Wet Weather

Samples taken on July 26, 2001 were analyzed using mTEC. On July 27, 2001 two samples were taken at each station and analyzed using MPN and mTEC. The mTEC value is presented in parenthesis in the table below. Only MPN values were used when calculating geometric mean and 90th percentile values, except at station GA8-7 and GA8-23 where MPN data did not exist. All other samples were analyzed using MPN.

Date	Tide	Days Since / Rain Amount (inches)[1]	GA8-1	GA8-2	GA8-3	GA8-4	GA8-5	GA8-6	GA8-7	GA8-8	GA8-10	GA8-12	GA8-13	GA8-15	GA8-17	GA8-18	GA8-21	GA8-22	GA8-23	GA8-25	GA8-26
26-Jul-01	H	0.5 / 0.71	200	200	13	**1**	**1**	**1.75**	12	**36.5**	180	3	2	4	0.5	0.5	10	54	280		200
27-Jul-01	F	1 / 0.71	43 (13)	43 (32)	**3** (8)	7 (3)	9 (<1)	93 (9)	(2)	43 (10)	93 (24)	**3** (4)	**3** (<1)	**3** (<1)	**3** (1)	**3** (10)	14 (**14**)	23 (38)	(14)	21 (3)	15 (4)
22-Sep-01	F	0.5 / 3.13		930	930	**190**	430	230	430	4300	*23000*	750	230	43	4	43	930	930		430	***16150***
23-Sep-01	F	1.5 / 3.14		930	430	230	230	230	430	930	2300	23	23	230	43	230	140	2300	4300	230	***1365***
24-Sep-01	F	2.5 / 3.15		210	9	7	23	4	9	9	43	9	3	23	9	23	43	43		43	23
18-Oct-02	E	2 / 1.33	23	43	93	9	75	39	93	15	150	15	9	93	**3**	4	43	93	43	240	93
		COUNT	2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	4	5
		GEOMETRIC MEAN	68	275	85	19	44	27	71	115	572	23	12	39	5	14	75	215	373	179	393
		90th PERCENTILE	182	930	730	214	350	230	430	2952	14720	459	147	175	29	155	614	1752	3496	373	10236

[1]Rain measured at TF Green Airport.

Appendix B Tributary Station Locations and Data

Tributary Station Locations

Station	Name	Location
HB00	Hardig Brook	Barton Farm
HB01	Hardig Brook	Glen Drive at Nursing Home Entrance
HB02	Hardig Brook	Quaker Lane
HB03	Hardig Brook	Crossing south of Route 117 in YMCA driveway
HB04	Hardig Brook Tributary	Entrance to Preschool, Route 117
HB05	Hardig Brook	Hardig Brook Road
HB06	Hardig Brook	Orchard Avenue, Sample at Green Railing
HB06A	Hardig Brook	Downstream bridge at 257 Centerville Road
HB06B	Hardig Brook	Downstream waterfall at Grist Mill Apartments
HB06C	Hardig Brook	Upstream Route 115
HB07	Hardig Brook	Below Routes 117 and 1, Warwick
HB08	Hardig Brook	Route 1 (Marine Station), Warwick
GP01	Gorton Pond Tributary	Gorton Pond Outlet
GP02	Gorton Pond Tributary	Little Gorton Pond Outlet
GP03	Gorton Pond Tributary	Route 117 below Apponaug Mill Complex, Warwick
MB01	Mill Brook	Inlet to long pond at Cowesett Apartments
MB02	Mill Brook	Outlet of long pond at Cowesett Apartments
MB03	Mill Brook	Outlet of 36 inch culvert at Cowesett Apartments
MB04	Mill Brook	Rock Bridge, 75 yards upstream from Meadow Street Culvert, Warwick
BC03	Baker Creek	Mouth of Baker's Creek (Marine Station)
GC01	Greenwood Creek	Upstream of the Route 117 crossing of Greenwood Creek
GC02	Greenwood Creek	Headwaters of Apponaug Cove (Marine Station)
SC01	Southern Creek	Upstream of the Route 117 crossing of Southern Creek
SC02	Southern Creek	Downstream culvert at Buttonwoods Avenue
SC03	Southern Creek	Upstream of culvert at White Avenue
TB01	Tuscatucket Brook	Outlet of airport drain on Warwick Industrial Drive
TB01A	Tuscatucket Brook	Outlet of drainage culvert on Warwick Industrial Drive
TB04	Tuscatucket Brook	Liverpool Drive
TB02	Tuscatucket Brook	Downstream of Route 117 crossing of Tuscatucket Brook
TB03	Tuscatucket Brook	At headwaters of Brushneck Cove (Marine Station)
WW8	Maskerchugg River	Maskerchugg River at I-95
WW2	Maskerchugg River	Maskerchugg River at Cedar and Division St
WW4	Maskerchugg River	Maskerchugg River at Kenyon
M01	Maskerchugg River	Maskerchugg River at Route 1
WW11	Maskerchugg River	Maskerchugg River at Greenwich Cove (Marine Station)
WW7	Saddle Brook	Unnamed Tributary at Saddle Brook
WW1	Saddle Brook	Unnamed Tributary at Green Bush Road

Station	Name	Location
WW9	Dark Entry Brook	Dark Entry at Major Potter
WW3	Dark Entry Brook	Dark Entry at Brisas Circle
WW10	Nichols Brook	Tributary at Hemlock (Nichols Brook)
WW5	Nichols Brook	Tributary at Glenwood Cemetery (Nichols Brook)

The following tables list the study when the data was collected. Here is a list of all the studies mentioned in the tables.

Study ID	Study Name
URI HB	DeMelo, Ana C.M., Oran J Viator, and Raymond M. Wright. 1997. *Greenwich Bay Initiative – Water Quality Evaluation of Hardig Brook*. Final Report Submitted to the Rhode Island Department of Environmental Management and the Narragansett Bay Project, by the Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, RI.
URI NW	Wright, Raymond M. and Oran J. Viator. 1999. *Greenwich Bay Initiative – Northern Watersheds Loading Estimates to Greenwich Bay*. Final Report Submitted to the City of Warwick, by the Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, RI.
URI DS	Wright, Raymond M., Michael Fanning, and Oran Viator. 1998. *Characterization of Nonpoint Source Pollutant Sources to an Estuary under Wet Weather Conditions – Direct Stormwater Discharges*. Final Report Submitted to the City of Warwick, by the Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, RI.
URI BASE	Wright, Raymond M. 2000. *Baseline Monitoring Project*. Draft Report Submitted to the Rhode Island Department of Environmental Management, by the Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, RI.
TMDL GB	RIDEM. 2002. G*reenwich Bay Watershed Final Data Report, Bacteria Sampling 2000 - 2002, December 5, 2002*, Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.
TMDL HB	RIDEM. 2004. *Hardig Brook Watershed Final Data Report, Bacteria Sampling 2001 - 2003,* Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.
RI SP 98	RIDEM. 1998. *Greenwich Bay Growing Area 8 Shoreline Survey, 1998 Report,* Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.
RI SP 01	RIDEM. 2001a. *Greenwich Bay Growing Area 8 Shoreline Survey, 2001 Report,* Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.
URI WW	Herron, Elizabeth, Linda Green, Arthur Gold, and Guy Boisclair. 1998b. *Maskerchugg River Watershed – Warwick, West Warwick, and East Greenwich, R.I.* Data Submitted to the Rhode Island Department of Environmental Management, by the Cooperative Extension, University of Rhode Island, Kingston, RI.

Dry Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	GP01	GP02	GP02A[2]	GP02B[2]	GP02C[2]	GP02D[2]	GP03[2]
URI HB	31-Aug-94	9 / 0.88	210	23					
URI HB	31-Aug-94	9 / 0.88	160	45					
URI HB	31-Aug-94	9 / 0.88	170	40					
URI HB	07-Sep-94	2 / 0.2		3					
URI HB	14-Sep-94	5 / 0.22		27					
URI HB	16-Sep-94	7 / 0.22	120	11					
URI HB	16-Sep-94	7 / 0.22	78	12					
URI HB	16-Sep-94	7 / 0.22	23	17					
URI HB	05-Dec-94	7 / 1.5	1600	1					
TMDL GB	28-Aug-01	0.5 / 0.2							150
TMDL GB	31-Aug-01	3 / 0.2							400
TMDL HB	11-Sep-02	7 / 0.22							580
TMDL HB	15-Sep-02	11 / 0.22							510
TMDL HB	20-Sep-02	4 / 1.39							830
TMDL HB	01-Nov-02	6 / 1.17	56	13					510
TMDL HB	21-Nov-02	4 / 1.11		40	32	24	57	48	120
TMDL HB	30-Apr-03	4 / 1.14							44
TMDL HB	07-May-03	7 / 0.18							24
TMDL HB	08-May-03	<1 / 0.11							300
TMDL HB	08-May-03	<1 / 0.11							180
TMDL HB	08-May-03	<1 / 0.11							150
TMDL HB	08-May-03	<1 / 0.11							85
TMDL HB	09-May-03	2 / 0.11							110
TMDL HB	14-Oct-03	2 / 0.39							1400
TMDL HB	03-Nov-03	5 / 1.57		70	40	90	40	170	140
		COUNT	8	12					16
		GEOMETRIC MEAN	135	16					210
		80th PERCENTILE	194	40					NA
		90th PERCENTILE							705

[1]Rain measured at TF Green Airport.

[2]The URI Hardig Brook Study sampled this station. The data is not included here because mitigation activities after the URI study have changed the water quality conditions.

Dry Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	HB00[2]	HB01[2]	HB02[2]	HB03[2]	HB04[2]	HB05[2]	HB06[2]	HB06 A	HB06B	HB06 C	HB07[2]	HB08[2]
TMDL GB	28-Aug-01	0.5 / 0.2		1900					360				2000	923
TMDL GB	31-Aug-01	3 / 0.2		3100	1200				48				195	300
TMDL HB	01-May-02	3 / 0.73							70	100	34	52	43	
TMDL HB	11-Sep-02	7 / 0.22		750	580	300		102	210	390	140	560	410	
TMDL HB	15-Sep-02	11 / 0.22		510	150	270		220	130	150	28	100	70	
TMDL HB	20-Sep-02	4 / 1.39		745	930	230		100	93	120	82	160	110	
TMDL HB	01-Nov-02	6 / 1.17											41	230
TMDL HB	21-Nov-02	4 / 1.11											28	
TMDL HB	30-Apr-03	4 / 1.14	74	42	900	250		50	42		37	24	29	100
TMDL HB	07-May-03	7 / 0.18	230	170	150	220	24	21	35		93	100	150	
TMDL HB	08-May-03	<1 / 0.11						180					63	
TMDL HB	08-May-03	<1 / 0.11	170	320	160	230	120	340	235		49	82	84	
TMDL HB	08-May-03	<1 / 0.11												
TMDL HB	08-May-03	<1 / 0.11	2500	580	270	540	3500	450	250		210	190	96	
TMDL HB	08-May-03	<1 / 0.11	850	420	420	400	1100	280	160		160	200	255	
TMDL HB	08-May-03	<1 / 0.11	1400	270	330	360	66	365	100		130	130	180	
TMDL HB	09-May-03	2 / 0.11	490	150	440	770	3	380	180		180	190	160	
TMDL HB	14-Oct-03	2 / 0.39		180	820	565		120	42		67	72	69	370
TMDL HB	03-Nov-03	5 / 1.57											380	260
		COUNT	7	13	12	11	6	12	14	4	12	12	18	6
		GEOMETRIC MEAN	458	400	418	344	114	161	109	163	82	116	120	291
		80th PERCENTILE	1290	748	884	540	1100	360	220	246	156	190		
		90th PERCENTILE											389	647

[1]Rain measured at TF Green Airport.

[2]The URI Hardig Brook Study sampled this station. The data is not included here because mitigation activities after the URI study have changed the water quality conditions.

Dry Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	MB01	MB02	MB03	MB04	GC01	GC02	BC03	SC01	SC02	SC03	TB01	TB01A	TB02	TB03	TB04
URI NW	12-Apr-95	3 / 0.56	320	5	2	30	4	1	5	2	1	1	5	5	2	42	
URI NW	12-Apr-95	3 / 0.56	1	8	57	32	4			1	1	2	24	1	9		
URI NW	12-Apr-95	3 / 0.56	79	10	5	49	1			1	1	2	19	1	5		
URI NW	13-Apr-95	4 / 0.56						40	2200							55	
URI NW	14-Apr-95	5 / 0.56						1	29							53	
URI NW	26-Apr-95	5 / 0.4	410	9	330	170	12	**1**	11	**1**	**1**	**1**	81	17	16	15	
URI NW	26-Apr-95	5 / 0.4	110	17	5	47	3			1	**1**	**1**	3	4	8		
URI NW	26-Apr-95	5 / 0.4	570	7	19	17	1			1	**1**	1	3	1	11		
URI NW	27-Apr-95	6 / 0.4						3	4							13	
URI NW	28-Apr-95	7 / 0.4						4	23							10	
URI NW	12-Jun-95	4 / 0.3	2900	170	10	570	300	410	920	550	490	1200	11	250	160	560	
URI NW	14-Oct-95	7 / 0.16	500	140	20	120	52			2	**1**	130	2	17	76		
TMDL GB	07-Jul-00	3 / 0.09										74			60		
TMDL GB	18-Jul-00	3 / 0.9										390			70		
TMDL GB	28-Aug-01	0.5 / 0.2				230											
TMDL GB	31-Aug-01	3 / 0.2				160											
TMDL HB	11-Sep-02					260											
TMDL HB	15-Sep-02					250											
TMDL HB	20-Sep-02					210											
TMDL HB	01-Nov-02					750											
TMDL HB	21-Nov-02					60											
TMDL HB	30-Apr-03					170											
TMDL HB	07-May-03					175											
TMDL HB	08-May-03					300											
TMDL HB	08-May-03					520											
TMDL HB	08-May-03					330											
TMDL HB	08-May-03					600											
TMDL HB	08-May-03					240											
TMDL HB	09-May-03					280											
TMDL HB	14-Oct-03					270											
TMDL HB	03-Nov-03					60											
		COUNT	8	8	8	25	8	7	7	8	8	10	8	8	10	7	
		GEOMETRIC MEAN	177	18	16	158	7	6	44	3	2	11	9	6	19	39	
		80th PERCENTILE	542	91	42	306											
		90th PERCENTILE	1269	149	139	550	126	188	1432	166	148	471	41	87	84	257	

[1]Rain measured at TF Green Airport.

Dry Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	WW08	WW02	WW04	M01	WW11	WW07	WW01	WW09	WW03	WW10	WW05
URI WW	20-Jul-96	3 / 0.45			190	100	100		1000			340	210
URI WW	02-Nov-96	4 / 0.09	6	7	120	19	10	1	5	100	80	26	19
URI WW	10-May-97	0.5 / 0.27	20	23	36				25		22	9	13
URI WW	14-Jun-97	0.5 / 0.07	1	170	145	290		430	221	240			2710
URI WW	06-Sep-97	8 / 1.04	30	26				72	280	40	42		95
URI BASE	16-Mar-00	4 / 0.56				12							
URI BASE	31-May-00	7 / 0.87				44							
URI BASE	18-Sep-00	3 / 0.96				280							
URI BASE	11-Dec-00	0.5 / 0.06				44							
URI BASE	20-Mar-01	3 / 0.08				1							
URI BASE	23-Jul-01	6 / 0.08				150							
URI BASE	02-Nov-01	10 / 0.07				15							
		COUNT	4	4	4	10	2	3	5	3	3	3	5
		GEOMETRIC MEAN	8	29	104	39	32	31	95	99	42	43	106
		90th PERCENTILE				281	91						
		80th PERCENTILE	24	84	163	176	82	287	424	184	65	214	710

[1]Rain measured at TF Green Airport.

Wet Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	GP01	GP02
URI HB	18-Nov-94	0.5 / 2.78		220
URI HB	18-Nov-94	0.5 / 2.78		3600
URI HB	18-Nov-94	0.5 / 2.78		3600
URI HB	18-Nov-94	0.5 / 2.78		7800
URI HB	19-Nov-94	0.5 / 2.78		5100
URI HB	19-Nov-94	0.5 / 2.78		5100
URI HB	19-Nov-94	0.5 / 2.78		2500
URI HB	19-Nov-94	0.5 / 2.78		4400
URI HB	19-Nov-94	0.5 / 2.78		4400
URI HB	19-Nov-94	0.5 / 2.78		5600
URI HB	19-Nov-94	0.5 / 2.78		500
URI HB	05-Dec-94	0.5 / 1.1	1000	96
URI HB	05-Dec-94	0.5 / 1.1	1700	42
URI HB	05-Dec-94	0.5 / 1.1	980	26
URI HB	05-Dec-94	0.5 / 1.1	1200	62
URI HB	05-Dec-94	0.5 / 1.1	990	110
URI HB	05-Dec-94	0.5 / 1.1	1000	81
URI HB	05-Dec-94	0.5 / 1.1	820	32
URI HB	05-Dec-94	0.5 / 1.1	640	44
URI HB	05-Dec-94	0.5 / 1.1	490	260
URI HB	06-Dec-94	1 / 1.1	530	780
URI HB	06-Dec-94	1 / 1.1	88	310
URI HB	17-May-95	0.5 / 0.3	160	110
URI HB	17-May-95	0.5 / 0.3	1600	48
URI HB	17-May-95	0.5 / 0.3	200	40
URI HB	17-May-95	0.5 / 0.3	170	50
URI HB	17-May-95	0.5 / 0.3	640	59
URI HB	18-May-95	1 / 0.3	17	58
		COUNT	17	28
		GEOMETRIC MEAN	465	320
		80th PERCENTILE	1000	4080

[1]Rain measured at TF Green Airport.

Wet Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	GP03[2]	HB00[2]	HB01[2]	HB02[2]	HB03[2]	HB04[2]	HB05[2]	HB06[2]	HB06 A	HB06B	HB06 C	HB07[2]	HB08[2]	MB04
TMDL GB	26-Jul-01		7800		12000					4600				12000		
TMDL GB	27-Jul-01		3800		6400					920				1300		
TMDL HB	15-Sep-02								300					110		340
TMDL HB	15-Sep-02								600							
TMDL HB	15-Sep-02		3700		4200	1600	14000	1300		14000		4950	8800	9700		21000
TMDL HB	15-Sep-02		4500		47000	45000	16000	36000		24000		9200	5500	5300		4800
TMDL HB	15-Sep-02		2750		36000	75000	38000	55000		5300		20000	24000			
TMDL HB	16-Sep-02													14000		1800
TMDL HB	16-Sep-02													5500		1200
TMDL HB	16-Sep-02													4100		7200
TMDL HB	16-Sep-02													7500		
TMDL HB	16-Sep-02		3000		22500	7300	20000	11000	21000	22000	15000	15000	10000	8550	7900	26000
TMDL HB	16-Sep-02		2100		12000	7600	8300	5100	9700	9550	9600	11000	11000	9000		5200
TMDL HB	17-Sep-02		1105		1100	1900	2000	1100	4200	2000	3400	2800	2500	3000	2900	1900
TMDL HB	15-Oct-03		5500											660		7600
TMDL HB	15-Oct-03		10000		**23000**	12000	10000	5900	1800	11000		7400	11000	10000		13000
TMDL HB	15-Oct-03		7500		19000	18000	**14500**	7200	18000	11000		11000	12000	7500	9100	8600
TMDL HB	15-Oct-03		14000		13000	11000	13000	5900	14000	14000		11000	**14500**	16000	20000	6500
TMDL HB	15-Oct-03		6900											10000		4500
TMDL HB	15-Oct-03		11200											8200		2800
TMDL HB	15-Oct-03		8100		1800	4400	4200	8300	**5900**	5200		7100	7500	5800	5900	2300
TMDL HB	16-Oct-03		800		440	**1195**	1400	340	1100	1100		1600	1300	**1250**	1200	110
TMDL HB	17-Oct-03		240		700	710	**1400**	9	210	210		300	460	610	**385**	120
		COUNT	17		14	12	12	12	11	14	3	12	12	21	7	48[3]
		GEOMETRIC MEAN	3780		6859	6436	7706	3165	2835	5019	7882	5742	6117	4225	3796	1952[3]
		80th PERCENTILE	8040		22700	16800	15700	10460	14000	14000	12840	11000	11800	10000	8860	
		90th PERCENTILE	10480											12000	13460	19600[3]

[1]Rain measured at TF Green Airport.

[2]The URI Hardig Brook Study sampled this station. The data is not included here because mitigation activities after the URI study have changed the water quality conditions.

[3]These numbers include values from station MB04 from the following table.

Wet Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	MB01	MB02	MB03	MB04	GC01	GC02	BC03	SC01	SC02	SC03	TB01	TB01A	TB02	TB03	TB04
URI NW	12-Jun-95	0.5 / 0.47	1400	130	6	240	650			200	220	890	7	430	2700		
URI NW	12-Jun-95	0.5 / 0.47	1700	180	5200	940	200			310	80	850	5	170	910		
URI NW	12-Jun-95	0.5 / 0.47	990	120	50	290	370			470	110	9	1	140	550		
URI NW	12-Jun-95	0.5 / 0.47	10000	180	17000	1600	410			10000	7900	2800	170	1500	1300		
URI NW	12-Jun-95	0.5 / 0.47	3200	230	9200	240	380			7500	2100	5500	7	660	1900		
URI NW	12-Jun-95	0.5 / 0.47	7800	150	4800	810	290			3600	2000	2000	1	200	310		
URI NW	12-Jun-95	0.5 / 0.47	3600	440	830	370	310			620	840	1000	2	190	4300		
URI NW	12-Jun-95	0.5 / 0.47	2400	390	320	210	190			410	26	30	1	200	160		
URI NW	13-Jun-95	1 / 0.47	6200	170	40	130	89	450	380	850	230	420	46	270	760	440	
URI NW	14-Jun-95	2 / 0.47	310	170	9	190	53	400	540	52	9	32	1	86	130	1200	
URI NW	17-Sep-95	0.5 / 2.65	2300	42	27000	3900	3400	2100	220	1200	910	510	1800	220	3300	260	
URI NW	17-Sep-95	0.5 / 2.65	4600	280	27000	10000	6900			22000	13000	21000	26000	1300	2700		
URI NW	17-Sep-95	0.5 / 2.65	79000	6800	43000	16000	26000			47000	32000	19000	40000	17000	11000		
URI NW	17-Sep-95	0.5 / 2.65	47000	4100	11000	38000	71000			42000	29000	39000	2500	4800	21000		
URI NW	17-Sep-95	0.5 / 2.65	36000	17000	10000	6000	66000			32000	17000	22000	5500	2200	35000		
URI NW	17-Sep-95	0.5 / 2.65	30000	41000	79000	73000	20000			4400	8600	13000	390	2700	16000		
URI NW	17-Sep-95	0.5 / 2.65	28000	280000	5700	21000	6200			4900	2600	10000	570	750	14000		
URI NW	18-Sep-95	1 / 2.65	3300	13000	750	990	3200	160	1100	4400	5	570	170	630	1900	210	
URI NW	19-Sep-95	2 / 2.65	560	9200	2700	370	380	950	430	16	10	210	31	350	310	420	
URI NW	14-Oct-95	0.5 / 0.82	380	150	210	220	250			4900	170	13000	4900	2100	7500		
URI NW	15-Oct-95	0.5 / 0.82	5000	600	10000	13000	440			4700	1600	8400	5700	1300	2800		
URI NW	15-Oct-95	0.5 / 0.82	5000	670	4400	19000	940			20000	9100	4600	1300	6600	1300		
URI NW	15-Oct-95	0.5 / 0.82	8600	330	2000	9100	770			8900	8800	9300	7500	5000	570		
URI NW	15-Oct-95	0.5 / 0.82	8600	240	2500	4100	2900			6500	7300	7800	3500	3200	610		
URI NW	15-Oct-95	0.5 / 0.82	5000	120	4200	920	4500	3100	12000	3100	3000	3500	620	860	2500	2100	
URI NW	15-Oct-95	0.5 / 0.82	1300	200	3800	940	3300			820	2000	2000	230	550	3900		
URI NW	15-Oct-95	0.5 / 0.82	1400	210	2600	590	2100			730	950	1300	170	300	3500		
URI NW	16-Oct-95	1 / 0.82	2000	440	17	170	58	94	2100	4	3	150	12	69	640	400	
URI NW	17-Oct-95	2 / 0.82						17	140							160	
TMDL GB	26-Jul-01	0.5 / 0.71	10000			2900	4800				18000	18500			1300		3800
TMDL GB	27-Jul-01	1 / 0.71	400			190	93.5				630	1700			950		520
RI SP 98	Not Known								2100								
RI SP 01	05-Jun-01	3 / 1.57							43								
		COUNT	30	28	28	30	48[2]	8	10	28	30	30	28	28	30	8	2
		GEOMETRIC MEAN	3993	655	1787	1523	1952[2]	360	607	1875	876	1928	157	723	1881	448	1406
		80th PERCENTILE	10000	5720	10600												
		90th PERCENTILE	30600	14200	27000	19200	19600[2]	2400	3090	25000	17100	19200	6240	4860	14200	1470	3472

[1]Rain measured at TF Green Airport.

[2]These numbers include values from station MB04 from the previous table.

Wet Weather

All samples analyzed using mTEC.

Study	Date	Days Since / Rain Amount (inches)[1]	WW8	WW2	WW4	M01	WW11	WW7	WW1	WW9	WW3	WW10	WW5
URI WW	07-Dec-96	0.5 / 2.02	14	21	69	62	75	7	10	30	64	36	32
URI WW	26-Jul-97	0.5 / 0.33	695	1035	1900			890	1400	39	180		
URI WW	26-Oct-97	0.5 / 0.91	9	4000		24			44	104	1700		
URI BASE	19-Jun-01	2 / 2.66				2400							
TMDL GB	26-Jul-01	0.5 / 0.71				1000							
TMDL GB	27-Jul-01	1 / 0.71				1200							
		COUNT	3	3	2	5	1	2	3	3	3	1	1
		GEOMETRIC MEAN	44	443	362	336	75	79	85	50	270	36	32
		90th PERCENTILE				1920	75						
		80th PERCENTILE	423	2814	1534	1440	75	713	858	78	1092	36	32

[1]Rain measured at TF Green Airport.

Appendix C Greenwich Bay Direct Storm Water Discharges

Potowomut / Goddard Park – Class SA Waters

The only station sampled by URI was WK05. The shoreline surveys would have sampled the identified sources if they were discharging. SP91-07 would not be an outfall.

	Shoreline Survey						NOTES			
ID	1991 ID	1998 ID	2001 ID	Location	X	Y	URI	1991 Survey	1998 Survey	2001 Survey
WK55				Collins Ave. at Ives Road	-71.411	41.662	No Info			
		SP98-01	SP01-01	Outflow from Marsh-Sandy Point					Stream	Stream
	SP91-07			31 Charlotte Dr				Foot Shower		
	SP91-06			41 Charlotte (3" Iron Pipe with PVC elbow)				3" Iron		
WK01	SP91-05			Charlotte Dr. at Sidney Ave.	-71.413	41.663	15" CC	24" CC		
	SP91-04	SP98-03		12" CMP in headwall - End of Robert Street				12" CMP	12" CMP	
WK02		SP98-04	SP01-02	Charlotte Dr. at Robert Ave.	-71.415	41.664	15" CC		18" CC	18" CC
WK03	SP91-03	SP98-02		Charlotte Dr. at Collins Ave. (171 Charlotte Rd)	-71.415	41.664	18" CC	21" CC	24" CC	
WK04	SP91-02	SP98-05	SP01-03	Charlotte Dr. at Hopkins Ave. (201, 205 Charlotte Rd)	-71.416	41.664	21" CC	24" CC	20" CC	18" CC
WK05	SP91-01	SP98-06	SP01-04	Beachwood Pond Outlet (212 Beachwood Rd)	-71.420	41.666	15" CC	24" Culvert	18" Culvert	Stream
WK06	SP91-08			Beachwood Dr. at Overlook Dr.	-71.424	41.669	12" CMP	12" CMP		
	SP91-09	SP98-07	SP01-05	Stream -100 yards west of Sally Rock Point (Potowomut Golf Course)				Stream	Stream	Stream
		SP98-08	SP01-06	Goddard Beach-2-24" concrete Pipes					2 - 24" CC	2 - 24" CC
		SP98-08	SP01-07	Goddard Beach-2-24" concrete Pipes					2 - 24" CC	2 - 24" CC
		SP98-08	SP01-08	Goddard Beach-2-24" concrete Pipes					2 - 24" CC	2 - 24" CC

CC: Concrete
CMP: Corrugated Metal Pipe

Greenwich Cove – Class SB/SB1 Waters
URI sampled EG01, EG06, EG07, WK08, and WK09. The shoreline surveys would have sampled the identified sources if they were discharging.

ID	Shoreline Survey 1991 ID	FDA ID	Louis Berger ID	Location	X	Y	NOTES			
							URI	1991 Survey	FDA	Louis Berger
EG01	SP91-143		002	Outlet south of Transfer Sta. towards Town Dock	-71.449	41.657	24" CC	24" CC		30" CC
EG02	SP91-148		003	Outlet in front of WWTP at the south end	-71.448	41.657	36" CC	36" CC		30" CC
EG03			004	Water Street, near Queen Street	-71.445	41.661	24" CC			27" CC
EG04	SP91-152	152/252	005	Water Street at Blue Parrot Restaurant (Harbourside)	-71.446	41.662	2 - 18" CC	3 - 18" CC		2 - 18" CC
EG05		264	006	Water Street & King Street (20 Water Street)	-71.446	41.662	30" CC		30" CC	30" CC
EG06	SP91-100(158)	263	007	Division Street	-71.445	41.664	36" CMP	30" CMP	36" CMP	36" CMP
EG07	SP91-141		001	South end of Crompton Ave (Rocky Hollow)	-71.452	41.654		36" CC		36" CC
EG08				Town Dock Parking Lot	-71.449	41.656				
WK07	SP91-23			Forge Rd. at AMTRAK ROW	-71.457	41.648	15" CC	12" CC		
WK08	SP91-103	262		Ladd St. at Nortons Marina	-71.446	41.665	30" CC	24" Clay	30" Pipe	
WK09				Post Rd. and Ocean Point Ave. (South)	-71.448	41.671	21" CC, 2 x 15" CMP			
WK20				Post Rd. and Ocean Point Ave. (North)	-71.447	41.671				
M1	SP91-24	306		Maskerchugg River						

CC: Concrete
CMP: Corrugated Metal Pipe

Greenwich Cove – Class SB/SB1 Waters – other pipes

Other Pipes		
SP91-A	SP91-144	SP91-153
SP91-22	SP91-145	SP91-154
SP91-101	SP91-146	SP91-155
SP91-102	SP91-147	SP91-156
SP91-104	SP91-149	SP91-157
SP91-105	SP91-150	SP91-158
SP91-142	SP91-151	SP91-159

Apponaug Cove – North of Chepiwanonxet

Chepiwanoxet – Class SA Waters

The only station sampled by URI was WK10. The shoreline surveys would have sampled the identified sources if they were discharging.

ID	Shoreline Survey			Location	X	Y	NOTES			
	1991 ID	1998 ID	2001 ID				URI	1991 Survey	1998 Survey	2001 Survey
WK10	SP91-107			Chepiwanoxet Way and Oak Grove Street	-71.447	41.674	36", 18" CC			
WK11	SP91-108	SP98-09	SP01-09	Louise Street (ROW at 90 Herbert St)	-71.446	41.675	12" CMP	8" CMP	12" CMP	12" CMP
WK14				Neptune Street	-71.448	41.677	12" CC			

CC: Concrete
CMP: Corrugated Metal Pipe

North of Chepiwanoxet – Class SB Waters

The only station sampled by URI was WK13. The shoreline surveys would have sampled the identified sources if they were discharging.

ID	Shoreline Survey 1991 ID	Location	X	Y	Notes	
					URI	1991 Survey
	SP91-112	Mary's Creek				
WK12	SP91-109	Fred Humlak Way at Folly Landing	-71.450	41.683	24" CC	24" CC
WK13		Masthead Dr. and Fred Humlak Way	-71.451	41.685	30" CC	
WK56	SP91-113	Post Road at Ashmont St.	-71.456	41.688	No Info	2 - 36" Culverts
WK97	SP91-114	Paul Avenue	-71.448	41.689	12" CC	

CC: Concrete

Apponaug Cove – Class SB Waters

URI sampled HB08 and GC01. Both are streams. The shoreline surveys would have sampled the identified sources if they were discharging.

ID	Shoreline Survey 1991 ID	Location	X	Y	Notes	
					URI	1991 Survey
HB08	SP91-120	Hardig Brook at Route 1				
GC01	SP91-124	Greenwood Creek				48" CMP Culvert
WK16		Dory Road	-71.450	41.696	15" CC	
WK17	SP91-125	Edgewater Drive (64 Edgewater)	-71.446	41.695	Not Found	12" CC
	SP91-126	Edgewater Drive (143 Edgewater)				10" CC
WK18	SP91-127	Grandview Drive (217 Grandview)	-71.443	41.692	12" CC	10" Pipe

CC: Concrete
CMP: Corrugated Metal Pipe

Hardig Brook – Class B Waters

ID	Shoreline Survey 1991 ID	Location	X	Y	Notes	
					URI	1991 Survey
WK15	SP91-119	Post Road in Apponaug	-71.460	41.697	18", 12" CC	10" Pipe

CC: Concrete

Greenwood Creek – Class B Waters

ID	Shoreline Survey 1991 ID	Location	X	Y	Notes	
					URI	1991 Survey
WK86		West Shore Road at AMTRAK ROW	-71.452	41.699	No Info	

Apponaug Cove – Class SB Waters – other pipes

Eagle's Lumber Pipes	
SP91-115	SP91-121
SP91-116	SP91-122
SP91-117	

Other Pipes	
SP91-106	SP91-118
SP91-111	SP91-123

Northern Shoreline – Class SA waters

URI sampled BC03 and WK19 (dry weather only). The shoreline surveys would have sampled the identified sources if they were discharging.

ID	FDA	Shoreline Survey			Location	X	Y	NOTES				
		1991 ID	1998 ID	2001 ID				URI	FDA	1991 Survey	1998 Survey	2001 Survey
WK83		SP91-10	SP98-10	SP01-10	58 Melbourne Avenue (Cedar Tree Point)	-71.441	41.687	No Info		Stream	Marsh	Stream
BC03	304	SP91-11	SP98-11	SP01-11	Baker Creek				Stream	Stream	Stream	Stream
			SP98-12		Stream draining Nausaket area wetland							
WK19	212	SP91-12	SP98-13	SP01-12	Capron Farm Rd.	-71.430	41.689	Inaccessible	Stream	Stream	Stream	Stream
	213	SP91-13		SP01-13	Stream east of Capron Farm Road							Stream
	214	SP91-14	SP98-14	SP01-14	Stream west of Andrew Comstock Rd. (Buttonwoods Camp)				24" Culvert		18" CI	Stream
	261				20" CC pipe - 60 ft North of Andrew Comstock Rd				20" CC			
WK89					Promenade Ave. and Andrew Comstock Rd.	-71.422	41.685	No Info				
WK90	215	SP91-15			Promenade Ave. and Hemlock Ave.	-71.420	41.685	No Info	12" Steel	12" CMP		
WK91	216	SP91-16	SP98-15	SP01-15	Promenade Ave. and Laurel Ave. (339 Promenade St)	-71.418	41.685	No Info	24" CC	30" CC	24" CC	24" CC
WK92	217	SP91-17	SP98-16	SP01-16	Promenade Ave. and Armore Rd. (271 or 259 Promenade Ave)	-71.417	41.684	No Info	12" CC	15" CC	12" CC	18" CC
	218	SP91-18	SP98-17		6" PVC Corner Wall 100 ft East of SP98-16 (255 Promenade)				4" PVC	4" PVC	6" PVC	
WK93	219	SP91-19	SP98-18	SP01-17	Promenade Ave. and Cooper Rd.	-71.415	41.684	No Info	8" CI	12" CI	12" CI	12" CI
WK94	220	SP91-20			Promenade Ave. and Eighth Ave. (215 Promenade)	-71.414	41.684	No Info	8" CI	8" CI		
WK95	221	SP91-21	SP98-19		Promenade Ave. and Beach Park Ave.	-71.411	41.684	No Info	8" CI	8" CI	8" CI	

CC: Concrete
CMP: Corrugated Metal Pipe
CI: Cast Iron

Baker Creek – Class SA waters

ID	FDA	Shoreline Survey			Location	X	Y	NOTES				
		1991 ID	1998 ID	2001 ID				URI	FDA	1991 Survey	1998 Survey	2001 Survey
WK81					Long St. to Creekwood Dr	-71.435	41.695	No Info				
WK82					Clinton Ave.	-71.437	41.693	Not Found				
WK96					Helen Avenue	-71.434	41.694	No Info				

Melbourne Avenue Stream – Class SA waters

ID	FDA	Shoreline Survey			Location	X	Y	NOTES				
		1991 ID	1998 ID	2001 ID				URI	FDA	1991 Survey	1998 Survey	2001 Survey
WK28					Midget Avenue	-71.439	41.690	No Info				

Brush Neck Cove – East – Class SA waters

URI sampled WK30, WK35, and WK38. The shoreline surveys would have sampled the identified sources if they were discharging. SRICD did not sample any sources. WK31 and WK32 may not exist.

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES			
					URI	SRICD	1991 Survey	Other
SRICD-100		Pine Grove Ave				Concen. Flow		
SRICD-101		Haswill St				Concen. Flow		
SRICD-102		Mohawk Ave				Concen. Flow		
SRICD-103		Canfield Ave				Concen. Flow		
SRICD-104		Northup St				Concen. Flow		
SRICD-119		Wilcox St				Concen. Flow		
WK85		Spring Grove	-71.416	41.699	No Info	12" CC		Vortech
WK29		Cottage Grove Ave	-71.416	41.699	21" CC	12" CC		Vortech
WK30	SP91-137	Shand Ave	-71.414	41.698	30" CC	30" CC	36" CC	Vortech
WK31		Hollis Avenue to Tweed Street	-71.413	41.700	Inaccessible	No Outlet		
WK32		Reynolds Ave.	-71.412	41.699	Inaccessible	No Pipe Found		
WK59		Pettis Dr	-71.409	41.698	12" CC	18" CC		
WK33		Canfield Ct	-71.407	41.697	Not Found	18" CC		Vortech
WK34		Gordon Ave @ Lloyd Ave	-71.407	41.697	24" CC	***Pipe***		
WK35		Gordon, Hawksley, Seaview	-71.406	41.698	27" CC	30" CC		Vortech
WK36	SP91-133	Wilcox St	-71.404	41.692	18" CC - A	18" CC	18" CC	
WK37		Ottawa Ave	-71.401	41.690	2 x 24" CC	12" CC		
WK38		Mohawk Ave	-71.401	41.688	18" CC	12" CC		
WK39	SP91-131	Sea View Dr	-71.403	41.688	6' x 6' Culvert	12" CC	Culvert	
WK40	SP91-129	Strand Ave	-71.402	41.686	15" CC	12" CC	15" CC	

CC: Concrete

Brush Neck Cove – City Park – Class SA waters

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK27		Shamrock Drive	-71.417	41.693	No Info		

Oakland Beach – Class SA waters

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK41	SP91-128	Burr Ave. to Oakland Beach	-71.397	41.684	Not Found	24"	GW Seep

Brush Neck Cove – Tuscatucket Brook – Class A waters – discharge to upper Brush Neck Cove

SRICD did not sample any sources.

ID	Location	X	Y	NOTES		
				URI	SRICD	
	Upper Tuscatucket Brook					
SRICD-108	Carolyn St				No Info	
SRICD-109	Everglade Ave				Concentrated Flow	
SRICD-110	Brentwood Ave & Strawberry Field				18" CC	
SRICD-113	Hanover St				18" CC	
SRICD-114	Burbank St @ Deerfield & Perkins				12" CC	Vortech Planned
SRICD-115	Adrian St				No Info	
SRICD-116	Burgess Dr				12" CC	Vortech Planned
SRICD-117	Parkway Dr				12" CC	
SRICD-118	Parkway Circle				12" CC	
SRICD-120	Inman Ave				Concentrated Flow	
SRICD-121	Burbank Dr				15" CMP	Vortech Planned
SRICD-144	Warwick Industrial Dr				No Info	
SRICD-145	Warwick Industrial Dr				12" CC	
SRICD-146	Everglade Ave				No Info	
SRICD-161	Brentwood Ave				Concentrated Flow	
	Lower Tuscatucket Brook					
SRICD-105	Cove Ave				Concentrated Flow	
SRICD-106	Strawberry Field Road				12" CC	
SRICD-107	Almy Street				12" CC	
SRICD-111	Liverpool St				No Info	
SRICD-112	Main Ave				No Info	
WK87	West Shore Rd @ Cove Ave	-71.421	41.704	No Info	30" CC, 36" RCP	

CC: Concrete
CMP: Corrugated Metal Pipe
RCP: Reinforced Concrete Pipe

Brush Neck Cove – Southern Creek – Class A waters – discharge to upper Brush Neck Cove
SRICD did not sample any sources.

ID	Location	X	Y	Notes	
				URI	SRICD
	Upper Southern Creek				
SRICD-123	West Shore Rd				12" CC
SRICD-124	McKinley St				12" CC
SRICD-125	Vera St				18" CC
SRICD-126	Juliet St				12" CC
SRICD-127	West Shore Rd				18" CMP
SRICD-128	Wesleyan Ave & Capeway Rd				36" CC
SRICD-143	Warwick Housing				24" CC
SRICD-147	West Shore Rd				Concentrated Flow
SRICD-148	Buttonwoods Ave				Concentrated Flow
SRICD-151	Wilmar St				12" CC
SRICD-152	Grant St				12" CC
SRICD-154	Wicks Ct				12" CC
SRICD-155	Gladys Ct				12" CC
SRICD-156	Larkin @ Link				12" CC
SRICD-157	Larkin St				12" CC
SRICD-158	Woodwind Ct				12" CC
SRICD-159	West Shore Rd				12" CC
	Lower Southern Creek				
SRICD-122	City Park				Overland Flow
SRICD-129	Buttonwoods Ave				12" CC
SRICD-130	Marshall Ave				15" CC
SRICD-131	White Ave				Concentrated Flow
SRICD-132	East of Buttonwoods Ave				12" CC
SRICD-133	Asylum Rd & Boyle Ave				15" CC
SRICD-134	Warwick Housing				Overland Flow
SRICD-135	Sunny Cove Dr				15" CC
SRICD-136	Kerri Lyn Rd				15" CC
SRICD-137	Mystic Dr				Concentrated Flow
SRICD-138	Keystone Dr				12" CC
SRICD-139	MaCarthur Dr				Concentrated Flow
SRICD-140	Larson Dr				18" CC
SRICD-141	Long View Dr				12" CC
SRICD-142	364				15" CC
SRICD-149	Buttonwoods Ave				Concentrated Flow
SRICD-150	White Ave (So. Side, conc flow)				Concentrated Flow
SRICD-153	Off Buttonwoods Ave				Overland Flow
WK88	Moccasin Dr & Cove Ave	-71.420	41.699	No Info	12" CC

Buttonwoods Cove – Class A waters

ID	Location	X	Y	URI
WK21	Mill Wheel Rd.	-71.420	41.690	15" CC
WK22	Moulton Circle (Entrance)	-71.423	41.693	27" CC
WK23	Moulton Circle	-71.422	41.692	18" CC
WK24	Sea Breeze Terrace	-71.422	41.692	No Info
WK25	Ingersoll Avenue	-71.421	41.691	No Info
WK26	Ingersoll Ave. from Hagerstown Dr. and Griffin Dr.	-71.420	41.691	No Info
WK84	Flamingo Drive	-71.423	41.692	No Info

CC: Concrete

Buttonwoods Cove and Brush Neck Cove – Class A waters – other pipes

Other Pipes		
SP91-130	SP91-135	SP91-139
SP91-132	SP91-136	SP91-140
SP91-134	SP91-138	

Warwick Cove – West – Class SB waters

URI only sampled WK43 in dry weather. The shoreline surveys would have sampled the identified sources if they were discharging. SRICD did not sample any sources.

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK42		Suburban Parkway (East)	-71.394	41.687	15" CC	15" CMP	
WK43		Pequot Ave. and Prior St.	-71.398	41.697	36" CC	SRICD 217and 210	
WK44		Chiswick Road	-71.392	41.699	Not Found	12" CMP	
WK45		Searle Street	-71.389	41.698	Not Found	12"	
WK62		Wharf Street	-71.391	41.697	No Info	No Info	
WK72		Glenco Road	-71.394	41.698	No Info	SRICD 219	
WK76		Hackman Place (SRICD - Orrin Street)	-71.383	41.701	No Info	No Info	
SRICD-208		Walsworth Street				No Info	
SRICD-209		North Shore Street				4" PVC	
SRICD-222		Marina Yard, east of Searle Street				No Info	
SRICD-223		Marina Yard, Holden Street				No Info	
SRICD-230		Van Stone Avenue				No Info	
SRICD-224		West Shore Road to Brow Street				No Info	
	SP91-205	Warwick Cove Marina					2", 4" PVC
	SP91-206	Bay Marina - Bulkhead at south side travel-lift					

CC: Concrete
CMP: Corrugated Metal Pipe

Warwick Cove – Pequot Avenue Stream – Class B waters – discharge to northwestern Warwick Cove

SRICD did not sample any sources.

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK58		Pequot Ave. with Chelmsford Ave.	-71.398	41.697	No Info	No Info	
WK73		Quarry Road	-71.401	41.698	No Info	No Info	
WK74		Oakland Beach Ave. to Salix St. (North)	-71.399	41.697	No Info	SRICD 214	
WK75		Oakland Beach Ave. to Salix St. (South)	-71.399	41.697	No Info	SRICD 214	

Warwick Cove – East – Class SB waters

URI sampled WK46 and WK47 (dry weather only). The shoreline surveys would have sampled the identified sources if they were discharging. SRICD did not sample any sources.

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK46		Warwick Neck Ave. and Samuel Gorton Ave.	-71.382	41.699	Vortech	No Info	
WK47		Warwick Neck Ave. and Oakside St.	-71.380	41.697	Stream	opposite WK78	
WK48		Guild Avenue	-71.385	41.697	Not Found	12"	
WK50		Beaver Avenue	-71.380	41.696	Not Visited	Not Mentioned	
WK54		Fosters Brook at Meadow View Ave.	-71.386	41.693	Stream	Not Mentioned	
WK57		Harris Avenue	-71.385	41.697	Not Found	12"	
WK63		Millard Street	-71.385	41.695	No Info	No Info	
WK64		Progress Street	-71.389	41.691	No Info	No Info	
WK65		Tiffany Ave. to Greenwich Bay	-71.390	41.692	No Info	No Info	
WK77		Stephanie Court	-71.382	41.699	No Info	18"	
SRICD-235		Sayles Avenue				No Info	
SRICD-248		Pain Street and Progress Street				18" CMP	

CMP: Corrugated Metal Pipe

Warwick Cove – Oakside Creek - Class B waters – discharge to northeastern Warwick Cove

URI and SRICD did not sample any sources.

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK78		Studley Ave. to Oakside St.	-71.380	41.698	No Info	18"	
WK79		Leland Ave. to Oakside St.	-71.379	41.698	No Info	Not Mentioned	
WK80		State St. to Oakside St.	-71.379	41.697	No Info	No Info	
SRICD-243		Boylston Street				12"	

Warwick Cove – Fosters Brook

URI and SRICD did not sample any sources.

ID	Shoreline Survey 1991 ID	Location	X	Y	NOTES		
					URI	SRICD	1991 Survey
WK49		Meadow View Avenue	-71.385	41.693	No Info	No Info	
WK60		Randall Ave. (Upper to Fosters Brook)	-71.385	41.684	No Info	No Info	
WK61		Randall Ave. (Lower to Fosters Brook)	-71.385	41.684	No Info	No Info	
WK66		Tiffany Ave. to Fosters Brook	-71.385	41.693	Not Visited	18" RCP	
WK67		Carlton Ave.	-71.383	41.687	No Info	No Info	
WK69		Main Channel (Upper to Fosters Brook)	-71.385	41.683	No Info	12"	
WK70		Main Channel (Lower to Fosters Brook)	-71.385	41.683	No Info	12"	
SRICD-241		Leroy Avenue				24" RCP	
SRICD-251		Port Circle				15"	

RCP: Reinforced Concrete Pipe

Warwick Neck – Class SA waters

The only station sampled by URI was WK52. The shoreline surveys would have sampled the identified sources if they were discharging. SRICD did not sample any sources.

ID	Shoreline Survey		Location	X	Y	NOTES			
	1998 ID	2001 ID				URI	SRICD	1998 Survey	2001 Survey
WK51	SP98-20	SP01-18	Randall Ave. to Greenwich Bay	-71.389	41.683	18" CMP	No Info	Marsh	Marsh
WK52	SP98-21	SP01-19	Kirby Avenue	-71.391	41.677	18" CC	No Info	18" CC	12" CC
WK53		SP01-20	Narragansett Bay Avenue	-71.391	41.675	15" CC	15"		18" CC
WK68			Briarcliffe Avenue	-71.384	41.669	No Info	18" RCP		
WK71			Main Channel to Greenwich Bay	-71.390	41.682	No Info	to level spreader		
SRICD-225			Channel View South				15"		

CC: Concrete

Appendix D Direct Storm Water Discharge and Other Source Station Locations and Data

Direct Storm Water Discharge Locations

ID	Location
EG01	EG Transfer Station
EG06	Division Street
EG07	Crompton Avenue
WK05A	Beachwood Pond Outlet (Beachwood Drive)
WK05B	Beachwood Pond Outlet (Beachwood Drive)
WK05C	Beachwood Pond Outlet (Beachwood Drive)
WK05D	Beachwood Pond Outlet (Beachwood Drive)
WK08	Ladd St. at Norton's Marina
WK09	Post Road and Ocean Point Avenue (South)
WK10	Chepiwanoxet Way and Oak Grove Street
WK13	Masthead Drive and Fred Humlak Way
WK19	Capron Farm Road
WK22	Moulton Circle (Entrance)
WK28	Midget Avenue
WK30	Shand Avenue
WK35	Gordon Avenue, Hawksley Avenue, and Sea View Drive
WK38	Mohawk Avenue and Powhatan Street
WK43	Peqout Avenue and Prior Street
WK46	Warwick Neck Avenue and Samuel Gorton Avenue
WK47	Oakside Street Brook (Warwick Neck Ave and Oakside St)
WK52	Kirby Avenue
WK54	Fosters Brook (Meadow View Avenue)

Dry Weather

Study	Date	Days Since / Rain Amount (inches)[1]	EG01	EG06	EG07	WK05 A	WK05 B	WK05 C	WK05 D	WK08
URI DS	21-Mar-97	6 / 0.36	400	19	5	1				4600

Study	Date	Days Since / Rain Amount (inches)[1]	WK19	WK22	WK28	WK43
URI DS	21-Mar-97	6 / 0.36	8	12	4	30

[1]Rain measured at TF Green Airport.

Study	Date	Days Since / Rain Amount (inches)[1]	WK09	WK10	WK13	WK30	WK35	WK38	WK46	WK47	WK52	WK54
URI DS	21-Mar-97	6 / 0.36	1	44	22	4	1	360	17	590	1	33
RIDEM	07-Jul-00	3 / 0.09				5						

[1]Rain measured at TF Green Airport.

Wet Weather

Study	Date	Days Since / Rain Amount (inches)[1]	EG01[2]	EG06[2]	EG07[2]	WK05 A	WK05 B	WK05 C	WK05 D	WK08[2]
URI DS	12-Sep-96	0.5 / 0.04	460	190	670	60	60	150	550	400
URI DS	12-Sep-96	0.5 / 0.04	31000	2100	3700	60	130	1600	750	3100
URI DS	12-Sep-96	0.5 / 0.04	4000	47000	9900	160	64	1100	590	34000
URI DS	12-Sep-96	0.5 / 0.04	26000	62000	3800	120	110	50	630	5200
URI DS	12-Sep-96	0.5 / 0.04	29000	44000	2100	200	98	10	800	78000
URI DS	12-Sep-96	0.5 / 0.04		32000		170	130	60	800	99000
URI DS	17-Sep-96	0.5 / 0.93	15000	110000	9400	32000	9900	1700	3500	4300
URI DS	17-Sep-96	0.5 / 0.93	17000	6500	3900	33000	6000	9400	24000	11000
URI DS	17-Sep-96	0.5 / 0.93	20000	14000	8600	1200	3900	8600	16000	13000
URI DS	17-Sep-96	0.5 / 0.93	40000	12000	8700	750	4400	4600	4400	6800
URI DS	17-Sep-96	0.5 / 0.93	9100	5400	6800	14000	370	2600	2900	24000
URI DS	17-Sep-96	0.5 / 0.93	14000	4600	4700	26000	550	720	5400	3700
URI DS	17-Sep-96	0.5 / 0.93	7800	2800	31000	16000	4200	2200	3300	7500
URI DS	17-Sep-96	0.5 / 0.93	14000	4600	20000		8700	3100	54000	5300
URI DS	17-Sep-96	0.5 / 0.93	25000	5400	5000		3400	4300	24000	14000
URI DS	17-Sep-96	0.5 / 0.93	13000	5500	12000		11000	4400	2600	15000
URI DS	17-Sep-96	0.5 / 0.93	27000	8000	7500					15000
URI DS	17-Sep-96	0.5 / 0.93	12000	9200	6600					8000
URI DS	22-Sep-96	0.5 / 0.67	520							
URI DS	22-Sep-96	0.5 / 0.67	8200	8800	12	44	70	16	320	1300
URI DS	22-Sep-96	0.5 / 0.67	3800	66000	3400	64	180	9000	520	7200
URI DS	22-Sep-96	0.5 / 0.67	5000	31000	6200	48	110	740	300	12000
URI DS	22-Sep-96	0.5 / 0.67	13000	15000	6700	240	60	15000	370	2200
URI DS	22-Sep-96	0.5 / 0.67	2400	5500	3500	70	60	1100	350	6800
URI DS	22-Sep-96	0.5 / 0.67	12000	29000	2200	800	110	89	380	700
URI DS	22-Sep-96	0.5 / 0.67	7700	5800	2700	260	100	4600	130	2100
URI DS	22-Sep-96	0.5 / 0.67	9700	5800	3700	190	150	2200	1200	3000
URI DS	22-Sep-96	0.5 / 0.67	6200	4700	3100			1200	1100	3200
URI DS	22-Sep-96	0.5 / 0.67	5300	4600	5200					3200
URI DS	22-Sep-96	0.5 / 0.67			4400					
RI SP 98	Not Known					9300				
RI SP 01	04-Jun-01	2 / 1.51				150				
		COUNT	28	28	28	23	24	25	25	28
		GEOMETRIC MEAN	9196	9704	4205	560	430	1034	1532	6456
		80th PERCENTILE	23000	31600	8660					14600
		90th PERCENTILE				24000	7890	8840	20800	

[1]Rain measured at TF Green Airport.

[2]These waters drain to Class SB/SB1 waters.

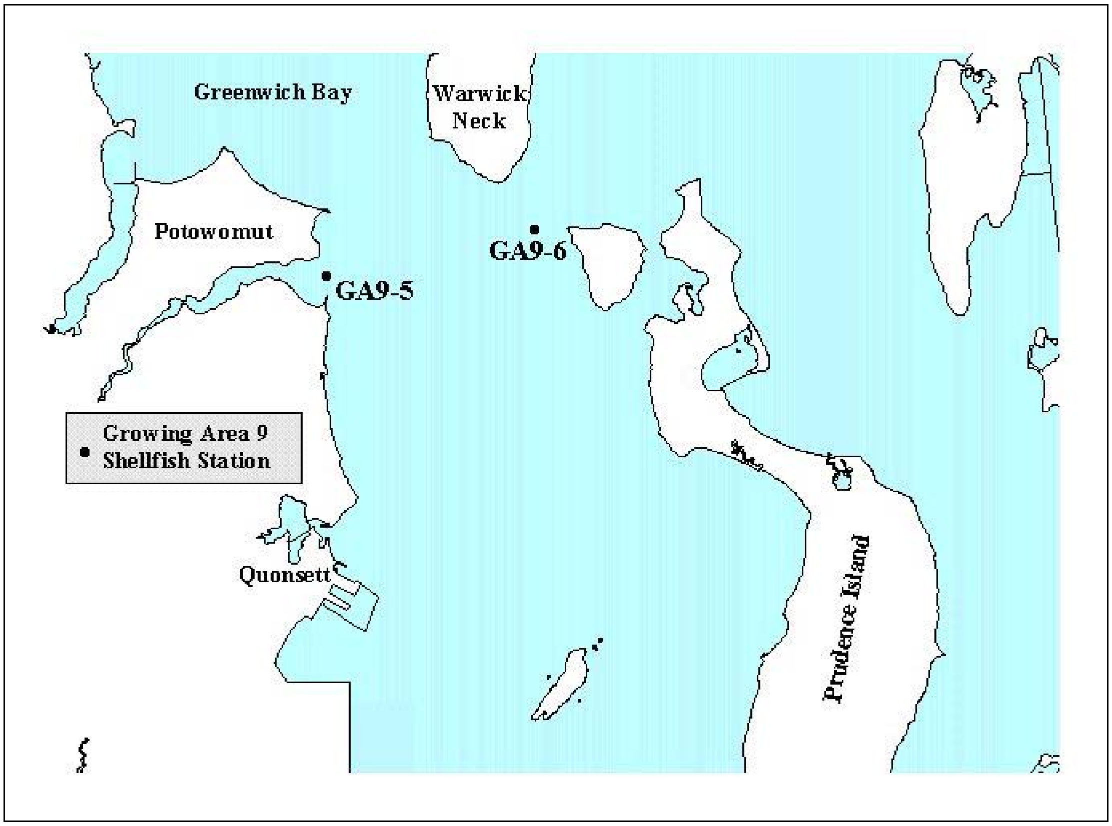
Study	Date	Days Since / Rain Amount (inches)[1]	WK09[2]	WK10	WK13[2]	WK30	WK35	WK38	WK46[2]	WK47[2]	WK52	WK54[2]
URI DS	08-Oct-96	0.5 / 2.36	6200	4500	21000	11	3000	550000	5000		1	5200
URI DS	08-Oct-96	0.5 / 2.36	14000	5400	20000	3800	11000	270000	4700		160	13000
URI DS	08-Oct-96	0.5 / 2.36	13000	28000	4900	4800	4800	110000	3000		5200	14000
URI DS	08-Oct-96	0.5 / 2.36	11000	7900	8600	8900	8600	76000	4400		2200	15000
URI DS	08-Oct-96	0.5 / 2.36	7600	6700	12000	6400	11000	10000	2200		1300	11000
URI DS	08-Oct-96	0.5 / 2.36	9200	11000	14000	3200	13000	13000	3500		1200	6400
URI DS	08-Oct-96	0.5 / 2.36	5300	11000	8600	1700	26000	10000	2000		1300	6400
URI DS	08-Oct-96	0.5 / 2.36	8200	6900	16000	1800	9600	270000	1600		600	13000
URI DS	08-Oct-96	0.5 / 2.36				3900	12000	6500	660			
URI DS	09-Nov-96	0.5 / 0.53	4	100	240	59	660	70000	8800		90	2100
URI DS	09-Nov-96	0.5 / 0.53	2600	1100	5400	28000	13000	75000	6900		6300	32000
URI DS	09-Nov-96	0.5 / 0.53	26000	11000	20000	11000	13000	22000	6800		1500	4200
URI DS	09-Nov-96	0.5 / 0.53	35000	11000	140000	9000	11000	14000	7000		590	3900
URI DS	09-Nov-96	0.5 / 0.53	5100	5900	24000	8400	7100	23000	7700		830	4000
URI DS	09-Nov-96	0.5 / 0.53	16000	5200	25000	4700	13000	11000	4300		800	1700
URI DS	09-Nov-96	0.5 / 0.53	6000	3200	12000	28000	7100	15000	1800		510	2500
URI DS	09-Nov-96	0.5 / 0.53	6500	3300	15000	8700	4800	14000	3000		570	3300
TMDL	26-Jul-01	0.5 / 0.71								19000		15000
TMDL	27-Jul-01	1 / 0.71								1700		1800
		COUNT	16	16	16	17	17	17	17	2	16	18
		GEOMETRIC MEAN	5668	4949	11894	3310	8000	35656	3580	5683	590	6105
		80th PERCENTILE	14000		21000				6880	15540		13600
		90th PERCENTILE		11000		17800	13000	270000			3700	

[1]Rain measured at TF Green Airport.
[2]These waters drain to Class SB/SB1 waters.

Appendix E Bacteria Concentrations at the Mouth of Greenwich Bay

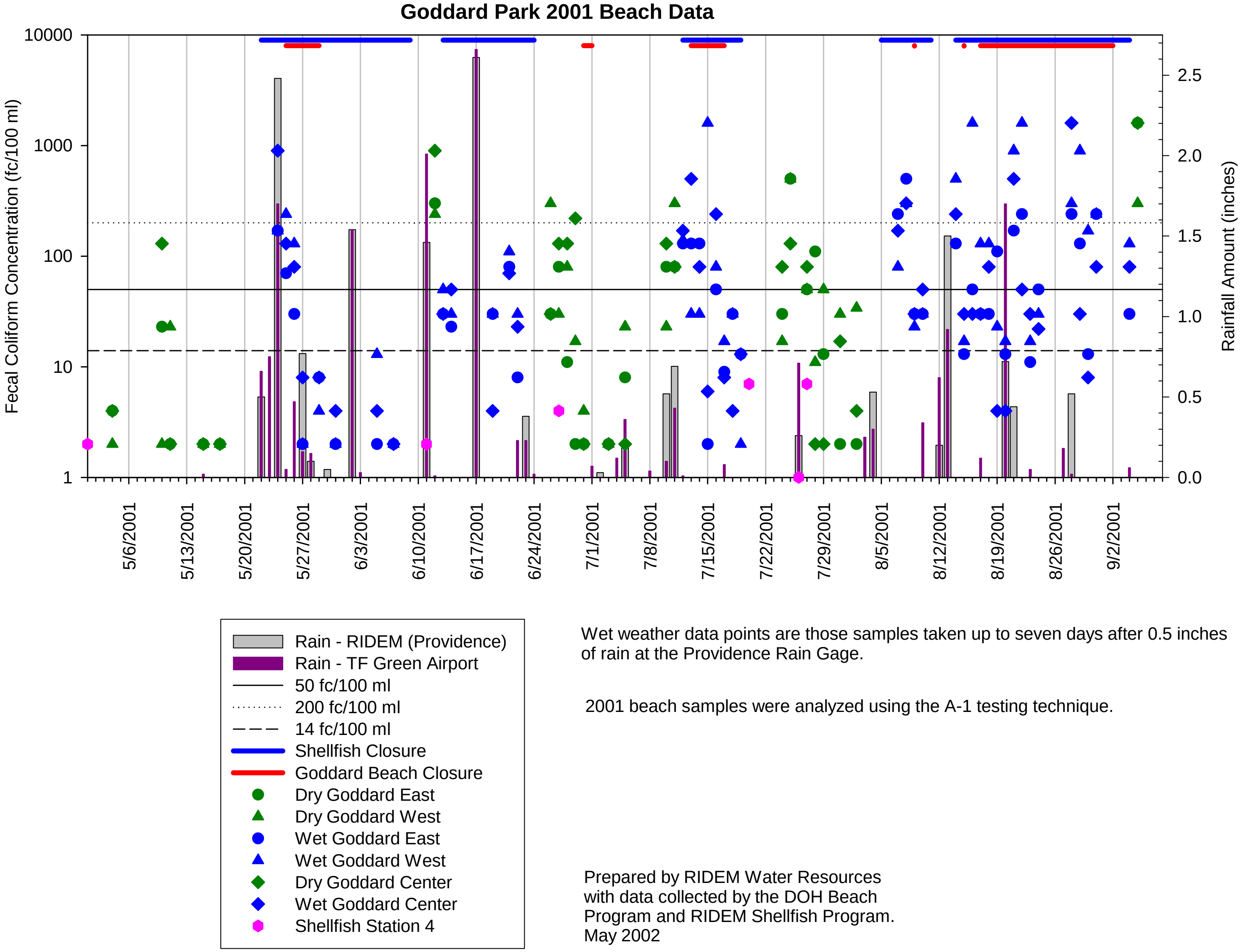
The Rhode Island Shellfish Program samples stations outside of Greenwich Bay six times per year under both wet and dry weather conditions. The results summarized below were taken between 1984 and 2002 from stations in Growing Area 9 (GA-9), also known as West Middle Bay.

Station	Wet Weather			Dry Weather		
	Number of Samples	Geometric Mean (fc/100 ml)	90th Percentile (fc/100 ml)	Number of Samples	Geometric Mean (fc/100 ml)	90th Percentile (fc/100 ml)
GA9-5	81	6	43	24	3	8
GA9-6	83	4	37	24	2	2



Appendix F 2000 and 2001 Beach and Shellfish Closures

2000 Goddard Park

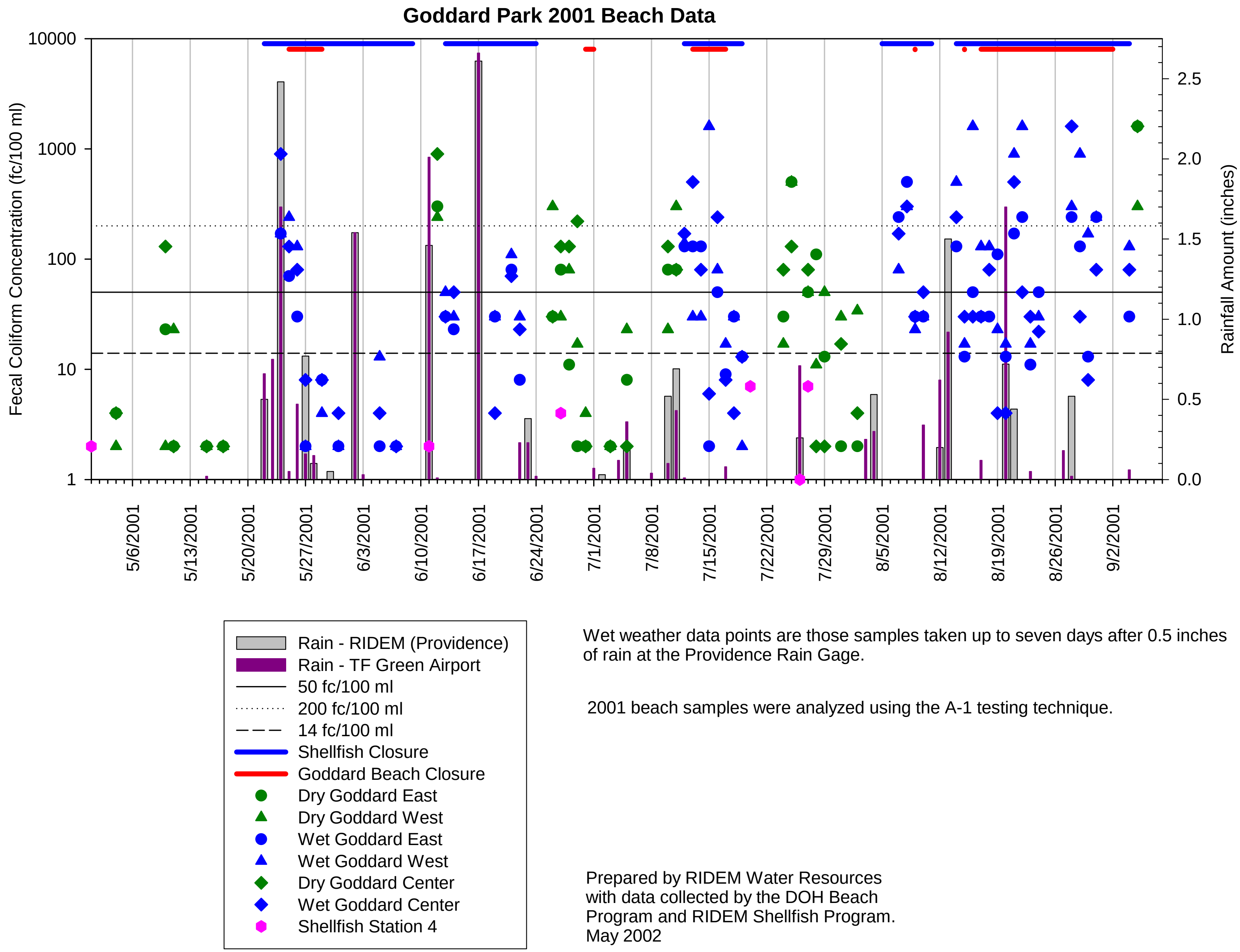


Wet weather data points are those samples taken up to seven days after 0.5 inches of rain at the Providence Rain Gage.

2001 beach samples were analyzed using the A-1 testing technique.

Prepared by RIDEM Water Resources
with data collected by the DOH Beach
Program and RIDEM Shellfish Program.
May 2002

2001 Goddard Park

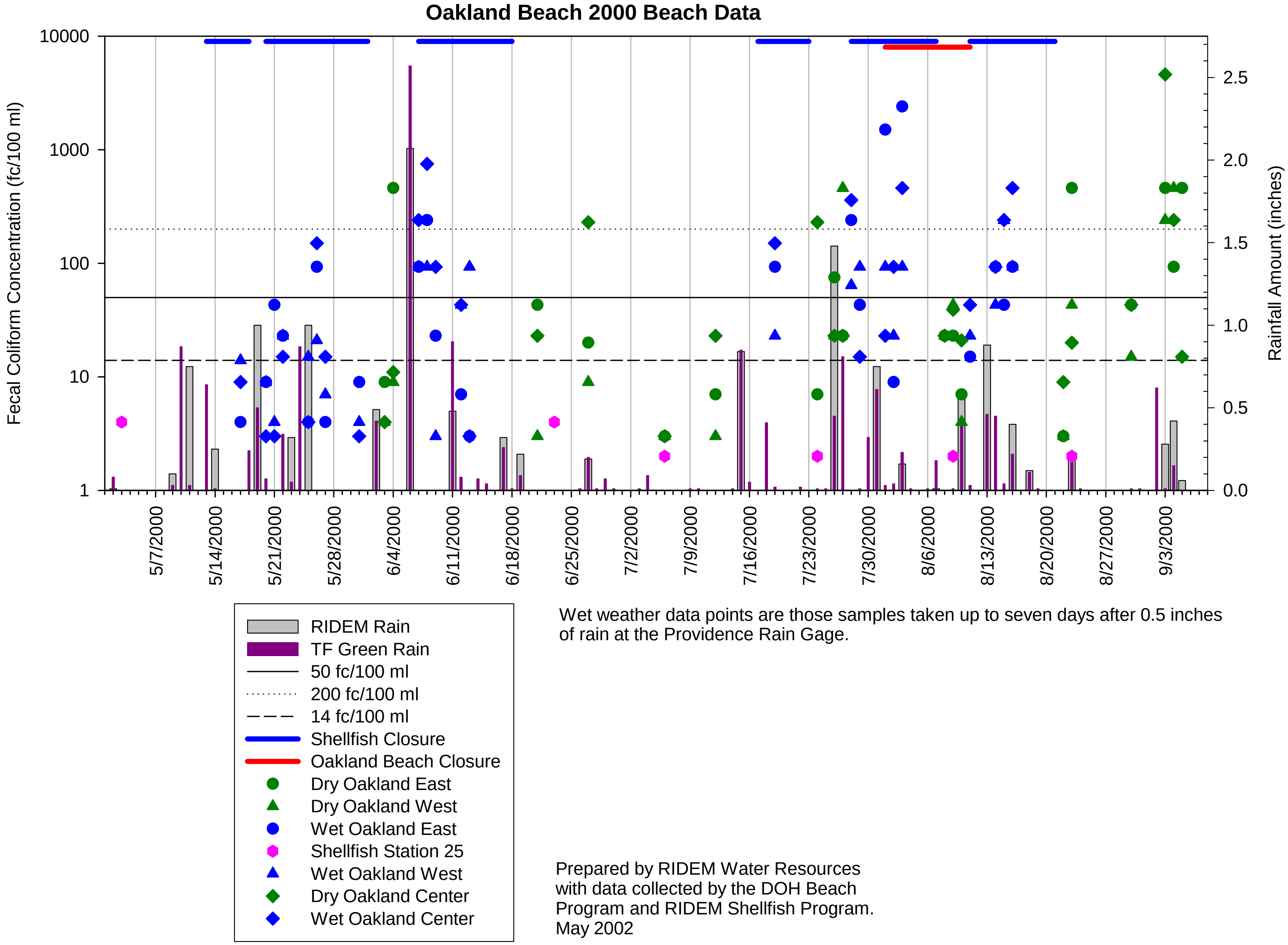


Wet weather data points are those samples taken up to seven days after 0.5 inches of rain at the Providence Rain Gage.

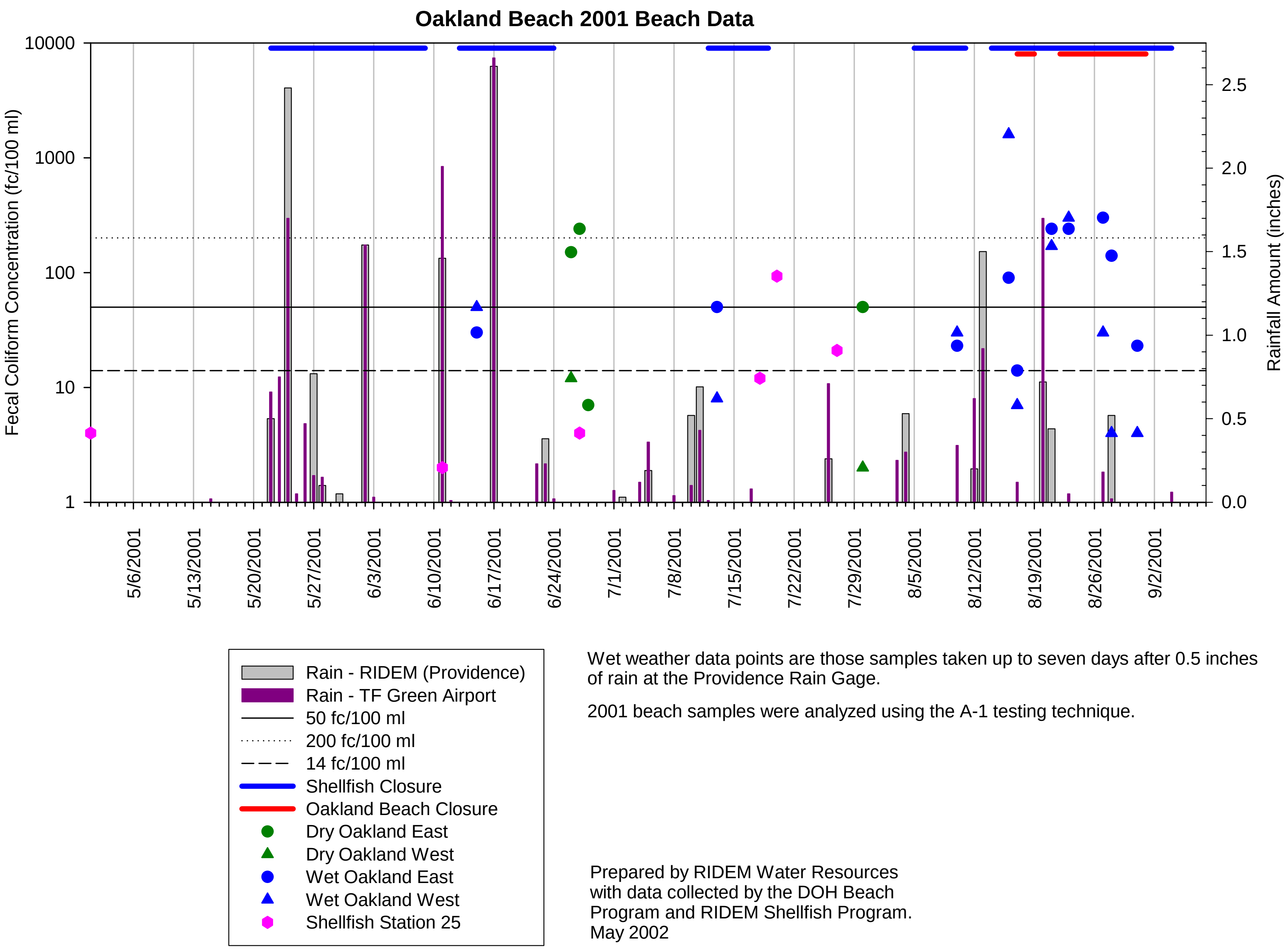
2001 beach samples were analyzed using the A-1 testing technique.

Prepared by RIDEM Water Resources
with data collected by the DOH Beach
Program and RIDEM Shellfish Program.
May 2002

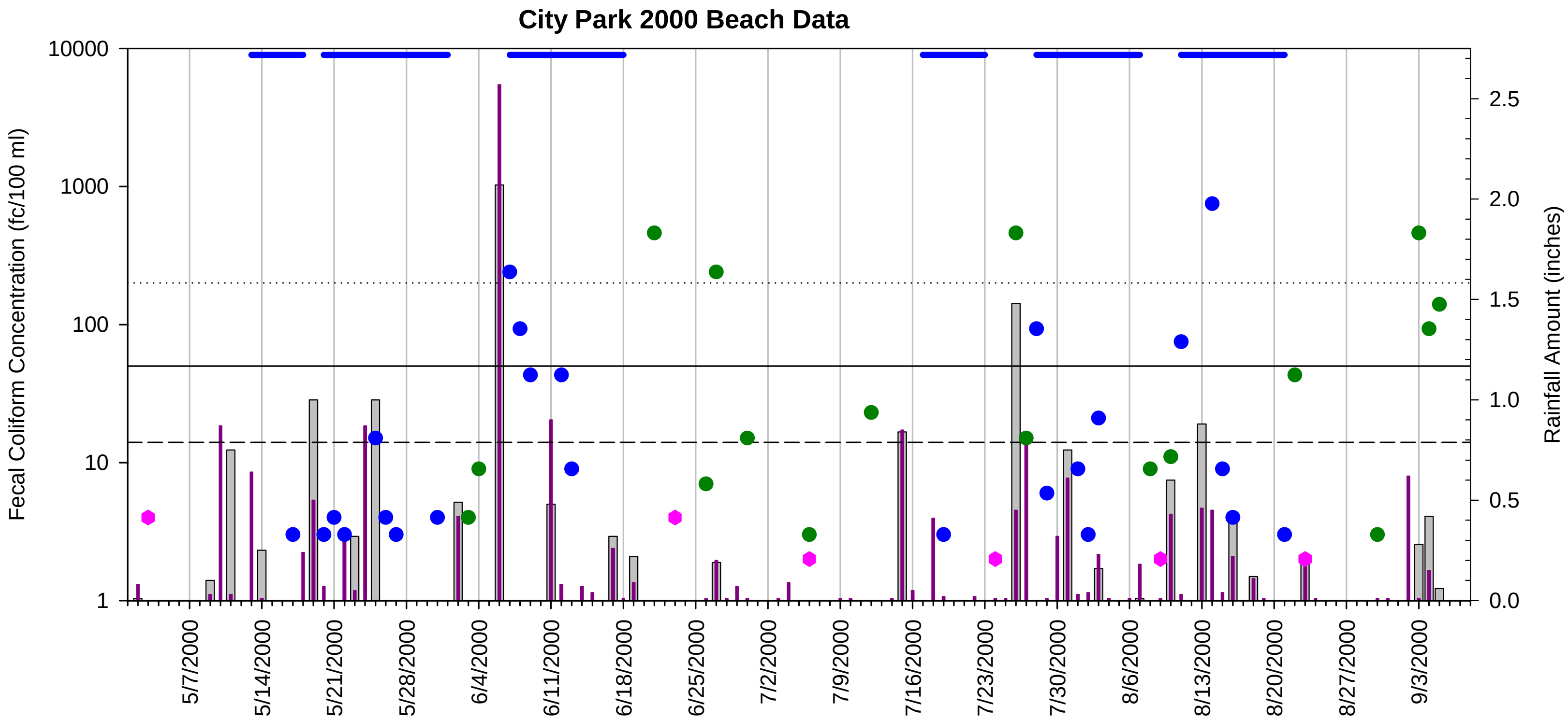
2000 Oakland Beach



2001 Oakland Beach



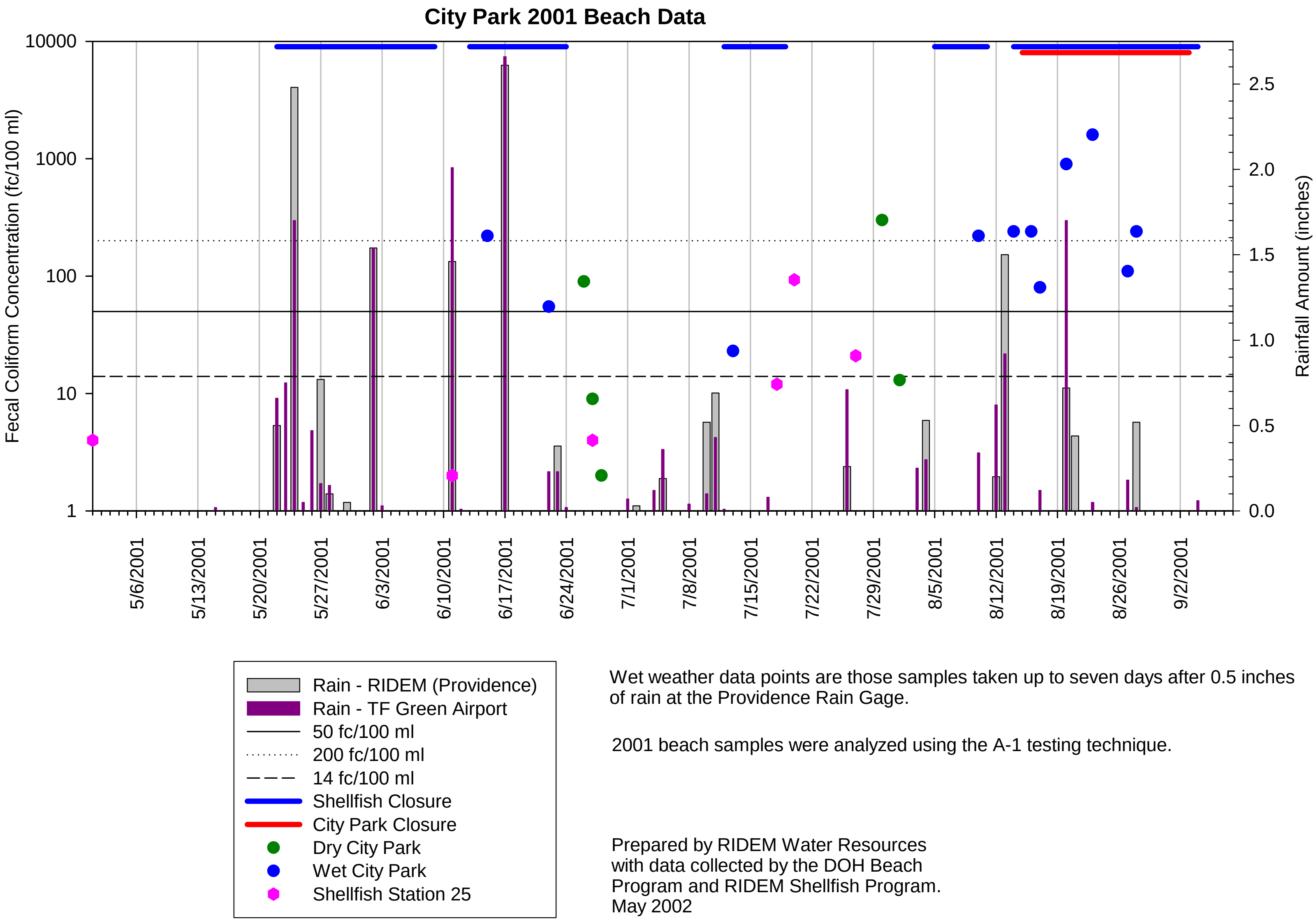
2000 City Park



Wet weather data points are those samples taken up to seven days after 0.5 inches of rain at the Providence Rain Gage.

Prepared by RIDEM Water Resources
with data collected by the DOH Beach
Program and RIDEM Shellfish Program.
May 2002

2001 City Park



Wet weather data points are those samples taken up to seven days after 0.5 inches of rain at the Providence Rain Gage.

2001 beach samples were analyzed using the A-1 testing technique.

Prepared by RIDEM Water Resources with data collected by the DOH Beach Program and RIDEM Shellfish Program. May 2002

Appendix G Response to Comments

The following comments were received by DEM during the public comment period for the draft Greenwich Bay TMDL document. The complete text of all comments received is on file in the Office of Water Resources at DEM.

Dick Langseth (email February 3, 2004)

Comment 1

As the representative of a group in the Northern Shore Sub-watershed I need to point out errors in Table 2.1 Greenwich Bay and Sub-watershed. You are reporting 3.2 km(2) of agricultural use and .2 km(2) of forest in the Northern Shore. The total land mass for the Northern Shore is indicated as 2.1 km(2).

During a recent Citizens Advisory Committee meeting, the group requested the conversion of metrics to common measurements whenever possible. Km(2) is an easy conversion to acres and it should be made. Since most of our citizens live on portions of an acre lots, this is the way they think. It is the way the City of Warwick tracks house lots, farm use and open space. For instance I know that the farm in our watershed has 22 acres under cultivation, 10 acres or so in pastures, and has committed 19 acres to open space. It has a five acre red maple swamp.

Adding all of the wooded part of Cedar Tree Point allocated to the Northern Shore, plus the wooded areas of Baker's Creek, the wooded areas of Budlong Farm and Capron Farm, and the wooded areas of the Buttonwoods Beach Fire District, one would come up with at least 220 acres of wooded area -- which is an eighth of a square mile. These woods represent an Alleghanian element and are significant from a botanical point of view. There are 32 acres of agricultural use on the Northern Shore.

Please recheck this entire table and convert km(2) to acres so that the general population can relate to the numbers.

Response 1

DEM has checked the Northern Shoreline land use areas in Table 2.1. The agricultural use number reported in Table 2.1 was incorrect. It should be 0.2 km^2. This will be corrected in future drafts of the TMDL document. All other land use numbers were found to be correct.

DEM will continue to use the metric system in this Table since all other units in this TMDL document are metric. DEM will provide a conversion factor as a footnote to the Table in future drafts (one square kilometer is approximately 247 acres).

James Boyd (email to Virginia Lee February 3, 2004)

Comment 2

The photograph on the cover struck me as odd until I realized that the photo is reversed. The picture appears to be taken from a helicopter with Chepwinoxet Point as the central nearshore object. Accordingly, Greenwich Cove and Goddard Park should be on the right hand side, but they are on the left. Also, in the distance is Warwick Neck (on the right), but it should be on the left.

Response 2
The photograph has been reversed.

Dick Langseth (email February 10, 2004)
Comment 3
I for one do not understand why the discussion is being limited to E. coli form bacteria-based Total Maximum Daily Load (TMDL). The substance that is making our bay as thick as soup in July and August and turns it into a lethal brew for menhaden is nitrogen. The cause of our mighty stink that must have some really nasty pathogens associated with it is nitrogen. Perhaps we have forgotten that fecal coli forms are measured because they are easy to measure and its fun to do so. Very high concentrations can cause gastroenteritis -- and encourage people to visit our bay rather than Mexico. American babies do not usually get sick and die when they put their hands in the wrong place. In fact, our bay is so clean where shell fishing is allowed that we can drink the water, E. coli and all!

It's the pathogens that kill. Lurking in the water where unacceptable concentrations of E. Coli are found may be the germs for diseases such as Cholera, Typhoid Fever, Hepatitis, Polio. No one wants to catch these critters in the bay. Deep down most of us know that drinking the water of Greenwich Bay a day or so after an August fish kill would be a very stupid thing to do. I'd probably rather die than drink water that has millions of dead fish floating in it. Clearly, the bay near Mary's Creek was not a good place to be last August. It was nitrogen that killed the fish -- and is going to kill the whole bay if we don't get the DEM and others to do something.

It's not very sexy but the TMDL should dig into nitrates. The nitrates flowing into the bay from thousands of approved and well-functioning septic systems is what we need to go after. There is nothing wrong with these systems. They are not failing -- except they kill the fish in the bay, If we address sewer hookups, the human source of E. coli will be swept down the sewer line to the Sewer Commission along with the nitrogen.

Wouldn't it be better to be able to see one's toes when one wades in Greenwich Bay? Wouldn't it be better for all of those little fish leaving Baker's Creek in August to have a chance to live? Then the Blues come inshore and that's true recreation for a lot of Rhode Islanders. And the claming is better too.

Heidi -- Stop the presses --- Please redraft your plan with nitrogen in mind. As the protector of the environment go after nitrogen and mandatory sewer hookups before it is too late. Please consider this comment as an official response to your plan and file it with the same,

And, everybody, come to the Sewer Commission Wednesday night to talk this over with DEM.

Response 3
The draft Greenwich Bay TMDL addresses elevated fecal coliform bacteria concentrations in the Greenwich Bay watershed that are responsible for wet weather related shellfish closures and beach closures. Fecal coliform bacteria are used as an indicator of potential pathogen

contamination. Although there are many potential pathogens and water-borne human health threats, testing for all of them is not feasible. The United States Food and Drug Administration through the National Shellfish Sanitation Program (NSSP) has established fecal coliform as the indicator for the shellfishing use. Prior to 2004, the Environmental Protection Agency (EPA) established fecal coliform as the indicator for recreational use. Beginning in 2004, the Department of Health's Beach Program began using enterococci as an indicator for recreational use, per EPA's new guidelines.

DEM has been actively pursuing nitrogen load reductions to Greenwich Bay. DEM began work on a nitrogen and low dissolved oxygen TMDL in 2000. On October 1, 2001, DEM issued a discharge permit to the East Greenwich Wastewater Treatment Facility (WWTF) for nitrogen reductions. Construction of modifications to the East Greenwich WWTF is currently underway and scheduled for completion in March 2006. Rather than develop a separate nitrogen TMDL for Greenwich Bay, DEM is continuing to work with CRMC to include these issues in the SAMP. DEM has also been working with other WWTFs to reduce nitrogen that impacts upper Narragansett Bay. The Narragansett Bay and Watershed Planning Commission has endorsed a 45 to 50% reduction in nitrogen from RI WWTFs and legislation proposed by the Senate and House, which codified this goal, has been signed into law.

Carol Wilbur (emailed letter February 12, 2004)

Comment 4

In the 1960's the city of Warwick installed a storm water outfall at Wilcox Street. The storm drain network extends to Manning Street. When the city unclogs the inlet at Manning Street, the trash that was blocking the inlet discharges to the shore of Brush Neck Cove.

Response 4

To comply with the DEM's small MS4 general permit the City is required to develop and implement a Storm Water Management Program Plan (SWMPP). The Plan must contain a description of "maintenance activities, maintenance schedules, and long-term inspection procedures for controls to reduce floatables and other pollutants from the MS4 (refer to Part IV.B.6.b.1.vii, page 25 of the permit). The City's SWMPP has been submitted to the DEM and is under review at this time. If the Plan does not identify proper procedures to prevent the discharge of floatables, the DEM will address this in its review and require an amendment to the Plan as appropriate. The Plan is a Public Record. You can obtain a copy by contacting DEM or the City.

DEM has made the City aware of the Manning Street situation. In the future, we recommend that you contact the City directly to report similar situations or concerns with the City's storm drainage system. The SWMPP must specifically identify the City's procedures for the receipt and consideration of complaints and how they will track and record complaints received and actions taken (refer to Part IV.B.3.b.5.ii and 10 of the general permit). The City should document this complaint and their subsequent responses. The City is also required to develop and submit to DEM an annual report regarding the activities of the previous year. The City must provide public notice of the availability of the report for public comment and must hold a public meeting if there is sufficient interest. If you feel that the Plan does not adequately address this issue and your particular concern is not addressed, you have the ability to comment on the Plan or the

Annual Report. The City is required to include a summary of public comments received, and planned responses or changes to the Plan in the Annual Report submitted to DEM.

Roy Jeffrey (emailed letter February 12, 2004)
Comment 5
This letter is written on behalf of the Rhode Island Shoreline Coalition (RISC) to express support for the Greenwich Bay Total Maximum Daily Load (TMDL) Plan. RISC is an organization of over 3,000 members (over 800 individual members) who represent many of the shoreline areas of the state.

It is understood that the cause of last summer's disastrous fish kill was due to issues related to nitrogen loadings and dissolved oxygen levels in the Bay and not to bacterial loadings. However, we know that bacterial loadings have historically caused a number of other negative impacts on the Bay such as shellfish closures and swimming restrictions and that aggressive actions are necessary to remedy these problems.

RISC wishes to express general support for the implementation activities outlined in the draft TMDL plan for Greenwich Bay. The plan's multi-faceted approach targeted to specific actions recognizes that a combination of public and private actions is necessary if we are to see a reduction of bacterial contamination.

It is clear that costs will be incurred to implement the sorts of actions recommended in the plan. Yet it is also clear that the plan is solidly grounded in science as it is based on careful review of the various research and monitoring activities conducted in and around the Bay over the past several years by a wide variety of highly reputable agencies, organizations and universities.

We thank DEM for taking a leadership role on this very important issue.

Response 5
No response needed.

Dick Langseth (email February 13, 2004)
Comment 6
One item that did not make the paper was the discussion on shell fishing. One of our people has done a great job analyzing the numbers. We at BBC are now pushing to shorten the resting period after a rain event from the present seven day wait down to perhaps four days. DEM agreed that seven days may be too long but felt that it would create an administrative burden for them to make the change. All of the SAMP people present objected to that argument during the hearing reminding DEM that people's livelihood is at stake here and we should do all that we can to make life better for our commercial fishermen. This position fits nicely into the economic impact component of the SAMP plan. Keep your fingers crossed! I would love to think that the knowledge we gained in our Wednesday night meetings could lead to a better situation for those who make a living on our bay. (And, as a reminder to DEM, this comment should be considered an official comment for inclusion in their hearing findings.)

Response 6
See Response to Comment 7.

Leah Robinson (email March 11, 2004)
Comment 7
3.1 Instream Water Quality: We now know the seven day closure of conditional shellfish stations directly following rain and/or snow in a 24-hour period has a conservation factor built in to the seven days. This must be identified in the tmdl.

Response 7
The DEM wet weather pollution closure of Greenwich Bay was established in 1993 based upon a review of historical wet weather data and the results of sampling conducted as part of the FDA Greenwich Bay Reclassification Study. The reclassification study found that the minimum total closure following a single rain event should be 6 days including 4 days for the effects of the event to pass and an additional 2 days for shellfish to eliminate contaminants. DEM believes that a seven day wet weather closure is appropriate to ensure the protection of public health and to maintain public confidence in the quality of the shellfish. At the current time, there is not sufficient data to evaluate whether a shorter closure period is possible. DEM intends to collect the data necessary to re-evaluate the closure period once water quality improvements or significant numbers of corrective actions are implemented.

The wet weather closure does include a safety factor to ensure suitable water quality; but not an explicit conservation factor. As you know, DEM Fish and Wildlife has established Greenwich Bay as a Shellfish Management Area. Conservation measures are explicitly implemented in Shellfish Management Areas via reduced bag limits and shorter harvesting seasons to help ensure a self-sustaining yield.

Comment 8
4.0 TMDL Analysis: Three out of the six wet weather samples were taken after a 3-inch rainfall. NSSP requirements state 10% of the samples cannot exceed MPN of 49. 10% of the samples is 3. I believe this is also a conservation effort.

Response 8
The TMDL program collected wet weather samples both to assess whether the conditions that existed in 1993 still exist today and to calculate reductions that incorporate wet weather conditions. The TMDL Program determined that this area is still impaired after wet weather events. The National Shellfish Sanitation Program (NSSP) requires that conditionally approved areas, like Greenwich Bay, meet the requirements of an approved area when that conditional area is in the open status. Therefore, for purposes of the shellfish annual classification evaluation, Greenwich Bay samples are collected monthly throughout the year during the periods when the waters are open to shellfish harvesting (i.e. dry weather). Therefore, the wet weather sampling results were not included in the annual classification review assessing compliance with NSSP criteria.

The statement that reads that 10% of the samples is 3 is incorrect. In this scenario, there are 21 samples. Three samples had results greater than 49 MPN/100 mL resulting in 14.2 % of the samples exceeding 49 MPN/100 mL. This would be a violation of the NSSP standards.

DEM will add the following statement to Section 4.2 in the TMDL document to better articulate differences in the analyses conducted to determine the required TMDL reductions versus the annual classification of shellfish waters under the NSSP:

> The goal of this TMDL is to fully restore the shellfishing use to Greenwich Bay Class SA waters, meaning that these waters would need to meet the approved shellfishing criteria at all times (i.e. open during wet and dry weather conditions). For this reason, both wet and dry weather sampling data were assessed to determine the required percent reductions needed for Greenwich Bay. In contrast, consistent with NSSP requirements that a conditional area meet the requirements of an approved area when that conditional area is in the open status, only sampling data collected in dry weather (when Greenwich Bay is open to shellfish harvesting) are currently considered in the DEM annual shellfish classification review of Greenwich Bay waters.

Comment 9
The DEM has Seasonal Shellfish Closures every year and announces in May. The reason for the closures is marine activity. My question is why is there no mention of marinas in the TMDL as a source of fecal coliform pollution.

Response 9
All shellfish monitoring program data (ongoing ambient water quality sampling and shoreline surveys of growing areas) are evaluated once a year. Changes in classification resulting from this analysis including any to seasonal shellfish closures are announced typically in the week prior to Memorial Day weekend. While it is correct that seasonal closures occur due to marina activity, these closures only occur in waters that are designated as Class SA{b}; however, Greenwich Bay currently has no waters with this designation and no waters closed on a seasonal basis due to pollution closures. A seasonal conservation closure does exist in Greenwich Bay for the commercial harvesting of shellfish. This is separate from the closures announced in May.

The TMDL document identifies marinas as potential sources of fecal coliform pollution and makes a number of recommendations to promote the maximum use and optimum operation of pump-out facilities. This section will be revised to also specifically recommend that DEM 1) work with harbormasters to intensify enforcement of the no-discharge law, particularly in the vicinity of Greenwich Bay's beaches: City Park, Goddard Park, and Oakland Beach, and 2) in conjunction with marinas, enhance public education and outreach efforts regarding the no-discharge law and availability of pump-out opportunities.

DEM's Division of Law Enforcement conducted patrols periodically throughout Narragansett Bay in the Summer of 2004 to check for boaters' compliance with the state's "no discharge" law. Officers conducted 31 documented boardings and made six arrests for non-compliance and issued one written warning. Additionally, in the Spring of 2004, DEM produced a new brochure on Rhode Island's "No-Discharge" policy including information on pump-out facility location and contact information. In a related action, DEM's Office of Water Resources also inspected fifty-six pump-out facilities (including pump-out boats) operating at Rhode Island's marinas and with the exception of six facilities temporarily closed due predominately to mechanical difficulties, reported that all facilities were fully operational. Section 5.4 has been updated to reflect recent activities.

Comment 10
The data in the tmdl is very old, in some cases 1995 and in some cases the data is just missing, no monitoring results. Example: TMDL, Appendix B Tributary Station... Pg 59, Brush Neck Cove, 2 out of 3 Southern Creek stations dry samples have not been tested since Oct 14, 1995. Pg 59, Bakers Creek, 1 station, dry samples have not been tested since Jun 12, 1995.

Response 10
DEM used all available resources to complete its Greenwich Bay bacteria TMDL. Given limited resources, DEM was not able to resample all stations in Greenwich Bay as part of its TMDL study. However, for the majority of the watershed DEM believes that the existing data are adequate to characterize water quality conditions – given that implementation of mitigation measures, while underway, had not progressed sufficiently to result in significant improvements in water quality. Results from a limited number of grab samples at stations throughout the watershed confirmed the best professional judgement of DEM.

DEM did conduct intensive sampling surveys in Hardig Brook and Gorton Pond Tributary in 2002 and 2003. Two pollution sources were found when these two tributary streams were sampled in 1994 and 1995. Mitigation measures completed after 1994 and 1995 made more recent sampling necessary. Sampling results from 2002 and 2003 confirmed the elimination of these sources, but highlighted the need for further bacteria reductions.

David Burnett (emailed letter March 12, 2004)
Comment 11
The problems at bathing beaches appear to be understated.

Response 11
DEM did not intend to understate problems at the beaches. DEM will add additional language to sections of the TMDL document pertaining to beaches as described in the following responses below (Comment 12 and Comment 13).

Comment 12
When calculating wet weather fecal coliform concentrations, it would seem more appropriate to use a three-day geometric mean at beaches. While a seven-day geomean may be suitable for shellfish calculations, this procedure would artificially lower the wet weather geomeans for bathing beaches. When using the seven-day geomean no wet weather violations were found (Table 3.2). HEALTH would like to see a comparison of the three and seven-day geomeans. Even within the shellfish program the wet weather effects are estimated at three-days, with a four-day depuration period. It seems the four-day depuration period would not, and should not, apply to bathing beaches.

Response 12

The draft TMDL document separates the sampling data into wet weather and dry weather categories. Data is then 'weighted' by occurrence of wet and dry weather conditions in the watershed. Statistics and required percent reductions are then calculated. This methodology is used to make sure that the sampled data is representative of weather conditions (i.e. wet or dry weather data is not over-represented). The TMDL document uses the Shellfish Program wet weather definition to analyze all data. DEM chose to apply the same wet weather definition to both shellfish and beach data to be consistent and to avoid introducing additional confusion to an already complicated analysis. The TMDL defines wet weather as the time that the shellfish growing areas in Greenwich Bay are closed for the direct harvesting of shellfish due to meteorological events. The direct harvesting of shellfish in Greenwich Bay is halted within twenty-four hours of a rain event of 0.5 inches or more for seven days. Over the last ten years, Greenwich Bay has been closed for harvesting shellfish (i.e. under wet weather condition) approximately fifty percent of the year.

HEALTH requested that DEM calculate geometric mean concentrations at the beaches when wet weather is defined as within three days of a rain event of at least 0.5 inches and then compare the results to the geometric mean values reported in Table 4.3 of the TMDL document. DEM needed to revise its calculations for the amount of time that Greenwich Bay experiences wet weather conditions to complete this comparison. In the TMDL document, when using the seven day wet weather closure, Greenwich Bay was found to experience wet weather conditions for 50% of the year. When using a three day wet weather closure, Greenwich Bay was found to experience wet weather conditions for one-third of the beach season.

The Table below shows that while wet weather geometric mean increase when using a 3 day wet weather closure, dry weather geometric means decrease. This results in only negligible changes in the weighted geometric mean values at each location. Based on these results, DEM will not change its definition of dry weather in the TMDL document.

Comparison of Geometric Mean Concentrations at the Beaches

Station	Location	Target	7 Day Wet Weather			3 Day Wet Weather		
			Dry	Wet	Station Weighted[1]	Dry	Wet	Station Weighted[2]
East	Goddard Park	50	25	22	45.1	22.2	25.4	44.1
Center[3]			22	37		27.9	40.4	
West			45	45		45.9	40.5	
East	Oakland Beach	50	34	44	39.1	29.2	63.7	40.7
Middle[4]			34	42		30.3	50.5	
West			17	31		15.2	50.5	
	City Park Beach	50	28	29	28.5	27.9	30.4	28.7

[1]The seven day wet weather closure was weighted using 50% wet weather and 50% dry weather.
[2]The three day wet weather closure was weighted using 33% wet weather and 66% dry weather (between May 15 and September 5).
[3]The Goddard Park Center Station was only sampled in 2001.
[4]The Oakland Beach Middle Station was only sampled in 2000.

As noted in response to Comment 7, DEM does not use a four day depuration period for Greenwich Bay. DEM will clarify language within the TMDL document that may indicate that it does.

Comment 13
In Section 2.2 (Water Quality History) some discussion of beach closures, in addition to the shellfish closures, may be beneficial.

Response 13
DEM will add the following text.

> Greenwich Bay contains three licensed beaches. These beaches are periodically closed throughout the summer months. In 2002, HEALTH completed surveys that evaluated the Greenwich Bay Beaches according to past and present conditions, known or likely sources of pollution, and user characteristics. Graded point classifications used to evaluate beach risk are based on numbers of days the beaches were closed, confirmed illnesses, point discharge proximity, bacteria monitoring, storm water, birds, number of users, and other relevant parameters. All Greenwich Bay beaches were classified as high risk and are sampled at least three times per week (HEALTH, 2002).

Table 2.2 Closure Days at Greenwich Bay Beaches and Shellfish Grounds[1].

	Number of Closure Days					
Location	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
City Park Beach	27	0	0	19	15	23
Oakland Beach	31	7	10	12	12	66
Goddard Park Beach	14	0	16	28	7	21
Shellfish Growing Area[2]			58	67	41	73
Rain (Inches) TF Green[2]			13.0	17.3	8.8	19.4

[1](HEALTH, 2000, 2001, 2002, and 2003) (RIDEM, 2000, 2001, 2002, 2003)
[2]Between May 15 and September 7

Comment 14
A more comprehensive data set for the three licensed beaches in Greenwich Bay is available for 2002 and 2003. HEALTH has provided this data, which may help characterize wet weather problems at these beaches.

Response 14
DEM completed its analysis of the existing data in early 2003 for the estuarine waters of Greenwich Bay. At this time, the shellfish sampling data from 2002 was not available for insertion into the TMDL document. The decision was made to use the shellfish program data from October 2000 until December 2002. This was the data used to complete the 2002 Shellfish Program review of Greenwich Bay. Since the TMDL was using data from 2000 and 2001 for the shellfish stations, DEM decided to use the Beach Program data from these years as well. Although more recent data exists from both of these data sources, DEM decided that there was not a change in water quality conditions and that use of the more recent data would not change the recommended mitigation actions. It should be noted that DEM did use more recent data from Hardig Brook (2002 and 2003) because there was no acceptable data set available.

Donald Pryor (emailed letter March 12, 2004)

Comment 15

In the context of TMDLs, implementation plans have been controversial. RI benefits from DEM's decision to include implementation plans. However, one important element, perhaps the most important element that should be included in the implementation measures, is some mechanism for updating the assessment, evaluating progress, identifying further needs, and finding ways of fulfilling those needs. DEM should be willing to cooperate, if not lead. CRMC, the cities of Warwick and East Greenwich, and citizens' organizations are alternatives but all should be involved. There may be differences about the calculation of load allocations but success of the TMDL as a restoration plan should be judged by whether designated shellfishing areas and beaches can be consistently open. It is not clear that the implementation plan as currently defined can assure that success.

Response 15

With respect to comments related to updating assessments and evaluating progress, DEM is committed to working with the newly created RI Environmental Monitoring Collaborative, CRMC, and others to establish a long term monitoring strategy for Narragansett Bay waters, including Greenwich Bay. The details of the bay monitoring strategy are still in development, however at a minimum, a continuation of the current level of monitoring effort is envisioned. The HEALTH Beach Program in conjunction with the beach operators will continue to sample the beaches during the beach season. The DEM Shellfish Program will continue to sample Greenwich Bay in accordance with NSSP requirements, including a comprehensive shoreline survey of Greenwich Bay waters in 2005, to update information on sources of bacteria to the Bay. Once sufficient progress is made in implementing corrective actions and dry weather improvements are observed, a more comprehensive wet weather monitoring effort will be undertaken and as appropriate, shellfish closures modified. Tributary sampling will occur as part of the rotating basins statewide monitoring plan. In this plan, the Greenwich Bay basin would be sampled every five years. In addition, Watershed Watch has begun a volunteer monitoring program for the Greenwich Bay tributaries. Funding for future years of this program is not assured.

In establishing the Narragansett Bay and Watershed Commission, Governor Carcieri set forth a goal that Greenwich Bay meet fishable/swimmable conditions by 2015. DEM believes that the TMDL sets forth a framework to achieve the goal of water quality conditions that consistently support swimming and the harvest of shellfish in designated areas. The agency is committed to working with the Town of East Greenwich, City of Warwick, Rhode Island Department of Transportation and others – ideally in a voluntary manner - to implement the TMDL recommendations. Achieving the fishable/swimmable goal by 2015 will require a significant commitment on the part of these entities. DEM envisions an iterative process whereby water quality improvements are evaluated once the most significant pollution sources have been mitigated, with additional control measures being implemented, on an as needed basis – until water quality goals are achieved.

Comment 16

In addition, the implementation plan, as written, may contribute to over-expectations regarding stormwater management measures. The public is often misled to think that swirl separators

(Vortechnics, Stormceptor, etc.) remove bacteria (and nutrient) pollution. The report does not do enough to dissuade that impression and, in fact, may be viewed as reinforcing it. In the implementation section (p. 34), for instance, the report recommends that design studies should evaluate end-of-pipe solutions. Are any practical end-of-pipe solutions known to be effective in reducing bacteria? Table 5.1, on that same page, lists 6 instances in which Vortechnics units are identified as BMPs. While they may be effective in reducing sediments, even the manufacturer does not claim they are effective in reducing bacteria. If DEM judges that it is important to include BMPs that do not address the pollutant of concern in this TMDL, perhaps an asterisk should be added and connected to a note that these systems are not expected to reduce bacteria.

Response 16

The TMDL document recommends use of storm water BMPs that both reduce bacteria concentrations in storm water and reduce the volume of storm water entering the Bay, coves, and tributaries. The document specifically gives preference to use of upland attenuation techniques to infiltrate and treat runoff as close to the source as possible, but also mentions other end-of pipe infiltration systems as effective means of accomplishing these stormwater management goals. DEM will add a footnote to Table 5.1 explaining that although swirl separators are effective at removal of sediments and associated pollutants they are not expected to reduce bacteria concentrations or storm water volume. These BMPs were listed in the Table to give credit to Warwick for beginning to address storm water issues.

Mayor Scott Avedisian (letter March 12, 2004)

Comment 17

The City is strongly in support of measures to improve water quality in Greenwich Bay as evidenced by the over $100 million commitment to install sewers, install BMPs, educate the public and research pollution sources. However, the Rhode Island Department of Environmental Management (DEM) must provide the City with a funding mechanism to assist in implementing these measures and the measures required under the newly adopted Phase II stormwater regulations.

Response 17

DEM recognizes the significant level of work that must be accomplished by the municipalities, particularly in mitigating stormwater impacts, to implement the TMDL and meet the fishable/swimmable goal by 2015. Though the State is not obligated to provide funding to municipalities to meet obligations of the Clean Water Act, DEM notifies state and federal authorities of local funding needs and makes every effort to identify sources of funds to support compliance efforts. Towards this end, DEM was instrumental in development of the 2004 Open Space, Recreation, Bay and Watershed Protection Bond, and fully supports its passage. Along with federal 319 funding, the proposed bond will provide needed financial assistance to municipalities and others to abate nonpoint sources of pollution, including corrective actions to mitigate stormwater discharges.

DEM would also encourage the municipalities to establish dedicated revenue streams for funding storm water requirements, for example through a storm water utility district. Establishing a storm water utility district would be an activity eligible for funds either from the proposed bond or from the 319 Nonpoint Source program. Also, as stated in the TMDL document, municipalities are encouraged to adopt ordinances requiring better site design and/or storm water management measures to reduce the volume of storm water generated at new development and redevelopment sites.

Comment 18
The City of Warwick is concerned with the impact the State drainage system has on Greenwich Bay. DEM must actively engage the RI Department of Transportation (DOT) to upgrade its drainage system within the Greenwich Bay watershed and install BMPs in appropriate locations.

Response 18
The DEM has been actively engaging DOT regarding storm water management statewide. DEM works with DOT to ensure that appropriate storm water BMPs are incorporated into all new construction projects and identifying retrofit opportunities during reconstruction of systems that discharge to impaired waterbodies where a TMDL hasn't been completed. Under the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, RIDOT was given monies for the "design and construction of a stormdrain retrofit on I-95 and other highway runoff programs to protect Narragansett Bay." The overall project goal is to ultimately implement BMP retrofit measures to the top 20 identified outfalls, which contribute the highest mass loadings to the Pawtuxet, Woonasquatucket, Moshassuck and Seekonk Rivers and/or contribute the greatest potential environmental impact. DEM has and will continue to serve in an advisory capacity to RIDOT on this project including the prioritization of future stormwater retrofit projects including those discharging into Greenwich Bay.

Similar to Warwick and East Greenwich, the RIDOT must comply with the Phase II Stormwater Permit requirements, including submittal of a Stormwater Management Project Plan (SWMPP). In areas where a TMDL has been completed and identifies discharges or areas of concern, Phase II stormwater general permit requires that responsible parties amend their plan accordingly.

Comment 19
Greenwich Bay should continue to be considered a vital part of DEM's Statewide monitoring plan and continued to be monitored accordingly.

Response 19
See Comment 15.

Comment 20
DEM should monitor Greenwich Bay in both wet and dry weather conditions. Currently DEM focuses its monitoring efforts during dry weather events and this monitoring is almost exclusively tied to shellfish closures and openings. The City, in cooperation with DEM, is currently embarking on a $500,000 infiltration project in the Brush Neck Cove sub-watershed. To evaluate the effectiveness of this system, water quality in Southern Creek and Brush Neck Cove should be tested before and after the BMP is constructed to monitor for improvements in water quality.

Response 20
DEM is developing approaches to assist municipalities with post-implementation monitoring. DEM is proposing a study that will evaluate the effectiveness of various BMP technologies installed throughout Rhode Island. Depending on the construction schedule, DEM would promote the White Avenue infiltration trenches as an appropriate project.

Comment 21
The data utilized for the draft TMDL (including the beach closure data) appears to be from October 2000 to December 2001. Why wasn't the data from the 2002-2003 monitoring program utilized for the TMDL?

Response 21
See Response to Comment 14.

Comment 22
Page 34
"*It is recommended that preliminary design studies should evaluate means of distributing treatment structures within the watershed in addition to end-of-pipe solutions at the water's edge.*" The City of Warwick has no objection to this recommendation provided that the RI Department of Environmental Management provides a funding source for such implementation measures.

Response 22
See Response to Comment 17.

Comment 23
Page 35
"*Warwick should also conduct a BMP feasibility study to identify locations and technologies for installing BMPs for Hardig Brook and the Gorton Pond tributary.*" The City of Warwick agrees to the need for this study. However, the City does not have capability of funding such study and requires that DEM provide financial and technical assistance to implement this measure.

Response 23
See Response to Comment 17.

Comment 24
Page 36 DOT
DOT should not only coordinate its efforts with the City of Warwick, but also with DEM. As the state-regulating Agency, it is DEM's responsibility to assure the City that DOT will improve its drainage system by designing and installing necessary BMPs. This implementation measure recommends that DOT complete feasibility studies for BMPs within the lower Hardig Brook and Gorton Pond tributary; this recommendation should also include implementation of the study findings. This section requires much more detail and additional recommended implementation measures. Please clarify DEM's efforts to bring state drainage systems into compliance.

Response 24
See Response to Comment 18.

Comment 25
Page 37
"*DEM recommends that communities adopt ordinances for those areas where sewers are not planned to establish an enforceable mechanism to ensure that existing septic systems are properly operated and maintained*." The responsibility for enforcement relative to septic system operation and maintenance belongs to DEM's ISDS division. This recommendation should be amended to substitute "*DEM*" for "*communities*." Should DEM seek to transfer responsibility of septic system enforcement to local communities, DEM should fund any and all such programs.

Response 25
Consistent with the Rhode Island's Coastal Nonpoint Pollution Control Program, the TMDL recommends, "that communities adopt ordinances for those areas where sewers are not planned to establish an enforceable mechanism to ensure that existing septic systems are properly operated and maintained". The recommendation is not meant to diminish DEM's role as the primary regulatory authority for the siting, design, and construction of septic systems (whether a new system or repair or upgrade to an existing system) and for the enforcement of state ISDS regulations. Adoption of a local ordinance to ensure the proper operation and maintenance of septic systems establishes a pro-active approach to prevent problems associated with improperly functioning systems. The emphasis is on avoidance of failures and extending the performance and service life of the systems. Such management approaches are not only in the best interest of the environment but also residents of the community. Improperly functioning septic systems can adversely affect property values, local resources of importance to neighborhoods, and the quality of life for many residents.

The TMDL's recommendation recognizes that local government is better able to provide oversight and management of such maintenance programs than state government. Local government often has more direct interaction with individual homeowners on a day-to-day basis than state government, such as through its schools, neighborhood contacts, sanitation programs, water and sewer services, grant/loan programs, minimum housing, and fire inspections. The state on the other hand is best positioned to manage the initial septic permitting requirements of individual homes and subdivisions, operation of high volume package plants, illegal installations, and enforce against egregious violators.

The majority of local governments has acknowledged these important connections and has already adopted maintenance management programs or is planning how to do so. To date, ten Rhode Island communities have implemented Septic System Management ordinances and another thirteen are in the process of developing plans to do so. Additionally, municipalities with plans meeting certain criteria are eligible to apply to the Community Septic System Loan Program, which provides loans to homeowners through the RI Clean Water Finance Agency for the replacement or repair of their ISDSs. To date, seven Rhode Island communities have established CSSLP loan programs and another three are in the process of developing loan programs. The local programs are seen as appropriate and complementary to DEM's regulatory programs.

Comment 26
Page 40
Table 5.2 Implementation Measures Summary
Implementation Measure Number 5 (wastewater treatment). *"Ordinances should be adopted for areas without sewers that require septic system maintenance*." These ordinances should be adopted and enforced by DEM ISDS division, not the municipalities.

Response 26
See Response to Comment 25.

Comment 27
Implementation Measure Number 12: Bacterial Source Monitoring-DNA. This measure is strongly supported by the City of Warwick and the City would support any measures by the State to monitor City beaches in the same fashion.

Response 27
DEM and HEALTH continue to work together to get funding to complete DNA sampling projects at the beaches.

Comment 28
Page 42
"*Also, as proposed BMPs are installed in the watershed, post-construction influent and effluent sampling will be required to assess the effectiveness of the selected technologies*." The City has no objection to this measure provided that DEM is responsible for all aspects of the monitoring or that DEM provides funding for the City to hire consultants to complete the monitoring.

Response 28
See Response to Comment 20.

Jon Torgan, Save the Bay (letter March 12, 2004)
Comment 29
Nutrients are as serious a source of pollution in Greenwich Bay as pathogens. While Save The Bay recognizes that nutrient pollution abatement is not the focus of this draft TMDL document, nutrient and pathogen pollution sources must be addressed concurrently with bacterial sources to meet water quality standards. The Department should continue to aggressively develop this TMDL incorporating and addressing all the major known sources of water quality impairment in Greenwich Bay Waters.

Response 29
See Response to Comment 3.

Comment 30
The section dealing with stormwater management and specific stormwater pollution control measures could be made stronger by clarifying which of the measures are enforceable/required

vs. which are voluntary or recommended by DEM. Loosely interpreted, the six minimum measures appear to exempt small flows. While the “illicit discharge detection and elimination” measure could provide some justification for enforcement, Save The Bay believes the Department needs to retain the authority to enforce against any dry-weather discharge taking place without a permit.

Response 30
In accordance with the Clean Water Act (CWA), the Department has the authority under the RI Water Quality Regulations and the RIPDES Regulations to address Illicit Discharges from small MS4s to waters of the State. Under the RIPDES Regulations, the operator of the MS4 is required to identify, investigate, eliminate illicit discharges, and track and report their actions. These regulations do not exempt small illicit discharges, as suggested by the commenter. The operator is required to develop local ordinances with enforcement authority to require the elimination of illicit discharges. The DEM did not delegate its authority under the CWA to the operator and maintains the right to intercede in any enforcement proceeding or take separate action if it becomes necessary. The operator is expected to use the local enforcement authorities established by local ordinances to effect the elimination of the discharge. The DEM encourages the operator to use local authorities to resolve illicit discharges. However, the DEM may take concurrent actions or intercede, especially in situations that are not being resolved in a timely manner or are causing significant environmental impact.

Comment 31
Save The Bay believes that all relevant sources of data, including beach monitoring information from the Department of Health, should be centrally compiled and managed in the future to ensure the collection and public accessibility of useful data.

Response 31
State legislation passed in 2004 tasks the newly created Rhode Island Environmental Monitoring Collaborative with developing a statewide data management system that would, among other objectives, make data publicly accessible (presumably web-based). Incorporation of a geographic referencing system, for example to allow for sorting of data by waterbody, is envisioned. The task of developing such a data management system is significant and will likely take dedicated resources and time to accomplish.

Comment 32
With respect to the no-discharge/marine pump-out issues, Save The Bay fully supports the Department’s recommendations and offers our continued assistance in making this program successful.

Response 32
No response needed.

Comment 33
We recognize that while technical staff is not in a position to advocate for funding or additional personnel, the existing state program cannot implement this TMDL without a significant commitment of additional resources. Save The Bay is concerned that the timetable for

implementation of this TMDL is too vague. Without a long-term commitment to the specific actions recommended in the TMDL, the implementation is at risk of open-ended delays.

Response 33
See response to comment 15.

Melville P. Cote, Jr., Environmental Protection Agency (letter March 16, 2004)
Comment 34
Our review did not raise significant concerns for 13 of the 15 waterbody segments covered by this analysis. EPA has accepted the percent reduction approach for bacteria TMDLs in some rivers and streams under the assumptions that in well-mixed systems bacteria densities are relatively uniform and that the reductions needed to meet applicable water quality standards (WQS) at ambient stations are representative of the reductions needed to meet the applicable standards throughout the waterbody.

Response 34
No response needed.

Comment 35
For the Greenwich Bay and Buttonwoods Cove segments . . . the State has not selected the appropriate water quality targets for waters adjacent to Oakland Beach, City Park/ Buttonwoods, and Goddard State Park. For these waters, the State has chosen the bacteria criteria to protect swimming as the water quality target. As the criteria to protect swimming are significantly less stringent than the criteria to protect shellfishing, another Class SA designated use that applies to these waters, the swimming criteria are not the appropriate water quality targets.

To calculate the reductions needed to support the shellfishing use in the Greenwich Bay and Buttonwoods segments of this TMDL, DEM relies solely on data collected at off shore ambient shellfish monitoring stations. For the Greenwich Bay segment, these stations are 250 yards and more from shore. EPA has significant concerns regarding whether these stations are representative of the bacteria densities in the near shore waters of these segments. The need for additional data in this case is supported by DEM's analysis of data collected at Greenwich Bay beaches by the Rhode Island Department of Health (DOH) that documents higher densities of bacteria in these near shore waters. The fact that federal Food and Drug Administration's (FDA) shellfish monitoring protocols require shoreline sanitary surveys in addition to ambient water quality monitoring further supports the need for supplemental near shore data.

Response 35
In response to EPA's concerns regarding the selection of appropriate water quality targets, DEM has revised Section 3.1 to clarify that waters adjacent to the licensed beaches located in Class SA waters have been evaluated for both shellfishing and swimming uses. The second sentence of the following passage has been added to the TMDL document. The first sentence existed in the original draft.

> The twelve stations located in Class SA waters will be used in this TMDL to set the percent reductions needed to attain compliance with the water quality standards for harvesting

shellfish. In addition, the swimming use at licensed beaches within these areas was evaluated utilizing HEALTH data as presented in the next section.

In response to EPA's concerns regarding the representatives of the sampling stations, the existing language in Section 7.0 Proposed Monitoring has been replaced with the following language.

Additional monitoring is required to ensure that water quality standards are met as remedial actions are accomplished. Monitoring by DEM will be the principle method of obtaining the data necessary to track water quality conditions in the watershed. Also, as proposed BMPs are installed in the watershed, post construction influent and effluent sampling may be required to assess the effectiveness of the selected technology.

In accordance with NSSP requirements, the DEM Shellfish Monitoring Program will monitor water quality and conduct shoreline surveys. DEM will ensure that ambient sampling stations are located adjacent to point sources and effectively evaluate all nonpoint sources of pollution, including the addition and/or modification of sampling locations, as necessary. Shoreline surveys entail the evaluation of the effect of each actual and potential source of pollution on shellfish waters including as necessary, the collection of ambient water quality samples. In addition, non-shellfish program data (such as information on potential sources, beach and volunteer monitoring) will be considered and followed up with confirmatory monitoring by DEM, following NSSP approved methods, as appropriate.

The continued water quality monitoring and future shoreline surveys will be used to help evaluate the effectiveness of the recommendations of the TMDL in restoring designated uses and attaining water quality standards. Ultimately, attainment of the designated shellfishing use requires compliance with the Rhode Island water quality standards including ambient water quality criteria and all NSSP requirements (including evaluation of non-shellfish program data/surveys, special sampling site data, beach and volunteer monitoring, as appropriate).

Comment 36

Section 1 Introduction and Section 2 Description of Study Area

The TMDL contains good descriptions of study area, the impaired segments, the history of water quality in Greenwich Bay and the pollutant of concern. While the draft contains an acceptable general description of the applicable water quality standards and setting numeric water quality targets, as described below, EPA is concerned with the way these are interpreted for the purposes of characterizing water quality and setting targets in this TMDL.

Response 36

See response to comment 35.

Comment 37

Shellfish Stations (pp. 12-13) and Table 3.1 (p. 14) – Offshore shellfish monitoring stations are used to represent water quality in the Greenwich Bay and Buttonwoods Cove segments of this TMDL. For Greenwich Bay, these stations are located 250 yards and more from shore. EPA does not agree that these stations are representative of water quality in the near shore waters of these segments. In large waterbodies that are less likely to have uniformly distributed pollutant loadings, such as Greenwich Bay, additional analysis is needed to demonstrate that the waterbody is spatially represented by ambient water quality data to support application of the percent reduction approach. The need for additional data is supported in this case by DEM's analysis of data collected at Greenwich Bay beaches by the Rhode Island Department of Health (DOH) that documents higher densities of bacteria in these near shore waters than at the offshore monitoring stations. The fact that FDA shellfish monitoring protocols require shoreline sanitary surveys in addition to ambient monitoring also supports the need for additional near shore data to assess water quality conditions in these segments.

The TMDL should be revised to use the DOH beach data, storm water and other shoreline survey data that are collected as part of the State shellfish monitoring program, or other appropriate near shore data along with the ambient shellfish monitoring stations to assess the water quality conditions of these segments. As necessary, EPA remains committed to assist the State in the selection, collection, and analysis of other appropriate near shore data, or the identification of other means to address this issue.

Response 37
See Response to Comment 35.

Comment 38
Beach Stations (p. 14) and Table 3.2 (p. 15) – The State has not selected the appropriate water quality targets for waters adjacent to Oakland Beach, City Park/Buttonwoods, and Goddard State Park. EPA regulations at 40 C.F.R. §130.7(c)(1) require states to develop TMDLs for waters listed in accordance with 40 C.F.R. §130.7(b) at levels necessary to "attain and maintain applicable narrative and numeric [water quality standards] with seasonal variation and a margin of safety." In the draft TMDL, the State asserts "[t]hough the beaches are located in Class SA waters; their water quality target is set to the swimming standard" (Table 3.2 – Beach Water Quality, Footnote 3,). As the water quality criteria that protect swimming are significantly less stringent than the criteria that have been established to protect shellfishing, another Class SA designated use that applies to these waters, this target is inconsistent with EPA regulations. The TMDL should be revised to establish water quality targets that are consistent with federal regulations regarding applicable water quality standards for all Class SA waters.

Response 38
DEM has consistently interpreted the water quality criteria for shellfish use and made decisions regarding attainment of shellfishing use consistent with the FDA administered National Shellfish Sanitation Program (NSSP) protocol. Unlike some states, RI applies the requirements of the National Shellfish Sanitation Program throughout all waters designated for the harvesting of shellfish for direct human consumption, not just designated shellfish beds within a waterbody. Therefore, the shellfish use of the waters in the vicinity of the beach was evaluated consistent with these NSSP protocol. With respect to the evaluation of swimming use, data collected from the RI Department of Health were compared with the water quality standards for swimming use and presented in Table 3.2. Footnote 3 on Table 3.2 will be revised to read, "Swimming use was evaluated utilizing data collected by HEALTH; shellfish use support has been evaluated consistent with NSSP protocol and is presented in Table 3.1." See also Response to Comment 35 (also from EPA).

Comment 39
The TMDL should also include more recent DOH beach monitoring data on Table 3.2. Data for 2002 and 2003 are available from DOH.

Response 39
See Response to Comment 14.

Comment 40
Water Quality Impairments (p. 23) – It should be noted, based on DOH data, that the waters adjacent to the beaches do not meet the Class SA water quality criteria for shellfishing during either wet or dry conditions.

Response 40
See Response to Comment 35.

Comment 41
Margin of Safety (p. 24) –Where monitoring stations are representative of water quality throughout the segment, the fact that 3 of 6 wet weather samples were collected after a 3" storm (see Comment 43) and the 7 day recovery period used to assess wet weather conditions provide adequate margins of safety (MOS). For sampling locations that are representative of the segment as a whole, the use of the station(s) in the segment with the highest values to calculate required reductions can also be reasonably included as a component of the MOS.

Response 41
No response needed.

Comment 42
Margin of Safety (p. 24) –Where sampling stations are not representative of water quality throughout the segment (e.g. Buttonwoods Cove and Greenwich Bay), the TMDL does not provide an adequate MOS.

Response 42
See Response to Comment 35.

Comment 43
It is not clear whether this storm (the 3 inch storm) was also captured by the wet weather samples used to characterize the cove and tributary water quality.

Response 43
Resources did not allow DEM to sample the tributaries during this storm. DEM used existing wet weather data for the tributaries. In all cases, except the Maskerchugg River, the tributaries were sampled intensively during their sampled storm events. Appendix B provides information on the tributary wet weather samples.

The coves were sampled as part of this rain event. In some cases, if there were three sample stations within a cove, DEM did not sample all three stations. DEM did not sample GA8-1 during this wet weather event, but DEM did sample GA8-2, an adjacent station also located within Greenwich Cove. Similarly, DEM sampled GA8-23 once during this wet weather event (other stations were sampled three times), but DEM did sample GA8-22, an adjacent station also location within Warwick Cove. Appendix A contains sampling results from all estuarine stations.

Comment 44
Establishing the Allowable Load (p. 25) – Both the offshore waters where the shellfish data are collected and the beaches are Class SA waters with the same applicable criteria. The final sentence of this section should be revised to clarify that all SA waters are required to meet the shellfishing criteria.

Response 44
See Response to Comment 35.

Comment 45
Comparison of the Weighted 90th Percentile Value to the percent exceeding standard (p. 26) – EPA is not convinced that it is appropriate to use separate wet and dry 90th percentile values to calculate weighted values. However, as the proposed approach does not appear to have a significant impact to the required reductions in this case, EPA does not believe revising the TMDL is warranted. This determination would need to be evaluated on a case-by-case basis.

Response 45
DEM believes that the "weighted" approach for determining the percent exceedance value produces more representative values than the "pooled" approach – particularly when the data set is not extensive and is biased toward dry weather conditions. We refer to the separate memorandum from Chris Turner to Steve Silva that draws upon the data from several TMDL studies to illustrate this point.

Comment 46
Required reductions (p. 26) – EPA appreciates the State's effort to distinguish load from waste load allocations in the draft TMDL. We interpret this section to mean that required reductions are to be met by point and nonpoint sources alike. We recommend that the sentence that begins "Storm water generated on developed land..." should be deleted or revised to read: "Channelized storm water associated with activities that are subject to phases I and II of EPA's regulations for storm water discharges (whether on developed or undeveloped land), are regulated under the RIPDES program as a point source, while unregulated and unchannelized storm water considered nonpoint sources."

Response 46
The purpose of this sentence is ***only*** to explain how DEM allocated reductions to point and nonpoint sources. In the DEM estimate, all storm water generated on developed land is assumed to act as point sources, whereas in storm water generated on undeveloped land is assumed to act as a nonpoint source. In actuality, DEM acknowledges that some storm water on developed will

infiltrate into the ground and never reach a point source conveyance and some storm water on undeveloped land will enter point source conveyance. The two are assumed to be equal. DEM will clarify the document, as follows:

> However, in implementing this TMDL both point and nonpoint controls are necessary to meet the TMDL plan's water quality targets. To guide TMDL Implementation, DEM evaluated Greenwich Bay watershed land use and pollution source data. Using the assumption that storm water generated on developed land is a point source and storm water generated on undeveloped land is a nonpoint source, two-thirds of the required reductions are estimated to be from point sources and one-third is estimated to be from nonpoint sources. These estimates do not alter the determination of point sources regulated under the RIPDES Storm Water Phase II Program. Channelized storm water associated with activities that are subject to phases I and II of EPA's regulations for storm water discharges (whether on developed or undeveloped land), are regulated under the RIPDES program as a point source, while unregulated and unchannelized storm water considered nonpoint sources.

NOTE: In response to comments received from EPA in a letter dates on December 5, 2005, DEM further modified this section. The following statement was added to precede the previous paragraph.

> As is the case for most bacteria impairments, insufficient data existed to accurately differentiate between point and nonpoint sources of bacteria. As recommended by EPA Region 1, all bacteria source reductions for this TMDL will be combined into the wasteload allocation.

Comment 47

Greenwich Bay and Coves (p. 26) – Reductions needed to support shellfishing in the Class SA segments of the draft TMDL, are based on data collected at offshore ambient shellfish monitoring stations. As discussed above, EPA does not agree that these stations are representative of water quality in near shore waters of these segments or that reductions based on these stations will meet applicable water quality standards throughout these segments, as required by the EPA's regulations at 40 C.F.R. §130.7(c)(1).

Response 47

See Response to Comment 35.

Comment 48

The DOH beach data, storm water and other shoreline survey data that are collected as part of the State shellfish monitoring program, or other appropriate near shore data should be used along with the ambient shellfish station data to calculate the highest percent reductions needed to meet the applicable water quality criteria in these segments.

Response 48

See Response to Comment 35.

Comment 49
Evaluating Swimming Use (p. 27) **–** As discussed above, DEM's evaluation of swimming use for beaches in Greenwich Bay is based on an incomplete application of the water quality criteria for these waters. The required reductions for these waters must be based on meeting the standards applicable to the shellfishing use for these Class SA waters.

Response 49
The title and purpose of this section is to discuss the swimming use. Since the Department of Health uses the swimming water quality standard and not the shellfish standard when evaluating the beach data, DEM believes that this section does not need to be changed. See also response to comment 38.

Comment 50
Table 4.4 (p. 29) **–** For tributary reaches where either dry or wet weather data are missing (i.e. Stations HB00 and TB04), the State should acknowledge the data gaps and calculate required reductions using the available data.

Response 50
DEM will add a footnote to Table 4.4 stating that the surrounding stations adequately characterize the water quality conditions and required reductions at these locations.

Comment 51
Figure 3.1 (p.13) **–** EPA recommends that this table be updated to a more current shellfish closure map.

Response 51
This is the appropriate shellfish closure map because it corresponds with the dry weather data that was used for the TMDL analysis.

Comment 52
Figure 3.2 (p. 18) **–** Poor reproduction of this figure makes it impossible to identify the location of the monitoring points referenced in the text and tables.

Response 52
File size increases as figure quality increases. DEM wanted the online document to be accessible to those without high-speed Internet connections. DEM will attempt to make this figure more legible in future versions of the TMDL document. DEM did provide a description of all station locations in Appendix B.

Comment 53
Table 4.4 (p. 29) **–** For Stations HB07 and HB08, it appears that there should be a superscript 3 in the "Water Quality Classification" column here and on Table 3.3 (p. 19). For Stations GP03, MB04, M01 and WW11, it appears that the superscript 2 in the "Water Quality Classification" column should be replaced by a superscript 3. For Station SC03, it appears that the Superscript 1 in the "Water Quality Classification" column should be replaced by a superscript 2.

Response 53
These changes will be made to the TMDL document.

Comment 54
Table 3.5 (p. 21) – It would be helpful to provide the 80th percentile data for the East Greenwich WWTF bacteria discharge to better characterize this bacteria source.

Response 54
It is not clear why EPA believes it would be helpful to see the 80th percentile value from the East Greenwich WWTF. The facility discharges to a Class SB1 water. The water quality standard for Class SB1 waters includes a 90th percentile requirement. Specifically, not more than 10% of all samples can exceed 500 MPN / 100 mL. For the time period reviewed (299 samples taken between January 1, 2000 and December 31, 2001), the 90th percentile value is 14 MPN / 100 mL for the East Greenwich WWTF.