FECAL COLIFORM TMDL

FOR

PALMER RIVER, RHODE ISLAND

Prepared by:

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March 15, 2002

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EXECUTIVE SUMMARY

TMDL: Palmer River, Rhode Island (RI0007022E-01)
Effective Date: 10/20/2000

This document addresses fecal coliform impairments to the Palmer River, extending north from the Bike Path Bridge in the Towns of Warren and Barrington to the Massachusetts State line as shown in Figure 1. The River has been listed in Rhode Island's 1998 303(d) List of Impaired Waters for not supporting its designated uses: shellfish harvesting for direct human consumption; primary and secondary contact recreational activities; and fish and wildlife habitat.

Section 303(d) of the Clean Water Act and EPA's implementing regulations in 40 CFR § 130 describe the statutory and regulatory requirements for approval of Total Maximum Daily Loads (TMDLs). This executive summary contains the information generally considered to be necessary for EPA to determine if the TMDL contained in this document generally fulfills the legal requirements under Section 303(d) and EPA regulations.

1 Description of waterbody

The Palmer River lies in northeastern Rhode Island and southeastern Massachusetts. The upper fresh water reach of the River lies in the Town of Rehoboth. Smaller portions of the River extend into Seekonk, Attleboro, Swansea, Norton, Taunton, and Dighton. Significant areas of the watershed drain to Shad Factory Pond and Warren Upper Reservoir, which are water supply reservoirs for the Bristol County (RI) Water Authority (BCWA). The BCWA provides drinking water to the communities of Bristol, Warren and Barrington in Rhode Island.

Below the Shad Factory Pond Dam, the Palmer River flows along a sinuous course south into Rhode Island. The lower river has a number of oxbows and is tidal in this reach, periodically to the Shad Factory Dam. The salinity intrusion may extend as far north as the Providence Street Bridge. Shortly after the River passes seaward under the Route 6 bridge, it enters the Town of Swansea and widens into a tidal embayment. The majority of the river has salt marshes along its banks and it is one of the least developed rivers in the State of Rhode Island. Belcher Cove extends to the east off the southern end of the lower Palmer River and is fed by two small streams that flow through the Town of Warren, RI. At upper Grinnell Point, the Palmer flows through a constriction that is spanned by the East Bay Bicycle Path and Route 114. A few hundred meters south of the Route 114 Bridge, the Palmer merges with the Barrington River at Tyler Point to form the Warren River.

This TMDL addresses the Rhode Island portion of the Palmer River from the state boundary to the East Bay Bicycle Path Bridge. The waterbody identification number of this reach of the Palmer River is RI007022E-01 and its water quality classification is SA. The reach of the River from the Bike Path Bridge to its confluence with the Barrington River is assigned a water quality designation of SB1 and is not included in this TMDL.

2 Description of applicable water quality standards and numeric water quality target

State water quality standard

The Rhode Island portion of the Palmer River is a Class SA waterbody. Table 2 of Rule 8.D of the State's Water Quality Regulations lists the conditions that need to be met in a Class SA waterbody. Fecal coliform concentrations are, "*not to exceed a geometric mean MPN value of 14*

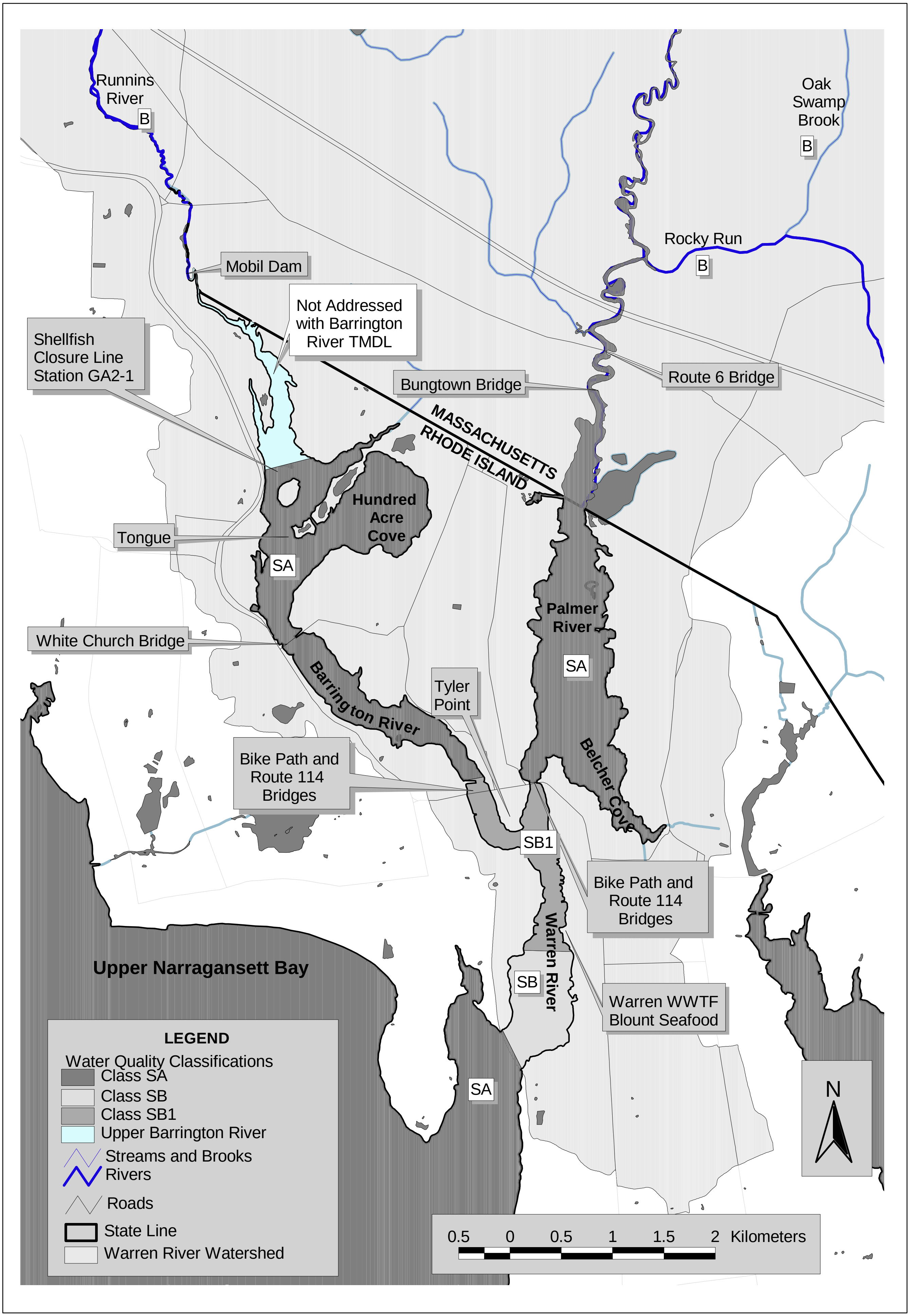


Figure 1. The Barrington, Palmer, and Warren Rivers and their water quality classifications.

and not more than 10% of the samples shall exceed an MPN value of 49 for a three-tube decimal dilution."

Designated uses

The Regulations describe Class SA waters as "*designated for shellfish harvesting for direct human consumption, primary and secondary contact recreational activities and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation, and industrial cooling. These waters shall have good aesthetic value.*" The Palmer River is regionally significant as a habitat and shellfish resource. The area supports hard and soft-shell clams, blue crab, and oyster fisheries. The State of Rhode Island has historically maintained commercial shellfishing in the Palmer River. The area is also locally used for recreational boating, fishing, and bathing.

Numeric Water Quality Target

The numeric water quality target for the Palmer River is a geometric mean fecal coliform concentration of 14 fc/100 ml, with not more than 10% of the samples exceeding 49 fc/100 ml.

Antidegradation Policy

The State's antidegradation policy requires that existing uses and the level of water quality necessary to protect existing uses shall be maintained and protected. Existing uses for the Palmer River include fishing, shellfishing, swimming, and boating. The State's water quality goals for the Palmer River are consistent with these uses therefore the antidegradation policy is met by attaining the water quality standards.

3 Current conditions, pollutant of concern, pollutant sources, and priority ranking

Current conditions

The current condition of the Palmer River was determined by calculating a weighted average fecal coliform concentration for each of the 5 stations in the Palmer River sampled by the RIDEM Shellfish Program (Figure 2). This calculation includes concentrations from wet and dry weather and incorporates the percentage of days the river is in dry and wet weather states. For more information on the weighted average calculation please refer to the weighted average section. The weighted average geometric mean concentrations are higher in the upper part of the River and decrease in a downstream direction with the exception of station 7A located in Belcher Cove (Table 1).

Table 1: Receiving water characterization summary.

Station	Dry Weather Geometric Mean (fc/100 ml)	Number of samples, dry weather	Wet Weather Geometric Mean (fc/100 ml)	Number of samples, wet weather	Weighted Average Geometric Mean fc/100 ml	Percent of values > 49 fc/100 ml
6A	62*	44	1400*	4	1066*	59%*
6	18*	54	582*	5	441*	30%*
7	10	55	82*	5	64*	17%*
7A	14	53	105*	5	82*	8%
8	10	62	54*	5	43*	6%

*Values violate water quality standards

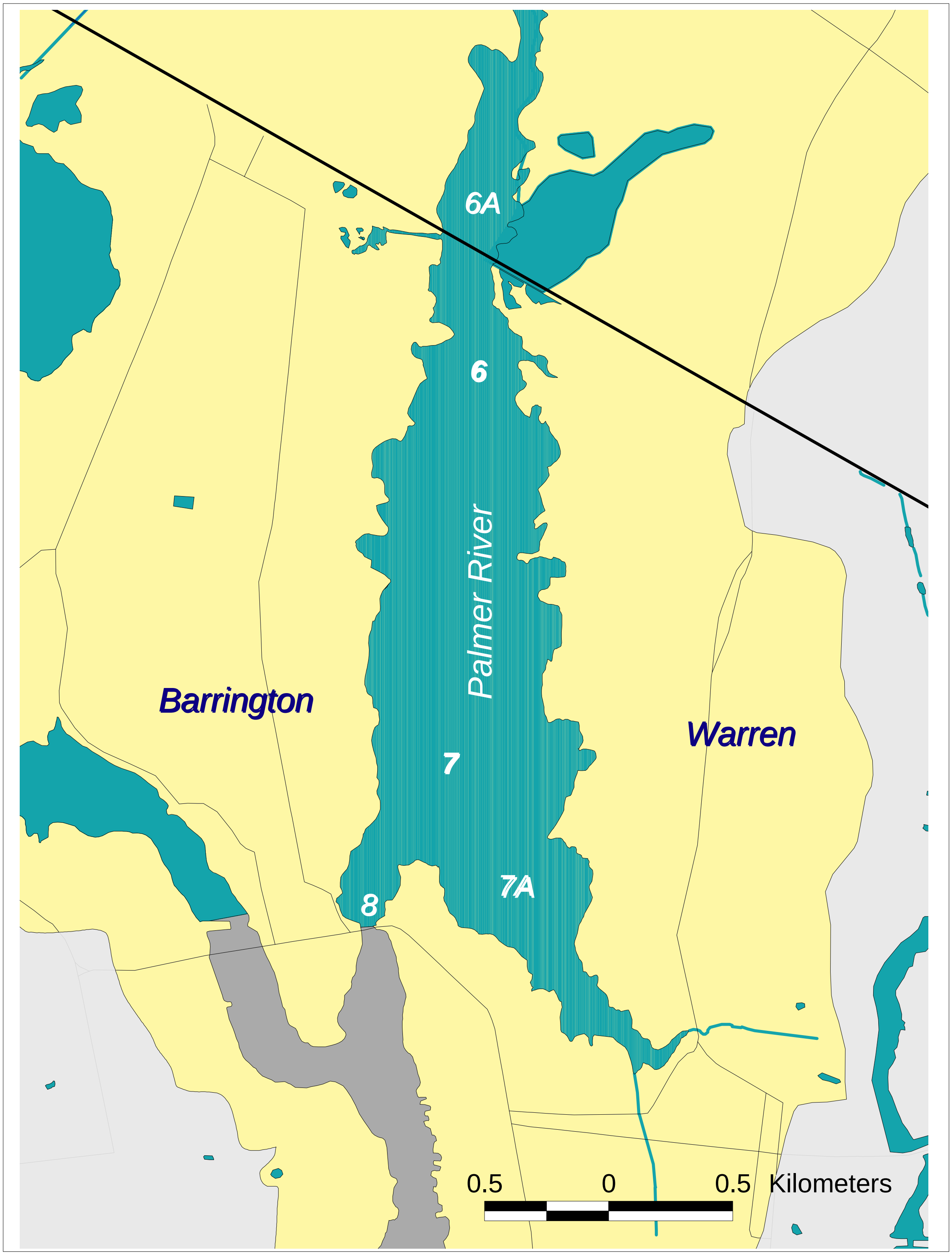


Figure 2. RIDEM shellfish survey station locations in the Palmer River

Priority ranking

The Palmer River was placed on the State of Rhode Island's 1998 303(d) List of Impaired Waters for pathogens (RIDEM, 1998b). Because the River had historically been used as a shellfish harvesting area, it was listed as a Group 1 waterbody, to be given the highest priority for TMDL development.

Pollutant of concern

The 303(d) listing was based on the results of ambient water sampling for fecal coliform, which is used by the State as an indicator of pathogen contamination.

Pollutant sources

The impaired reach of the Palmer River was divided into three segments. These include the upper Palmer River, lower Palmer River and Belcher Cove (Figure 3). Additionally, sources in the Warren and Barrington Rivers, seaward of the Palmer River were also evaluated, as this is a tidal system. A detailed description of individual sources is presented in the TMDL report (page 11). A brief summary of pollutant sources by stream segment is presented below.

Upper Palmer River

The predominant sources of fecal coliform are located in the tributaries to the upper Palmer River in Massachusetts. These fecal coliform sources are the predominant contributors to the high bacterial concentrations downstream in the main body of the Palmer River. The highest bacterial concentrations observed in the upper Palmer River watershed during wet weather were associated with runoff from adjacent cropland, pasture, and dairy farms. Fecal matter from domestic animals, wildlife, waterfowl and failing septic systems may also be washed off forested areas, lawns, golf courses, and roadways into the Palmer River during rain events. RIDEM considers station 6A, located in the upper portion of the main body of the Palmer River to represent Massachusetts' sources to the Rhode Island portion of the Palmer River in both dry and wet weather (Table 2).

Lower Palmer River

The lower Palmer River is influenced by sources upstream in the Palmer River, which include the upper Palmer River and Belcher Cove. Other sources along the banks of the Palmer River, including the large wetlands bordering either side of the river, were determined to be negligible in dry weather. The RIDEM Shoreline Survey sampled all sources including pipes and streams located along the shoreline of the Palmer and Warren Rivers in Rhode Island. The survey found three dry weather sources that may also be potential wet weather contributors to the system. The areas along the river may serve as sources during wet weather due to wash off of fecal matter from domestic animals, wildlife, waterfowl and failing septic systems. RIDEM has concluded that there are no significant sources in this area of the river other than sources in the headwaters and natural background.

Belcher Cove

Two streams flow into Belcher Cove and contribute to the fecal coliform concentrations. These two streams, Belcher Stream East and Belcher Stream West have higher weighted geometric mean fecal coliform concentrations than station 6A in the upper Palmer River. The flow rates from these small streams are much lower, whereas station 6A is in the main body of the river where downstream flow and the total contribution of bacteria is much higher. Belcher Stream West has high bacteria concentrations in dry and wet weather due several pet waste problems and urban runoff from roadways and commercial properties. Belcher Stream East is problematic

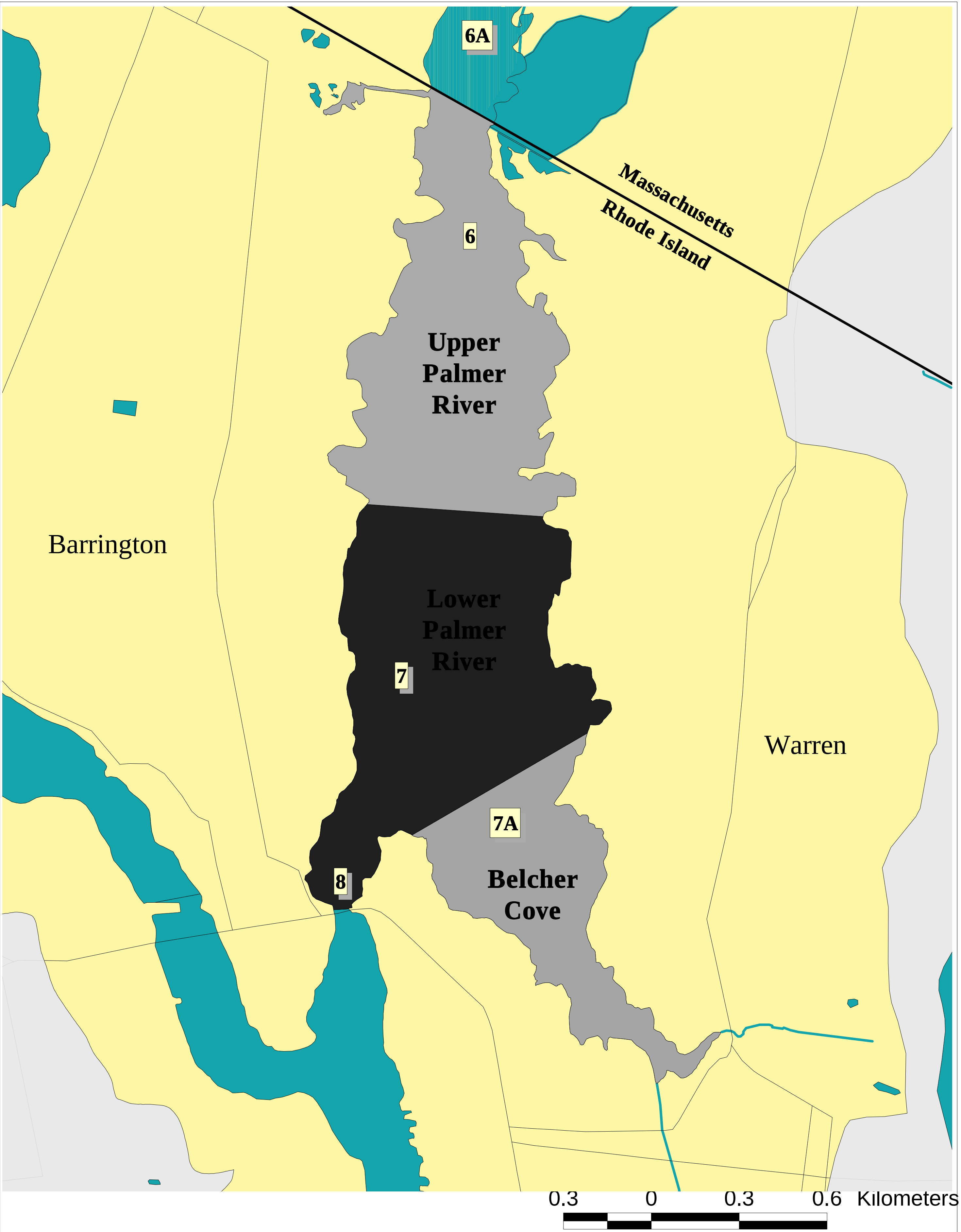


Figure 3. Segments of the Palmer River including survey station numbers.

only in wet weather. The predominant source in this stream is a small cattle farm located upstream on the southern fork of the tributary (Table 2). Other sources in this stream include wildlife, waterfowl, domestic animals and possible failing septic systems on the north fork of the stream.

Warren/Barrington Rivers

RIDEM determined that the influence from the Warren and Barrington Rivers is insignificant because their combined contribution to the Palmer River fecal coliform elevation is less than 1 fc/100 ml. This was determined based on water quality modeling performed for the Barrington River TMDL. The model was run using the conditions of the October 1998 storm described in the Barrington River TMDL document (RIDEM, 2000c). The storm event was evaluated with and without bacterial loadings from runoff to the Barrington and Warren Rivers. The model showed that the mean concentrations at the mouth of the Palmer River over the course of the storm event were elevated by 0.3 fc/100 ml from the influence of the Warren and Barrington Rivers.

Table 2: Weighted average geometric mean values for pollutant sources to the Palmer River.

Section of River	Sources	Weighted Average Geometric Mean fc/100 ml	Dry Weather Sources	Wet Weather Sources
Upper Palmer River	Station 6A	1066	Farms, domestic animals, wildlife, and waterfowl.	Farms, agricultural lands, domestic animals, wildlife, waterfowl and failing septic systems
Lower Palmer River	Upper Palmer River and Belcher Cove (Station 7)	64	None	Storm water runoff
Belcher Cove	Belcher Stream East	5753	None	Cattle farm, wildlife, waterfowl, domestic animals, storm runoff from urban and suburban sources
	Belcher Stream West	3888	Pet Waste	Pet Waste, runoff from roadways and commercial properties
Warren and Barrington Rivers	Palmer River, Narragansett Bay	6	None	Urban/ suburban runoff

Point Sources

The only point source that discharges directly to the Palmer River is Lloyd Manufacturing Company. This company makes rubber sheeting and thread, and discharges cooling water into Belcher Cove via Belcher Stream West. Point sources downstream of the Palmer River include the Warren WWTF, Blount Seafood, and upper Narragansett Bay. Downstream point sources in the Warren and Barrington Rivers are not significant dry or wet weather fecal coliform sources, nor is upper Narragansett Bay (Tables 2 and 3). The influence of downstream point sources, including the Warren River, on the lower Palmer River is not distinguishable from natural background levels, or from the influence of earlier upstream loading. For a more detailed description of the point sources please see section 4.6 in the main body of this document.

Table 3: Waste load concentrations for point sources in the Palmer River.

Point Source	Present concentration
Lloyd Manufacturing Company	Not measured
Warren Wastewater Treatment Facility	10.1 fc/100 ml Geometric mean (1998-2000)
Blount Seafood	29.3 fc/100 ml (1998-2000)

Natural background

It was not possible to separate natural background from the total nonpoint source load due to a lack of site specific data on fecal coliform contributions from wildlife in the watershed.

4 TMDL endpoint – linking water quality and pollutant sources

Loading capacity

As described in EPA guidelines, a TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards (40 C.F.R. 130.2). The loadings are required to be expressed as mass-per-time, toxicity, or other appropriate measures (40 C.F.R. 130.2[I]). EPA Region 1 has determined that it is appropriate to express a bacteria TMDL in concentration units. The loading capacity for this TMDL is therefore expressed as a concentration set equal to the state water quality standard.

Linking water quality and pollutant sources

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

Supporting documentation for the TMDL analysis

Studies considered significant to the determination of the TMDL are presented in Table 4. Included are those studies containing information used to characterize the present water quality condition, significant sources, factors significant in affecting bacterial conditions in the river, and the analysis framework. References to external documents are cited in the reference section to this document.

Table 4: Supporting Documentation

Study name	Reference
Oceanography of the Palmer River	Brown University, 1997
Water Quality Regulations	RIDEM, 1997b
Characterization to Support TMDL Development for the Barrington, Palmer, and Runnins River Watershed	RIDEM, 1999b
Fecal Coliform TMDL for the Barrington River	RIDEM, 2000c
Fecal Coliform TMDL for the Hunt River	RIDEM, 2000b
Fecal Coliform TMDL for the Runnins River	RIDEM, 2000d

Strengths/weaknesses in the analysis process

The Palmer River TMDL was developed using data from a number of sources. The majority of data used were collected by RIDEM between 1996-1999. Both dry and wet weather fecal coliform concentrations were measured over a range of seasons and land use was investigated. The Massachusetts Department of Marine Fisheries collected data in many of the tributaries feeding the upper Palmer River during 1997. Brown University collected hydrologic data that included time series measurements of tidal properties and variations in salinity at the Route 6 Bridge in Swansea in the fall of 1997.

Strengths:

- Dry weather data were collected over several years
- Relatively detailed sampling was conducted in the Rhode Island tributaries to identify sources.

Weaknesses:

- Only one complete wet weather event was sampled for fecal coliform from pre-storm to 6 days after the storm.
- Stations in the upper Palmer River were sampled less frequently than stations lower down because low tidal conditions made the upper river too shallow to access by boat.
- Given RIDEM's limited resources and that the majority of the watershed lies in Massachusetts, sampling primarily focused on the lower Palmer River watershed. Sampling in the headwaters was limited to the characterization of loads from tributaries, with some bracketing of significant sources.

Critical conditions

- Wet weather, summer season.

5 Waste Load Allocations (WLAs)

Allocations for the point sources discharging to the Palmer and Warren Rivers are the same in dry and wet weather and have been set to their current RIPDES permit limits (Table 5). Although, technically considered point sources, storm water pipes were included in the LA because no information was available on specific storm drains. Other than storm water pipes, the only point source in the Palmer River watershed is the Lloyd Manufacturing Company (RIPDES permit number RI000074). Other point sources that have the potential to impact the Palmer River include Blount Seafood (RIPDES permit number RI0001121) and the Warren Wastewater Treatment Facility (RIPDES permit number RI0100056). Both facilities discharge to the Warren River, which lies just downstream of the Palmer River, sources that discharge to the Warren River could potentially impact the Palmer River during flood tide. Based on dye studies, the RIPDES permits for the Warren Waste Water Treatment Facility and Blount Seafood established acute mixing zones for their discharges. These mixing zones were determined to dilute the effluent to a concentration well below the SB limit in the Warren River. From examining the dye studies, RIDEM has concluded that increasing or decreasing loadings from these sources has very little impact on water quality in the Palmer River.

Table 5: Waste load allocations to point sources.

Point Source	Existing Concentration fc/100 ml	Allocated Concentration fc/100 ml	Percent Reduction
Lloyd Manufacturing Company	N/A	0	N/A
Warren Wastewater Treatment Facility	10.1[1]	200	0 %
Blount Seafood	29.3[1]	200 summer / 3100 winter*	0 %

[1] 1998-2000data

6 Load allocations (LAs)

Nonpoint Sources

The goal of this TMDL is to ensure that water quality is sufficient to meet designated uses of the waterbody. Nonpoint sources were assigned allocations in the Palmer River system based upon a comparison of the current RIDEM data to the water quality standards. A loading reduction is calculated when the water quality criteria were exceeded at a particular location. Required reductions represent an overall reduction goal that is applicable to the composite of all tributary, point and nonpoint sources contributing to the water quality impairment. Two different calculations were made because there are two parts to the fecal coliform standard. Loading reductions for the first part of the water quality standard, which includes the 14 fc/100 ml limit, were based on a weighted average calculation described below.

Weighted average calculation

The weighted average calculation considers the frequency that a waterbody is in a dry or wet weather condition. The dry and wet weather geometric mean concentrations are multiplied by their frequency of occurrence (0-1.0) and summed to determine the weighted average value. This approach is discussed further in section 7.0 of the TMDL report.

Reductions

The first part of the water quality standard for SA waters requires that the geometric mean fecal coliform value for the sampling area not be greater than 14 fc/100 ml. The percent reductions needed for nonpoint sources in the Palmer River to meet this first criterion are presented in Table 5. Fecal coliform concentrations at the Rhode Island – Massachusetts state line must be reduced by 98% to meet the 14 fc/100 ml standard. In the absence of data to determine if each tributary discharging at the Class A criteria will provide water quality sufficient to meet appropriate uses in the Palmer River, the TMDL requires that each tributary meet the Class SA standard at the point of discharge. Therefore, both Belcher Stream East and Belcher Stream West concentrations must be reduced in excess of 99%, in order to meet the Class SA standard concentration of 14 fc/100 ml. As stated above, storm water pipes although technically considered point sources were included in the LA due to a lack of detailed site-specific information.

The second part of the water quality criteria for Class SA and Class A waters requires that not more than 10% of all samples taken exceed a concentration of 49 fc/100 ml and 200 fc/100 ml, respectively. The reduction necessary to meet this part of the standard at the state line is 79%. For the nonpoint sources in Belcher Cove the required reductions are greater than 99% for both Belcher Stream East (BSE) and Belcher Stream West (BSW).

RIDEM anticipates that, if the reductions discussed above are met, the water quality goals for the Rhode Island portion of the Palmer River will also be achieved. The in-stream reductions required at the Rhode Island stations are presented in Table 6.

Table 6: Percent reductions needed in the Palmer River sources based upon weighted average geometric means and 90th percentile values.

Station/ Location	Weighted Average Geometric Mean			90th percentile value		
	Present condition fc/100 ml	Allocated concentration fc/100 ml	Percent reduction	Present condition fc/100 ml	Allocated concentration fc/100 ml	Percent reduction
State Line	719	14	98%	230	49	79%
BSE	5753	14	99+%	37208	49	99+%
BSW	3888	14	99+%	7273	49	99+%
6	441	14	97%	230	49	79%
7	64	14	78%	93	49	47%
7A	82	14	83%	94	49	48%
8	43	14	67%	50	49	2%

Critical conditions

Water quality monitoring carried out by RIDEM in recent years has shown that fecal coliform concentrations in streams and rivers tend to be highest during the summer months. We expect that this trend is the same for the Palmer River and its tributaries. In addition, past monitoring has shown that fecal coliform levels increase significantly during wet weather and high flow events. Therefore, monitoring conducted in support of this TMDL focused on the critical summer season and included both wet and dry weather conditions.

7 Margin of safety (MOS)

An implicit margin of safety was designed into the weighted average and the loading allocation prior to the final TMDL calculations. Conservative assumptions were made throughout the TMDL process. Conservative estimates of both the amount of rainfall needed to produce runoff and recovery time were used in the weighted average geometric mean calculations. The yearly rainfall estimate was based on the 90 percentile value of total yearly rainfall for ten years.

8 Seasonal Variation

The Palmer River TMDL is protective of all seasons. The highest fecal coliform levels in the Palmer River are expected to occur during the summer season from July through October. Most of the data used in the analysis were collected during the summer months. Any TMDL endpoint established for the summer months will therefore provide protection during the winter months

9 Implementation plans

Mitigation measures designed to bring about water quality improvements to the Palmer River are outlined below. The significant sources are nonpoint in nature, and the improvements achieved by implementing the measures outlined below cannot be quantified. RIDEM therefore recommends continued monitoring of the Palmer River to ensure that the numeric targets are met for the upper estuary.

Palmer River
Because the water quality goal for the Palmer River is SA up to the MA border, the Palmer River TMDL recommends that Massachusetts carry out actions needed to meet the SA standard at the state line. RIDEM studies in the MA portion of the Palmer River watershed determined that significantly elevated bacterial concentrations in storm runoff were associated with agricultural operations adjacent to the Palmer River and Rocky Run (RIDEM, 1999b). Other sources in the watershed could include domestic animals, wildlife waterfowl and failing septic systems. We recommend that the Commonwealth of Massachusetts conduct additional investigations into potential bacterial sources, focusing on areas adjacent to the Palmer River and Rocky Run. The Massachusetts Department of Food and Agriculture has been working with the identified farms and in some cases has provided financial assistance to install management measures to improve water quality. RIDEM recommends that MADEP conduct confirmatory sampling to evaluate the effectiveness of the installed pollution control measures in reducing bacteria concentrations.

Belcher Stream East (BSE) was found to contain significant fecal coliform concentrations during wet weather. A preliminary investigation by RIDEM pointed to several possible causes: septic systems, periodic failures of the sewage collection systems on St. Teresa Street and Metacom Avenue, agriculture, wildlife (i.e. Canada Geese), and storm runoff from the developed areas adjacent to the stream. Septic systems and sewage overflows were eliminated as possible causes upon further evaluation by RIDEM because no septic systems were identified in the area and only one failure of a sewage pumping station on St. Teresa St. (500 gallons on January 20, 1999) could be documented after interviews with local residents and Town officials. The RIDEM Division of Agriculture will provide technical support to the farmer to implement appropriate management practices on the farm.

Belcher Stream West (BSW) is impacted by dog waste and urban runoff. Jamiel Park, located at the mouth of the stream, is regularly used for dog walking, and RIDEM personnel have observed a good deal of dog waste in this park. It is probable that the pet waste is washed directly into the river during rainstorms. Recommendations for the park include the installation of more signage, providing dog waste bags and trash receptacles in strategic places to encourage residents to dispose of the dog waste properly, and enforcing the town's ordinance (3-35.1) for pick up of dog waste. In a letter addressed to the Warren Town Manager on December 12, 2000, RIDEM outlined the pet waste problem and requested Town assistance in coming up with a solution to this issue.

Upstream of the park, RIDEM personnel observed a dog penned up alongside the river where waste from the dog was not cleaned up regularly. During periods of rain accumulated waste would wash directly into the stream. A complaint was filed with OCI for enforcement action. OCI issued a notice to the owner on October 18, 2000, requesting clean up of the site so that the dog waste would not cause a water pollution problem. If the owner fails to comply with the notice, further enforcement action, including assessment of penalties, may be taken.

10 Proposed Monitoring
The RIDEM Shellfish Program limited its sampling of the Palmer River in 2001 since the area is designated as closed to shellfishing and the Food and Drug Administration does not require sanitary surveys in closed areas. RIDEM received information from MADFA prior to the start of

the public comment period in January 2002 that corrective measures had been completed at each of the three farms in Massachusetts. Given this information, the RIDEM Shellfish Program will resume sampling in Growing Area 2 on a systematic random basis. Sampling would therefore be conducted six times a year under randomly selected weather and tidal conditions.

A sampling station should be established at the Bungtown Bridge on Old Providence Road in Swansea during the months of June through October to better track trends in loadings entering the upper Palmer River. This sampling should occur near the time of low tide and could be conducted by the Pokanoket Watershed Alliance in addition to the sampling they conduct in the Runnins River and Hundred Acre Cove. Sampling of the streams that feed Belcher Cove is also recommended on a monthly basis.

RIDEM is currently working on a TMDL for the Palmer River for nutrients and dissolved oxygen. The Massachusetts Department of Environmental Protection has hired Environmental Science Services to conduct sampling for nutrients and bacteria in the Palmer River watershed in Massachusetts. Additionally Save the Bay will be conducting monitoring of the Palmer River Watershed in both Massachusetts and Rhode Island in an effort to assist the two states and their respective communities toward the common goal of a clean Palmer River.

11 Public Participation

Public participation in this TMDL has taken place in two forums. The New England Interstate Water Pollution Control Commission (NEIWPCC) established a steering committee comprised of members of local municipalities, state agencies, EPA, and the Pokanoket Watershed Alliance, in 1993. The Pokanoket Watershed Alliance holds bimonthly meetings that are open to the public.

The second element of public involvement for this TMDL is the presentation of this plan at two public meetings during January 2002. The two public meetings were held at the Barrington Public Library in Barrington, Rhode Island on January 9, 2002 and at the Beckwith School in Rehoboth, Massachusetts on January 10, 2002. During these public meetings, RIDEM solicited public comment on the content and recommendations of the TMDL. The public comment period was from January 9, 2002 through February 10, 2002. RIDEM has prepared responses to all the comments received in a separate document that will be submitted along with the TMDL document to the EPA.

1.0 INTRODUCTION

The State of Rhode Island's 1998 *303(d) List of Impaired Waters* identified the Palmer River (Figure 1.1) as being impaired by pathogens because of high fecal coliform concentrations (1998b). The purpose of this report is to establish a Total Maximum Daily Load (TMDL) addressing fecal coliform loads to the Palmer River. This TMDL serves as a restoration plan for abating fecal coliform sources so that the water quality goals for bacteria can be attained in the river.

1.1 Background

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires States to develop TMDLs for water bodies not meeting designated uses. The objective of a TMDL is to establish water quality-based limits for pollutant loadings that will allow a waterbody to meet its designated uses.

The TMDL analysis examines point source inputs, such as industrial and wastewater treatment facility discharges, and nonpoint sources. Natural background levels and a margin of safety are also included in the analysis to account for any monitoring uncertainties. The goal of this process is to reduce pollutant loadings to the point where the waterbody can achieve State Water Quality Standards for the parameter causing the impairment.

1.2 Pollutant of Concern

Pathogens are the pollutant of concern, as indicated by violations of water quality standards for fecal coliform in the Palmer River. Fecal coliform concentrations in this waterbody have been found to exceed the state's water quality standards. As reported on the 1998 303(d) list, RIDEM had identified the Palmer River as being impaired by pathogens over its entire length in Rhode Island.

1.3 Applicable water quality standards

All surface waters of the state have been categorized according to a system of water use classification based on consideration for public health, recreation, propagation and protection of fish and wildlife, and economic and social benefit. Each class is identified by the most sensitive, and therefore governing, water uses to be protected. Surface waters may be suitable for other beneficial uses, but are regulated to protect and enhance designated water uses. It should be noted that water use classifications reflect water quality goals for a waterbody, which for water bodies considered impaired, may not represent existing water quality conditions (RIDEM, 1997c).

Both Class SA and SB1 waters are found in the Rhode Island portion of the Palmer River. The standards meet the requirements of the Federal Clean Water Act of 1972 and Rhode Island General Laws (Chapter 46-12) and are intended to protect public health, safety, and welfare. The following waterbody segment classifications apply to the Palmer River:

- The Palmer River from the Massachusetts-Rhode Island State line south to the East Bay bike path trestle in Warren, approximately 1000 feet north of the confluence with the Barrington River, is designated as a Class SA waterbody, and is identified as waterbody number RI007022-01.
- The remainder of the Palmer River, south of the Bike Path to the confluence with the Barrington River is designated as Class SB1 and is identified as waterbody number RI007023. This part of

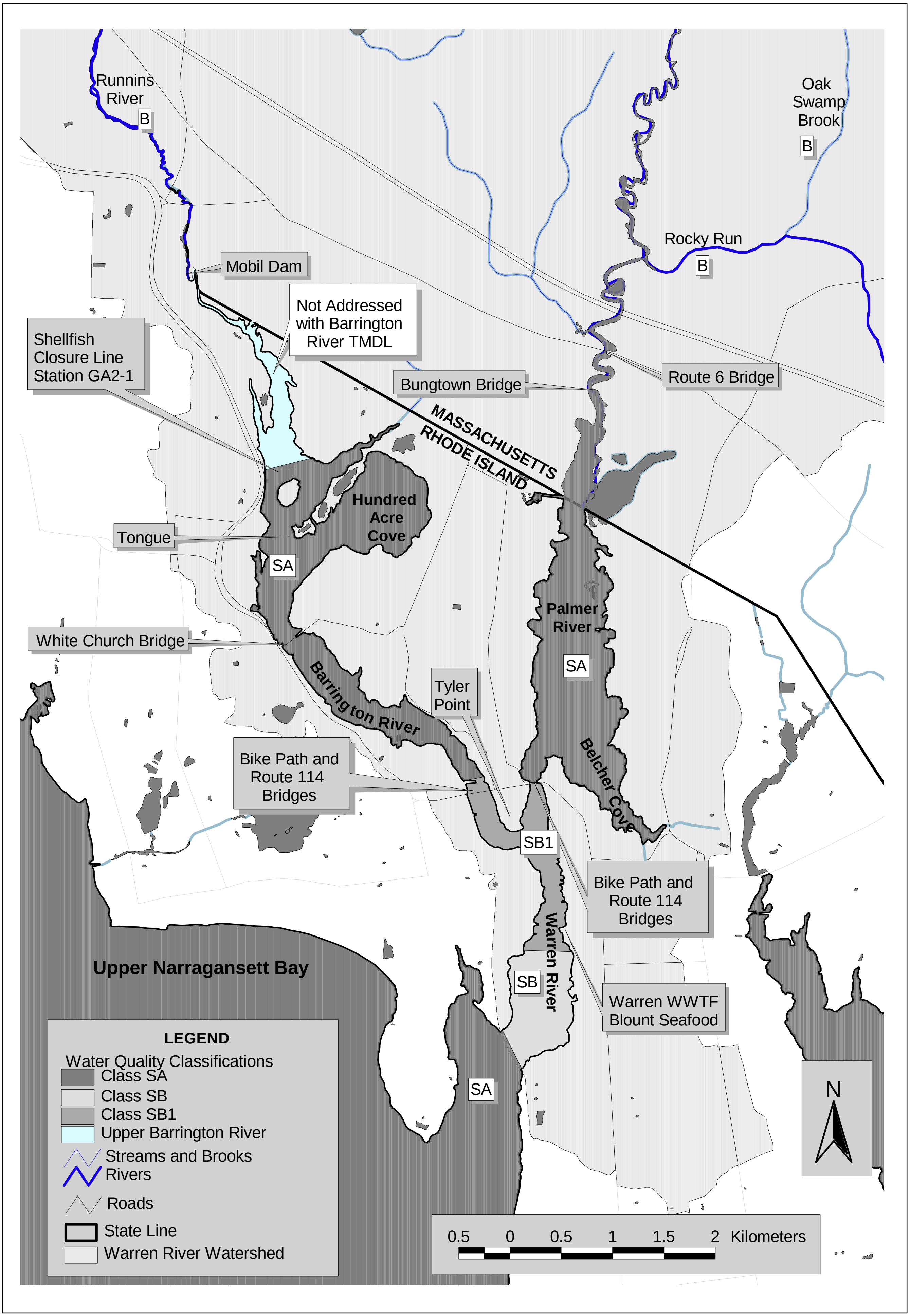


Figure 1. The Barrington, Palmer, and Warren Rivers and their water quality classifications.

the Palmer River is not listed on the *303 (d) List of Impaired Waters* and therefore will not be addressed in this TMDL.

- The two fresh water streams that flow into Belcher Cove in the southeastern portion of the Palmer River are required to meet Class A water quality standards because they flow into a Class SA waterbody. These streams are required to meet the standard of the receiving water body at their point of entry.

The following excerpts from the Rhode Island Water Quality Regulations describe Class A, SA, and SB1 waters:

Class SA- *These waters are designated for shellfish harvesting for direct human consumption, primary and secondary contact recreational activities, and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation, and industrial cooling. These waters shall have good aesthetic value*.

Class A- *These waters are designated as a source of public drinking water supply, for primary and secondary contact recreational activities and for fish and wildlife habitat. They shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. These waters shall have good aesthetic value.*

Class SB1- *These waters are designated for primary and secondary contact recreational activities and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation, and industrial cooling. These waters shall have good aesthetic value. Primary contact and recreational activities may be impacted due to pathogens from approved wastewater discharges. However all Class SB criteria must be met.*

Rule 8.D of the Water Quality Regulations establishes physical, chemical, and biological criteria as parameters of minimum water quality necessary to support the water use classifications of Rule 8.B. Therefore, sections of Rule 8.D are also applicable. In particular, Rules 8.D (2 & 3) establish class-specific criteria for fresh and salt waters. For waters of the State that are classified as Class SA, SB1 or Class A, the following fecal coliform criteria, excerpted from Tables 1 and 2, apply:

Class SA*- Fecal coliform not to exceed a geometric mean value of 14MPN/100 ml and not more than 10% of the samples shall exceed a value of 49 MPN/100 ml where MPN is most probable number.*

Class A*- Fecal coliform not to exceed a geometric mean value of 20 MPN/100 ml and not more than 10% of the samples shall exceed a value of 200 MPN/100 ml.*

Class SB1*- Fecal coliform not to exceed a median geometric mean MPN value of 50 and not more than 10% of the samples shall exceed a value of 500.*

2.0 PALMER RIVER STUDY AREA

2.1 Description

The Palmer River (Figure 1.1) lies in northeastern Rhode Island and southeastern Massachusetts. The lower river is tidal periodically all the way up to the Shad Factory Dam in MA. Downstream of the Shad Factory Pond Dam, the Palmer River winds its way south through a number of oxbows into Rhode Island. One main tributary, Rocky Run, feeds the Palmer River before it arrives in Rhode Island. The Rocky Run tributary, which is fed in part by Oak Swamp Brook, empties into the Palmer River north of Interstate 195. There are numerous smaller tributaries that flow through wetlands and farmland before they reach the main stem of the Palmer River. Shortly after entering the Town of Swansea, south of the Route 6 Bridge, the Palmer River widens into a tidal embayment. The river crosses into Rhode Island near the power line crossing.

East of the mouth of the Palmer River an embayment known as Belcher Cove extends to the southeast in the Town of Warren. Two small, unnamed streams empty into the head of Belcher Cove, and for the purposes of this study will be referred to as Belcher Stream West (BSW) and Belcher Stream East (BSE). Lloyd Manufacturing Company is permitted to discharge cooling water and boiler blow down into Belcher Stream West.

At upper Grinnell Point, the Palmer flows through a constriction that is spanned by the East Bay Bicycle Path and Route 114. Approximately 450 m south of the Route 114 Bridge, the river merges with the Barrington River at Tyler Point to form the Warren River. The Warren River opens out into Narragansett Bay about 3.5 km south of the confluence of the Palmer and Barrington Rivers. Two significant permitted dischargers, the Warren Waste Water Treatment Facility (WWTF) and Blount Seafood a shellfish processing facility discharge to the Warren River.

The Palmer River estuary is significant as a habitat and shellfish resource. It is one of Rhode Island's least developed estuaries with the majority of its banks being tidal salt marshes (Figure 2.1). The estuary supports wildlife habitat for many bird and fish species and is also one of the few places where northern diamondback terrapins live in Rhode Island.

The State of Rhode Island has historically supported commercial shellfishing in the Palmer River because the river sustains hard and soft-shell clam, blue crab and oyster fisheries. Between 1990 and 1996 the river was periodically approved for shellfishing on a conditional basis and portions were closed during that time. Over the past four years, however, the Palmer River has been permanently closed to shellfishing as a result of high fecal coliform measurements during routine monitoring. The closure of the Palmer River and adjacent areas of the Barrington River to shellfishing precipitated this TMDL.

From 1985 to 1992, the Palmer River was conditionally opened between Grinnell Point and the MA border, while Belcher Cove was closed. After 1992, the northern half of the river was changed to a prohibited status along with Belcher Cove, and only a small portion of the river around shellfish station GA2-7 remained opened on a conditional basis. In May 1996, the remaining area of the river was closed on a permanent basis. The shellfish closure maps differentiate management-related closures from water quality-related closures. Closures in the river have been due to water quality and not for shellfish management or other reasons.

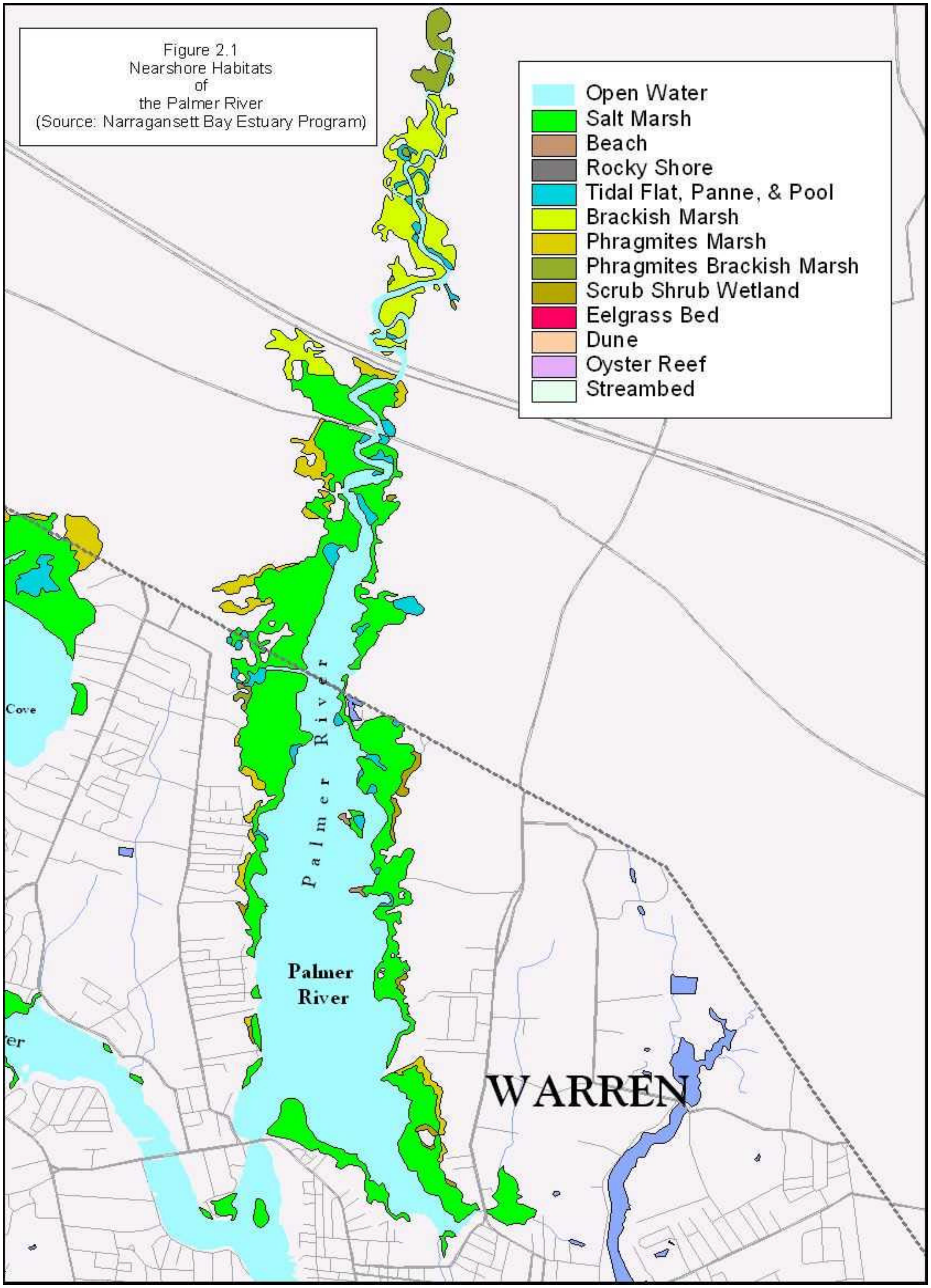


Figure 2.1: Near shore habitats of the Palmer River.

2.2 Characterization of the surrounding watershed

The vast majority of the Palmer River watershed, about 90%, is located in Massachusetts and can be divided into two sub-basins. The first sub-basin located in Rehoboth, Massachusetts drains into Shad Factory Pond. The second sub-basin, also found mainly in Rehoboth, forms the Rocky Run tributary on the east side of the watershed, which empties into the tidal reach of the Palmer River shortly upstream of Route 195. The Warren Upper Reservoir is located at the headwaters of Rocky Run. Both Shad Factory Pond and the Warren Upper Reservoir are water supply storage reservoirs used by the Bristol County Water Authority, which provides drinking water for the communities of Bristol, Warren and Barrington.

Land uses in most of the Palmer River watershed are of low intensity. Areas below Shad Factory Pond in Massachusetts contain several dairy and vegetable farms, and nurseries. Large areas of the watershed are undeveloped, either as upland woods or wetlands. Two golf courses are adjacent to the tidal portion of the river. Residential development is of low density in Massachusetts. Routes 195 and 6 cross over the upper tidal reach of the Palmer River.

A medium density residential area is located in Barrington on the west bank of the river a short distance below Route 6. The rest of the west side is made up of equal amounts of agriculture and salt marsh. Land use is higher near the mouth of the Palmer, which includes light industrial, commercial, and residential uses. The eastern banks of the Palmer River support a pond, hunting lodge, golf course, small farm, former junk yard, light industrial area and a residential development; this area of the lower estuary is largely buffered from these areas by an extensive salt marsh.

The two streams emptying into Belcher Cove have very different land uses. Belcher Stream East (BSE) is located in a more rural setting and flows through farmland and under Route 136, then through a wetland area and out into Belcher Cove. Belcher Stream West (BSW) is located in a highly developed area. The stream originates as a cooling water discharge from Lloyd Manufacturing Company. It flows north through an industrial area including a car dealership, an auto body shop, a dry cleaner and a public park where it empties into Belcher Cove.

2.3 Physical characteristics

The Palmer River is tidally influenced, and the saline intrusion may extend as far north as the Providence Street Bridge on a regular basis. Brown University (1997) reports the physical characteristics of the Palmer River described below. The maximum width of the Palmer River is roughly 1 km and the average depth is 1.9 m at Mean High Water (MHW), and 0.6 m at Mean Low Water (MLW). The surface area of the river at MHW is 2.5 x 10^6 m^2 with a volume of 4.75 x 10^6 km^2. The tidal flushing of the Palmer River estuary using tidal prism estimates (the volume of water entering the estuary on a flood tide) was estimated at 15.72 and 20.04 hours during spring and neap tides. The mean flushing time is 17.52 hours. Mean tidal salinities in the Palmer River range from 25.7 parts per thousand (ppt) near the Route 6 Bridge and 29.0 ppt near the Striper Marina. These differences are to be expected because of the tidal influence on the river from Narragansett Bay and the freshwater inputs from the north. The Bike Path Bridge is located over the southernmost opening of the Palmer River just north of the confluence with the Barrington River. The average tidal range at the Bike Path Bridge for the spring and neap tides are 1.65 m and 1.28 m respectively (Brown University, 1996).

Fresh water influxes into the Palmer River stem in large part from the runoff into and flows from the upper Palmer River, Shad Factory Pond and the Rocky Run tributary. Merriman's Pond, located in Massachusetts just north of the state line, is surrounded by a golf course, and is connected to the Palmer River by a dam that may overflow during high tide events. Brown University measured flow under the Route 6 Bridge and found that the average current speed was 4.9 cm/s seaward, which translates to a mean discharge of 1.56 m^3/s (Brown University, 1997). The report states that these numbers may be relatively high due to rainfall prior to sampling during the month of August; however, the results appear to agree with the long-term average. Water withdrawals from Shad Factory Pond by the Bristol County Water Authority may affect the fresh water flow more regularly than runoff.

2.4 Hydrography

Knowledge of the distribution and variability of salinity in an estuarine system can be useful in describing how other pollutants move and accumulate. Sources of tidal and salinity information include measurements from the 1996 and 1997 RIDEM studies (RIDEM, 1999b), and time series measurements by Brown University (1997).

The characteristics of the tides and salinity in the Palmer River have been documented by measurements made by the Environmental Studies Program at Brown University (1997). Continuous measurements were collected at the Route 6 Bridge in the northern end of the Palmer River from 12 September through 18 November 1997 (Figure 2.2). Salinity varies during the tidal cycle, with precipitation and with the proximity of fresh water sources. Dry weather measurements of salinity at the Route 6 Bridge range between 20-30 ppt with an average of 22.7 ppt. Salinity measurements at the Striper Marina have values from 28.5-30 ppt with an average of 28.6 ppt. The salinity at the Route 6 Bridge varies much more than the Striper Marina salinity because the Route 6 Bridge is located closer to the freshwater source and the Striper Marina is located nearer the Bay and thus the ocean, the primary source of saline water. The Brown University study demonstrated the change in salinity as a result of precipitation (Figure 2.2) showing a three-fold increase in the percentage of fresh water at the Route 6 Bridge.

Measurements made by RIDEM six times over the course of a year are consistent with Brown's findings (1999). The minimum salinity recorded at the northern station (station 5) in the Palmer River was 13.17 ppt and a maximum salinity of 27.92 ppt. For the more southerly station located in Belcher Cove (station 4) the minimum salinity was 17.90 ppt and the maximum was 27.94 ppt. The comparable station by Striper Marina had a low salinity of 21.25 ppt and a high of 30.76 ppt. These ranges are broader than the ranges Brown University found, however, they are similar in that the source closest to the freshwater input has the broadest range, 14.35 ppt, and the station closest to the Striper Marina and Narragansett Bay has a smaller range, 8.51 ppt.

The time required for the tide wave to propagate from the mouth of the Palmer River to the Route 6 Bridge is approximately 1.5 hours (Brown University, 1997c). In the Barrington River, the dominance by the ebb tide, in which ebb currents are stronger and the ebb period shorter, is apparent in the tide height curve. This characteristic is not apparent in the Palmer River, which appears to be flood-dominant during spring tides.

2.5 Tributary and point source flows

Freshwater sources considered to be significant to the distribution of salinity in the Palmer River were characterized by measurements made during the spring, summer and fall of 1996 as part of

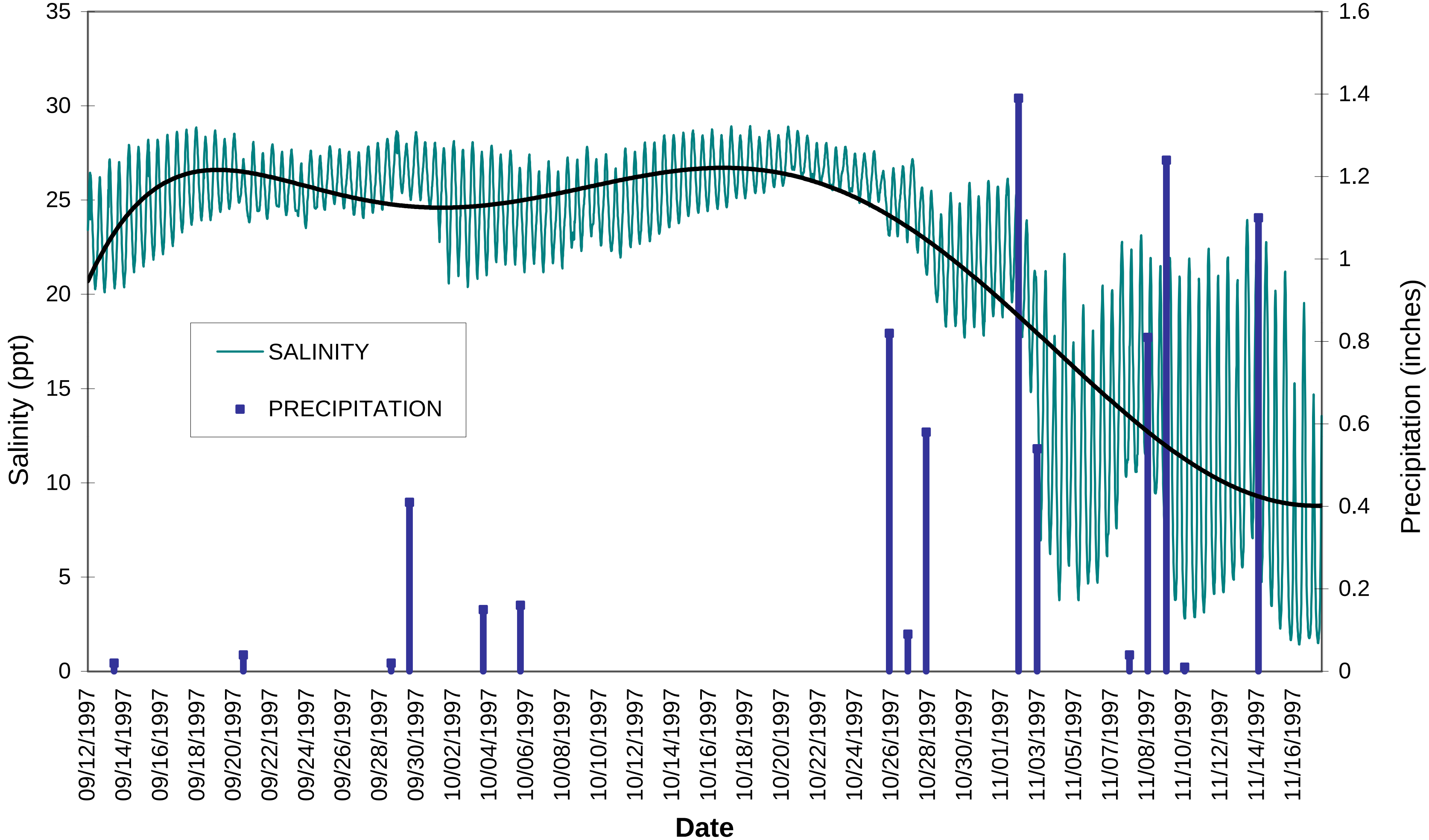


Figure 2.2 Salinity and Precipitation data at the Route 6 Bridge in 1997

the Barrington Palmer and Warren River Watershed study by RIDEM (RIDEM, 1999b). The measurements in the Palmer River basin included various points in the upper Palmer River and Rocky Run. Other pertinent sources measured by the RIDEM study were the Warren WWTF and the Blount Seafood facility.

Three stations were sampled in the upper Palmer River basin including the Reed Street Bridge, Oak Swamp Brook at Providence Street and Rocky Run at Davis Street. The Mason Street station was in tidal waters, therefore the discharge at Mason Street was calculated as the sum of the two upstream stations at Oak Swamp Brook and Davis Street. At the Reed Street Bridge tidal oscillations were found during spring tide conditions, however the influence on the calculated discharge was negligible. A maximum flow of 3.8 m^3/s was measured in the spring at the Reed Street Bridge (Table 2.1). For all locations sampled the yearly mean was higher than the summer mean, especially in the case of the Reed Street Bridge where the mean yearly discharge was more than three times the summer flow (Figure 2.3). The total discharges in 1996 were dominated by the main stem of the Palmer River in comparison to the discharge of Rocky Run (Figure 2.4). During the mid- to late summer the two streams have similar discharge rates, most likely as a result of withdrawals upstream of the Reed Street Bridge by the Bristol County Water Authority. During July and August 1996 the mean discharge was 0.119 m^3/s at Reed Street, and 0.157 m^3/s at Mason Street.

Table 2.1: Mean, minimum and maximum tributary and point source discharges, from direct measurements and stage-discharge measurements.

	T3 Palmer River, Reed St. (m^3/sec)	T4 Oak Swamp Brook (m^3/sec)	T5 Rocky Run, Davis St. (m^3/sec)	T6* Rocky Run, Mason St. (m^3/sec)	T7 Blount Seafood (m^3/sec)	T8 Warren WWTF (m^3/sec)
Mar-Oct						
Minimum	0.079	0.007	0.013	0.02	0.001	0.066
Mean	0.671	0.067	0.176	0.243	0.005	0.082
Maximum	3.774	0.308	0.791	1.038	0.008	0.136
July-Sept						
Minimum	0.079	0.007	0.013	0.02	0.001	0.066
Mean	0.119	0.042	0.115	0.157	0.004	0.075
Maximum	0.344	0.247	0.791	1.038	0.008	0.123

**T6 (Rocky Run at Mason Street) is the sum of T4, (Oak Swamp Brook) and T5 (Rocky Run at Davis Street). (RIDEM, 1999b)*

The Blount Seafood facility and the Warren WWTF discharge rates were obtained from plant records. During the study the discharge from Blount Seafood was small, 0.005 m^3/s (Figure 2.3) and the Warren WWTF discharged at 0.082 m^3/s.

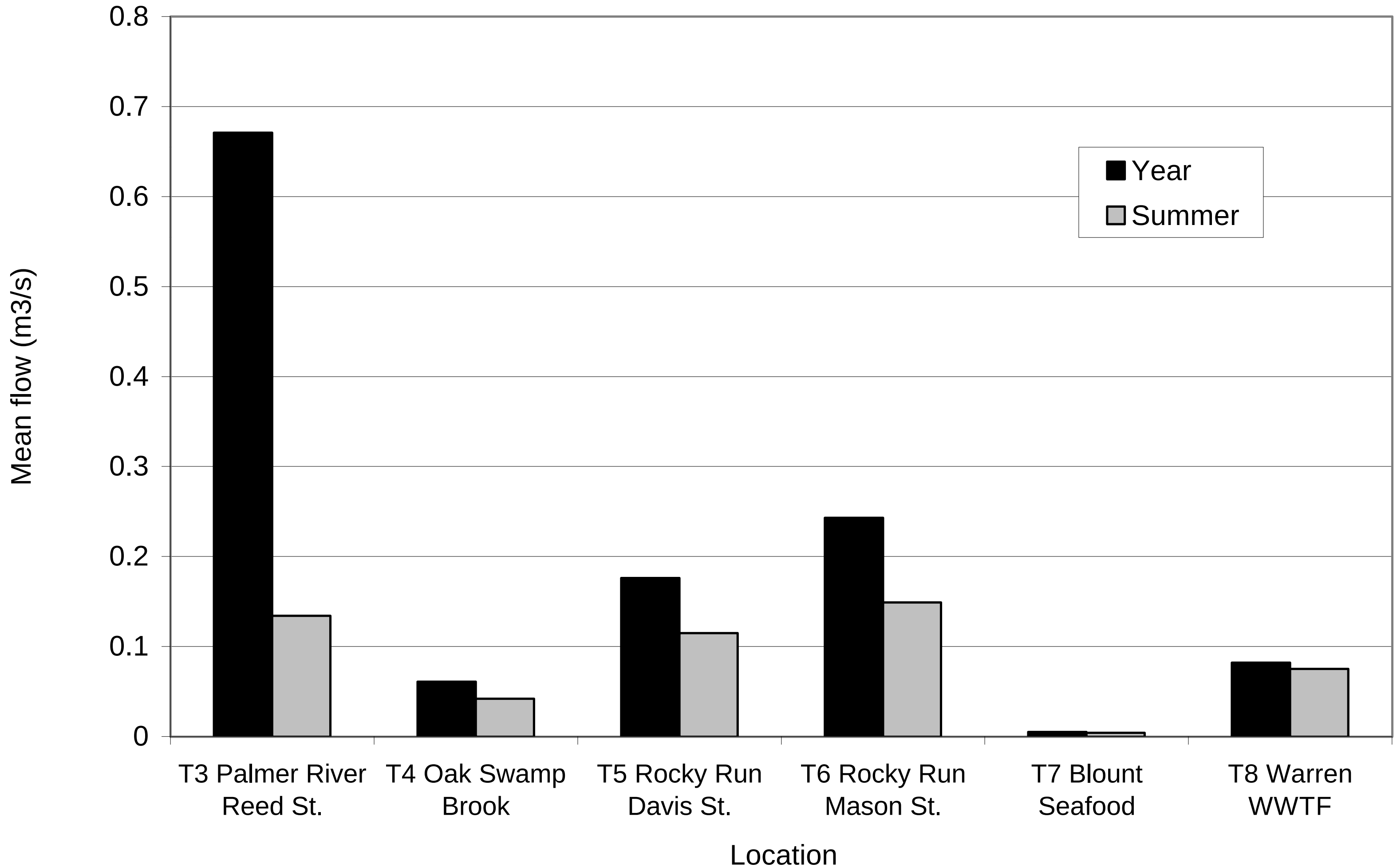


Figure 2.3 Yearly and summer (July-September) mean tributary and point source discharges into the Palmer River in 1996.

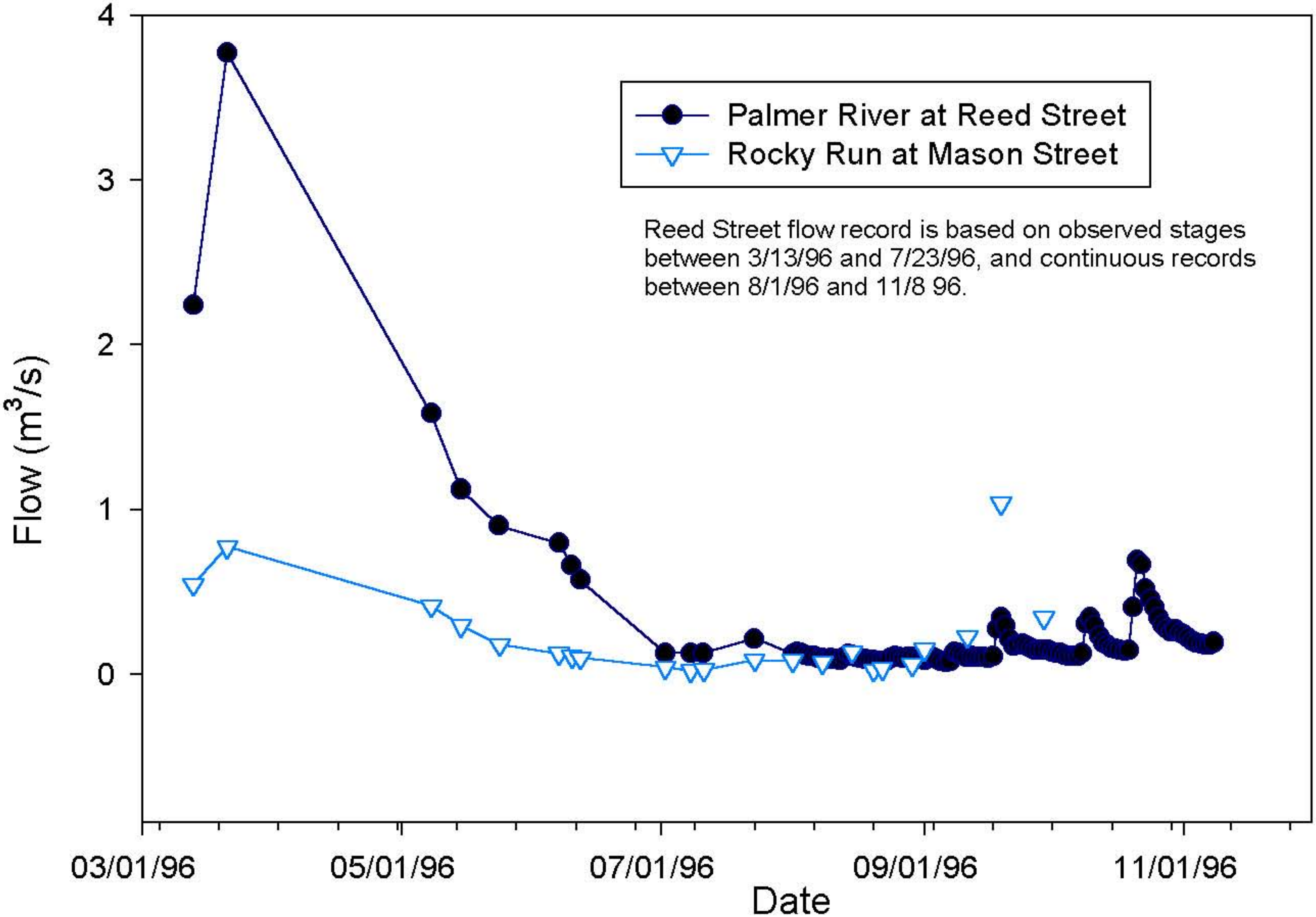


Figure 2.4 Discharge at Rocky Run and Reed Street

3.0 DESCRIPTION OF RIDEM WATER QUALITY MONITORING

3.1 Shellfish growing area monitoring

The Shellfish Growing Area Monitoring Program is part of the State of Rhode Island's agreement with the US Food and Drug Administration's National Shellfish Sanitation Program (NSSP). NSSP requires Rhode Island to conduct continuous bacteriological monitoring of the State's waters where shellfish is intended for direct human consumption. The Palmer, Barrington and Warren Rivers comprise shellfish Growing Area GA 2. Five of the sixteen monitoring stations in GA 2 are located in the Palmer River (Figure 3.1). The Palmer River stations include stations 6A, 6, 7, 7A and 8. The southern portion of the Warren River, adjacent to upper Narragansett Bay, includes two stations located in Conditional Area A.

The Palmer River is currently closed for shellfishing during all weather conditions. At times during the last ten years, it has been conditionally open for shellfishing and was managed as part of Conditional Area A in upper Narragansett Bay. Sampling runs are conducted monthly during dry weather periods when the conditionally approved portions of Growing Area 2 are open to shellfish harvesting. A conditionally approved shellfish area is open for shellfishing during dry weather and closed during wet weather. A dry weather period occurs at least seven days after a rainfall or snowmelt event of 0.5 inches or more, and/or seven days after a treatment facility bypass greater than 0.5 MGD by any municipal wastewater treatment facilities that impact upper Narragansett Bay. Sampling runs may also be conducted during wet weather periods, but on a more infrequent and random basis.

To maintain compliance with the NSSP, RIDEM also conducts periodic shoreline surveys of approved shellfish waters. The primary objectives of shoreline surveys are to identify and characterize new sources of pollutants to the shellfish growing area, to reevaluate point and nonpoint sources identified during previous surveys, and to update information regarding corrections made to previously identified sources. The most recent shoreline survey of the Palmer River was conducted on November 15, 16 and 22, 1999 during the ebb tidal cycle (RIDEM, 1999). No significant rain events occurred during the survey. The shoreline survey evaluated all pipes, drainage ditches, and culverts discharging to the river to determine whether they represented actual or potential sources of pollution (Figure 3.2). Bacteriological samples were collected from all flowing sources.

3.2 Dry weather monitoring

RIDEM conducted a series of surveys between 1996 and 1998 in the Barrington, Palmer, and Warren Rivers (BPW) to characterize wet and dry weather in-stream conditions. These activities are described in detail in RIDEM (1999b). In 1996 and 1997, dry weather surveys were conducted in the Barrington, Palmer, Warren (BPW) estuary system to resolve bacterial and nutrient levels and to quantify pollutant and fresh water influxes from the tributaries and point sources that contributed significantly to the system. The sampling cruises were carried out during five days in 1996 and one day in 1997, and spanned a late spring to early fall seasonal cycle.

Twenty-three stations were sampled in the BPW watershed (Figure 3.3). In-stream fecal coliform samples were collected during high and low tide. Salinity, conductivity and temperature were also measured in-situ at stations in the Palmer River during all surveys. Total suspended solids were measured at the Barrington River stations during the July survey. Samples were also

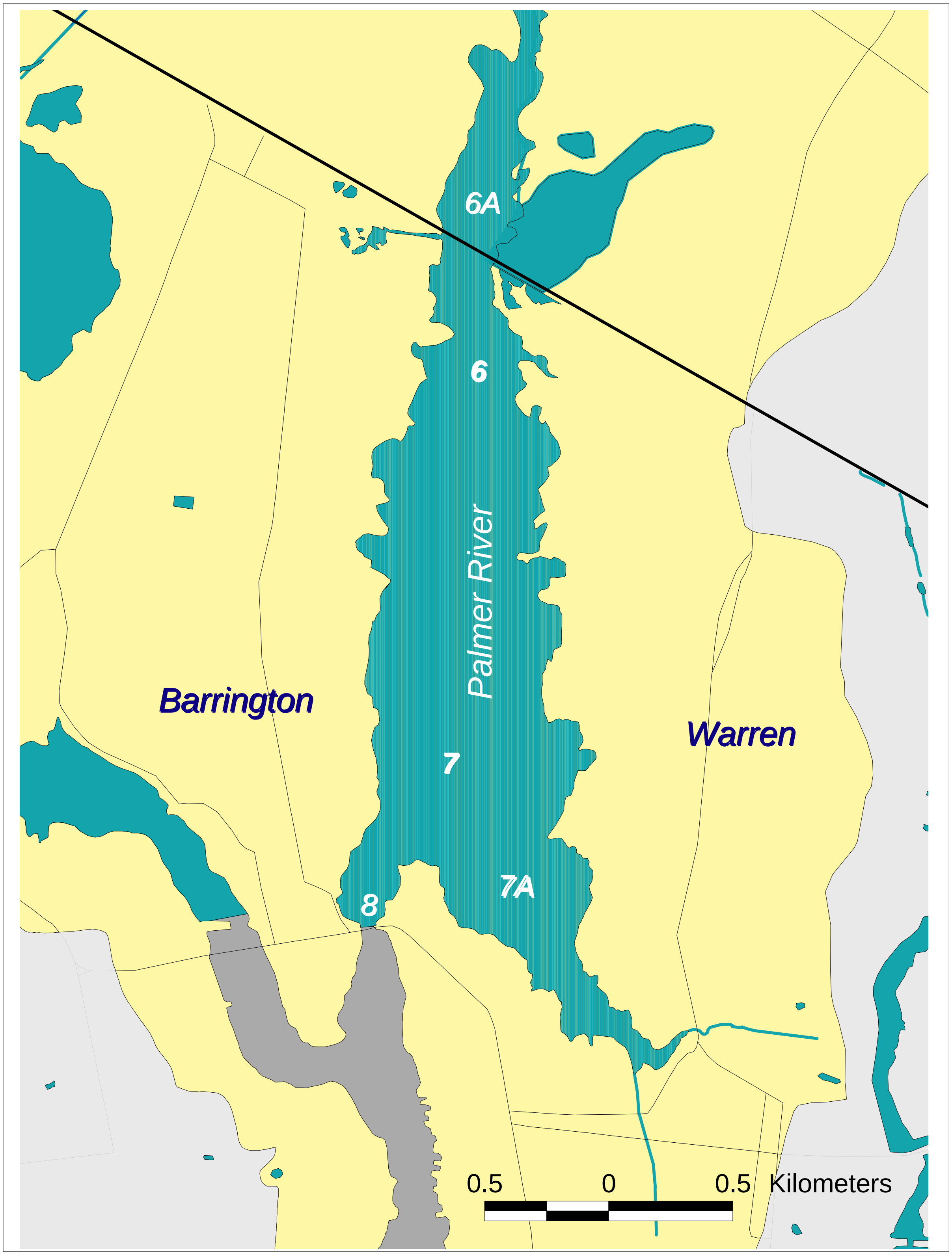
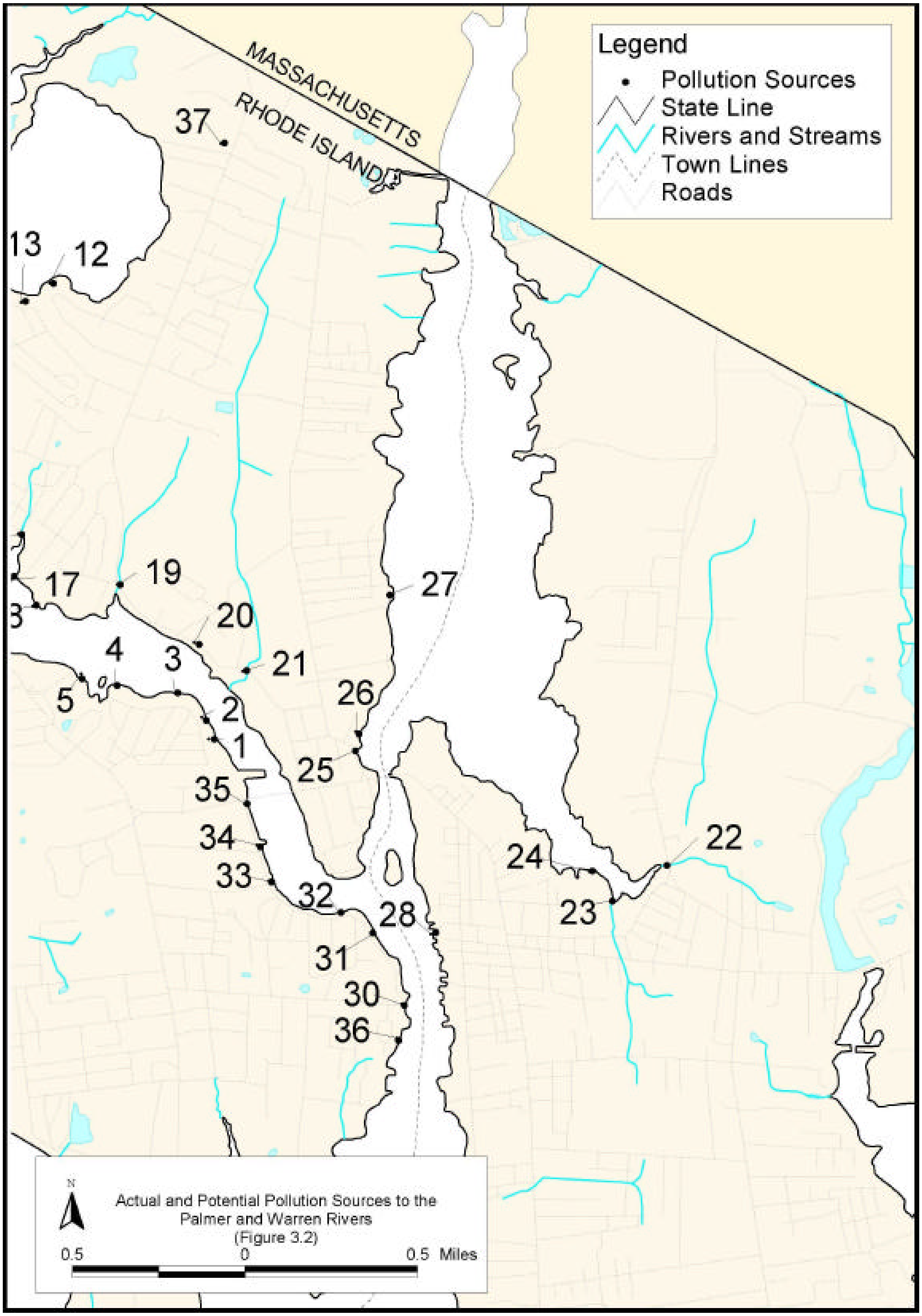


Figure 3.1 RIDEM shellfish survey station locations in the Palmer River



Actual and Potential Pollution Sources to the Palmer and Warren Rivers (Figure 3.2)

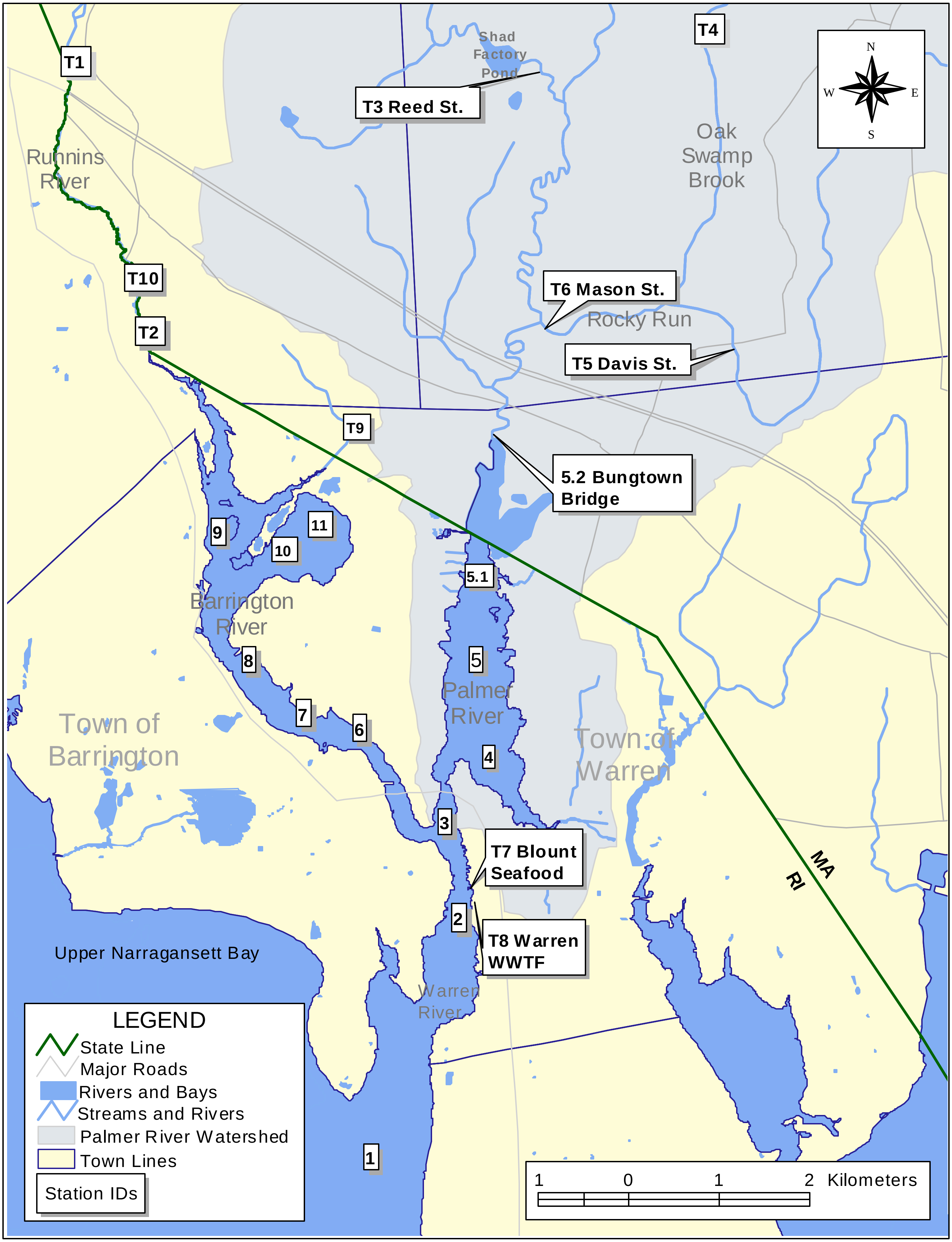


Figure 3.3 1996-1997 RIDEM dry weather sampling locations in the Barrington, Palmer and Warren River watershed

collected during low tide at tributary stations to the Barrington River during all three surveys capturing the freshwater inflow. Sampling stations and their specific measurements are presented in Table 3.1.

During dry weather (steady state), point sources and tributaries were sampled for fecal coliform and nutrient concentrations, and stage discharge measurements were made. Water chemistry samples were collected at a subset of the point sources and tributary stations (Table 3.1). In general these measurements were made the day before in-stream surveys to characterize loadings to the system. Monthly samples were taken to further characterize the strength of the sources. The number of samples was limited by the project budget. As a result, a subset of the tributaries was sampled for bacteria and nutrients, and for the remainder of the stations only discharge measurements were made. Some changes in the sampling plan occurred after the start of the study. A fecal coliform sample was added at station T5 (Davis Street) in Rocky Run to bracket a suspected source downstream of T5 and upstream of T6.

Table 3.1: RIDEM Dry weather tributary and point source stations.

Station	Location	Stage/ Discharge	Fecal coliform Sampling	Nutrient Sampling
T1	Runnins River, Route 6	♦	♦	♦
T2	Runnins River, School St.	♦		
T3	Palmer River, Reed St.	♦	♦	♦
T4	Oak Swamp Brook, Rocky Run	♦		
T5	Rocky Run, Davis St.	♦	♦	
T6	Rocky Run, Mason St.		♦	♦
T7	Blount Seafood	♦	♦	♦
T8	Warren WWTF	♦	♦	♦
T9	Unnamed tributary, Warren Ave.	♦		
T10	Runnins River, Mink St.	♦		

Measurements of tributary discharge were made on additional dates during 1996 and 1997 to better characterize tributary discharge rates. Continuous stage measurements were made in the Palmer River at the Reed Street Bridge from August 1 through November 8, 1996. Instantaneous gauge readings made in 1996 supplemented the continuous measurements.

The estuary measurements consisted of sampling cruises carried out six times during the winter through fall of 1996 and in July of 1997. Each estuary survey cruise was accompanied by sampling of the tributaries and point sources. In addition to fecal coliform sampling, parameters measured in the water column included salinity, temperature, dissolved oxygen, and in-vivo fluorescence. Other analyses performed included inorganic, particulate and total nitrogen, total inorganic phosphorus, BOD (on a subset of stations), and total suspended solids (RIDEM, 1999b).

Each estuary cruise was conducted for 12 hours, spanning a tidal cycle with high and low tide surveys conducted during each cruise. Measurements were taken around the time of high and low tide, within 1.5 hours of slack water. The measurements at each station consisted of water sample collection and vertical profiling. Figure 3.3 shows the stations in the Barrington, Palmer, and Warren Rivers. At two Warren River stations and the Upper Narragansett Bay station, water samples were collected from two depths, 1 m from the surface and 1 m from the bottom. At the remaining stations, one sample was collected at the 0.5 or 1 m depth, depending on local water depth. Five stations were located in the Palmer River.

3.3 Wet weather monitoring

Nutrient and fecal coliform loadings from the Runnins and Palmer Rivers and the Rocky Run tributary were measured during two wet weather events, one in August 1997 and the other in October 1998. The wet weather surveys provided a picture of the relative increase in nutrient and bacterial loadings during periods of rain in the area and the associated impacts on water quality in the two estuaries. The 1998 study is described in detail in RIDEM (1999b).

The 1997 rain event sampled occurred on August 14 and produced 0.65 inches of rain. Fecal coliform concentrations were sampled during ebb tide at the sixteen RIDEM Shellfish Program Warren River watershed stations including five stations in the Palmer River (Figure 3.1). Two sampling runs were made, one on August 14 prior to the storm and the other on August 15 after the storm. At the same time, personnel from the Massachusetts Division of Marine Fisheries (MADMF) sampled 20 tributaries flowing into the main stem of the upper Palmer River. The purpose of these surveys and the one in 1998 that followed was to quantify impacts of wet weather on bacterial concentrations in the estuarine areas of the Warren River Basin including the Palmer River.

In-stream fecal coliform sampling was conducted a second time in the Barrington, Palmer, and Warren Rivers before, during and after the October 1998 wet weather event, which produced 0.93 inches of rain. For three days, three sources were sampled including the Palmer River in the vicinity of the Route 6 Bridge, Rocky Run at Mason Street, and the Runnins River at School Street A pre-storm survey was conducted on October 14. Post-storm surveys were conducted on October 15, 16, 19, and 20. Each survey was centered on the time of low tide during daylight hours. Again, the sixteen RIDEM Shellfish Program Warren River watershed stations were sampled during each survey, including the five stations in the Palmer River.

In the Palmer River, net cross-section discharge was calculated by measuring current speed and direction with an InterOcean model S4 current meter in the eastern channel under the Route 6 Bridge. The current speed (in m/s) and sense (ebb/flood) measured by the S4 meter was used to calculate the net volume flow rate (m^3/sec ebb or flood) as a function of time (i.e. at 5 minute intervals). Concurrent nutrient and fecal coliform concentrations were sampled near the center of the river using an ISCO discrete sampler placed at the Bungtown Bridge, approximately 500m downstream of the Route 6 Bridge.

Measurements of local river stage and water sample collections were made with a third ISCO discrete sampler at the Mason Street Bridge in Rocky Run. Stage measurements were made from a staff gauge. The principal purpose of the Rocky Run station was to characterize wet weather concentrations in this tributary. Accumulated rainfall was measured at periodic intervals at locations adjacent to the School Street and Bungtown Bridge stations. Continuous rainfall data were also obtained from a station on Prudence Island and from T. F. Green Airport in Warwick.

Wet weather follow-up monitoring was conducted in the Belcher Stream East subwatershed in September 2001. Instream fecal coliform sampling was conducted at six stations over a 4-day period (Figure 3.4). Rainfall for the storm event measured 1.49" in the Town of Warren. A detailed description of the Belcher Stream East wet weather study may be found in Appendix B to this report.

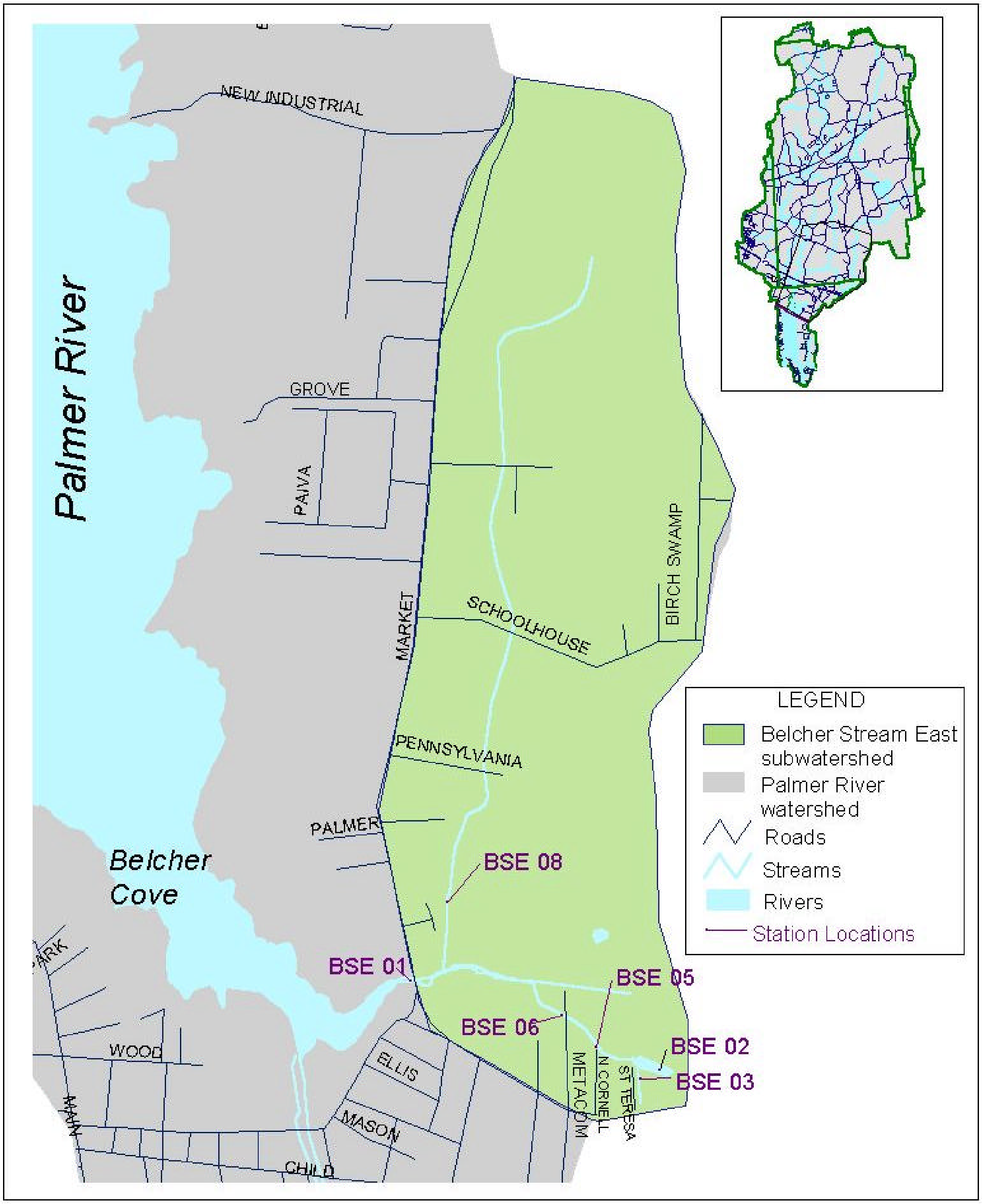


Figure 3.4. Wet weather sampling stations in the Belcher Stream East subwatershed, September, 2001.

4.0 FECAL COLIFORM SOURCE CHARACTERIZATION

The fecal coliform source characterization is separated into three sections. The sections cover upper Palmer River sources, lower Palmer River sources and Belcher Cove sources. These sections were separated on the basis of the location of the source tributaries and the reach of river that was affected by the sources.

4.1 Upper Palmer River Sources

Tributaries to the upper Palmer River are the main contributors to the fecal coliform concentrations at station 6A in the main body of the Palmer River north of the Massachusetts-Rhode Island State line. The evaluation of station 6A may be found in Section 5 below. The Commonwealth of Massachusetts has initiated a bacteria TMDL for the upper Palmer watershed that is expected to generate additional information on the nature of sources to the upper Palmer River.

4.1.1 Dry Weather

The upper Palmer River tributaries were sampled by RIDEM during 1996-1997 to characterize bacterial sources. Samples were initially collected (see Figure 3.3 for station locations) downstream of the Shad Factory Pond Dam at Providence Street, and along Rocky Run at Mason Street. When the Mason Street samples proved to be consistently high, a station was added at Davis Street in July 1996. The Rocky Run Davis Street station was placed upstream of a farm on which cattle had frequently been observed in or directly adjacent to the stream. RIDEM was not able to further segment Rocky Run downstream of the farm because no public access was available, however this downstream area is largely forested. One potential source, a home with an adjacent pond was also identified. The stream draining the pond was dry during the mid- to late summer of 1996, so no sampling was conducted. Fecal coliform levels at the downstream Mason Street station were significantly higher in subsequent 1996 samples than those at Davis Street (Table 4.1).

Table 4.1: Dry weather fecal coliform concentrations in the Upper Palmer River 1996-1997.

Station	Shad Factory T3	Mason Street T6	Davis Street T5
Geometric Mean fc/100 ml	145	413	146
Maximum fc/100 ml	1600	1300	660
# samples	10	10	5

Over the course of its investigations, RIDEM staff made visual observations and photographed conditions of areas adjacent to the river. RIDEM also made over flights between September 1995-September 1996 to document the presence of macroalgae in the Palmer and Barrington Rivers. During these flights, observations and photographs were made of the areas downstream of Shad Factory Pond. Both from the road and from the air, significant areas of exposed earth were visible adjacent to Rocky Run at the Davis Street farm. Similar conditions were observed at a second farm on Mason Street adjacent to the river where cattle traffic was evident at a stream crossing the field in an area between a pasture and an outbuilding. Similar conditions could also be seen at a third farm on Mason Street adjacent to Route 195. No sampling was conducted to support the visual observations.

The difference in concentrations between Davis and Mason Streets, the presence of cattle in the stream, and the absence of apparent downstream sources led to the hypothesis that the principal source to Rocky Run was the Davis Street farm. This hypothesis was tested during dry weather on June 16, 1997. Records from the National Weather Service station in Warwick show a total rainfall of 0.07" on June 13-14, a trace of rainfall on June 8, and 0.65" on June 1-2. RIDEM sampled the Davis and Mason Street stations, two locations along the main stem of the Palmer River (Reed Street and Providence Street), and a tributary to the Palmer at Barney Avenue (Table 4.2). A RIDEM engineer accompanied a MADMF official to collect an additional sample in Rocky Run at a location approximately 500 feet downstream of the cattle crossing area on the farm. The concentration at this downstream station was 23,000 fc/100 ml, while the concentration upstream at Davis Street was 930 fc/100 ml. The results strongly indicate that the cattle crossing area caused the elevation during the period of the sampling. Because this use continued through the period of the measurements, and because no similar conditions were present downstream, RIDEM concluded that this area was the dominant source to Rocky Run, which in turn was a major bacterial source to the Palmer River. Because conditions were similar at the other farms, they would also be considered as sources. Concentration in the main stem of the Palmer River increased from 93 fc/100 ml at Reed Street to 430 fc/100 ml at Providence Street. This result indicates that other sources were present in the reach upstream of Providence Street that may include septic systems, waterfowl, and wildlife.

The upstream concentration at Davis Street was high compared to values observed during the study and well above the geometric mean value of 146 fc/100 ml. This information indicates that other bacteria sources are present on Rocky Run upstream of the farm along Davis Street. The causes may include waste from domestic animals, wildlife, and waterfowl that enter the river directly in dry weather. No data available during the time of this study indicates that these sources would contribute to the water quality impairment of the Palmer River, however. Concentrations were 430 fc/100 ml at Mason Street near the mouth of the river. The decline in concentration at Mason Street is consistent with die-off of bacteria in the reach between the farm and Mason Street. If concentrations downstream of the farm were reduced to a level equivalent to the concentration at Davis Street, RIDEM expects that the concentrations at Mason Street will meet the water quality standard of the Palmer River due to die off

It is recommended that additional monitoring be conducted by the State of Massachusetts during their upcoming assessments for the Palmer River TMDL to further resolve the significance of these sources.

Table 4.2:Dry weather fecal coliform concentrations, June 16, 1997

Location	fc/100 ml
Rocky Run – Davis Street	930
Rocky Run – below farm	23000
Rocky Run – Mason Street	430
Rocky Run – Providence Street	430
Rocky Run – Reed Street	93
Rocky Run – Barney Avenue	430

4.1.2 Wet weather

The Palmer River was sampled prior to and during two wet weather events in 1997 and 1998. During the 1997 storm event MADMF staff collected in-stream fecal coliform samples at various locations along the river in Massachusetts to characterize inputs from small streams feeding the upper Palmer River. RIDEM sampled in-stream concentrations at the Shellfish Program stations.

Bacterial fluxes from the upper Palmer River were also characterized during the 1998 storm event including stations at the Bungtown Bridge and Mason Street along Rocky Run. The RIDEM shellfish survey stations were again sampled for the pre-storm condition and four post-storm periods in 1998.

A significant fraction the upper Palmer River watershed is agricultural and the remaining undeveloped area of the watershed is principally forest or wetland. The 1997 MADMF data were overlaid onto land use in the upper Palmer River (Figure 4.1) to infer potential causes of elevated fecal coliform concentrations. At the time of this report, a detailed shoreline GIS coverage showing smaller streams entering the Palmer was not available for this area. The sampling stations were sited on smaller streams that are not shown in Figure 4.1, but that are visible in orthographic photographs of the area. The stations having high fecal coliform counts in the MADMF sampling survey (concentrations equal to or exceeding 10,000 fc/100ml) drained catchments containing significant areas of land identified as agricultural land in the Massachusetts GIS 1999 land use coverage (Table 4.3). The geometric mean for samples

Table 4.3: Comparison of data collected by the MADMF in 1997 at various stations along the Palmer River with local land use.

Station #	Fecal coliform concentration fc/100 ml	Predominant land use in drainage area
PS1	<100	Forest
PS10D	300	Forest
PS11A	600	Roadway/ Wetland/ Forest
PS12	600 no flow	Wetland
PS12A	600	Developed open space (Golf course)
PS10C	1100	Cropland/ Residential/ Forest/Open land
PS1A	1200	Residential/ Forest
PS10B	4200	Forest/ Cropland/ Residential
PS10E	8700	Forest/ Cropland/ Nursery
PS11	19000	Wetland/ Cropland/ Forest
PS2	24000	Cropland/ Forest
PS3	94000	Cropland/ Forest/ Wetland
PS4	50000	Cropland/ Wetland
PS5	47000	Cropland/ Wetland
PS6	37000	Cropland/ Pasture/ Wetland
PS7	43000	Cropland/ Wetland
PS8	44000	Cropland/ Wetland
PS9	67000	Cropland/ Wetland
PS10	31000	Nursery/ Cropland/ Pasture/ Residential
PS10A	13000	Forest/ Cropland/ Residential/ Open land

collected from streams passing through cropland or intensively used agricultural lands was 22300 fc/100 ml. In contrast, all the other stations surveyed that drained forested, wetland and residential areas had a geometric mean of 400 fc/100 ml. The difference associates higher inputs of fecal coliform bacteria with agricultural operations in the area. Following discussions with Massachusetts agencies, RIDEM has concluded that the association does not imply causality, and that further sampling is needed to verify this relation. Other bacteria sources associated with

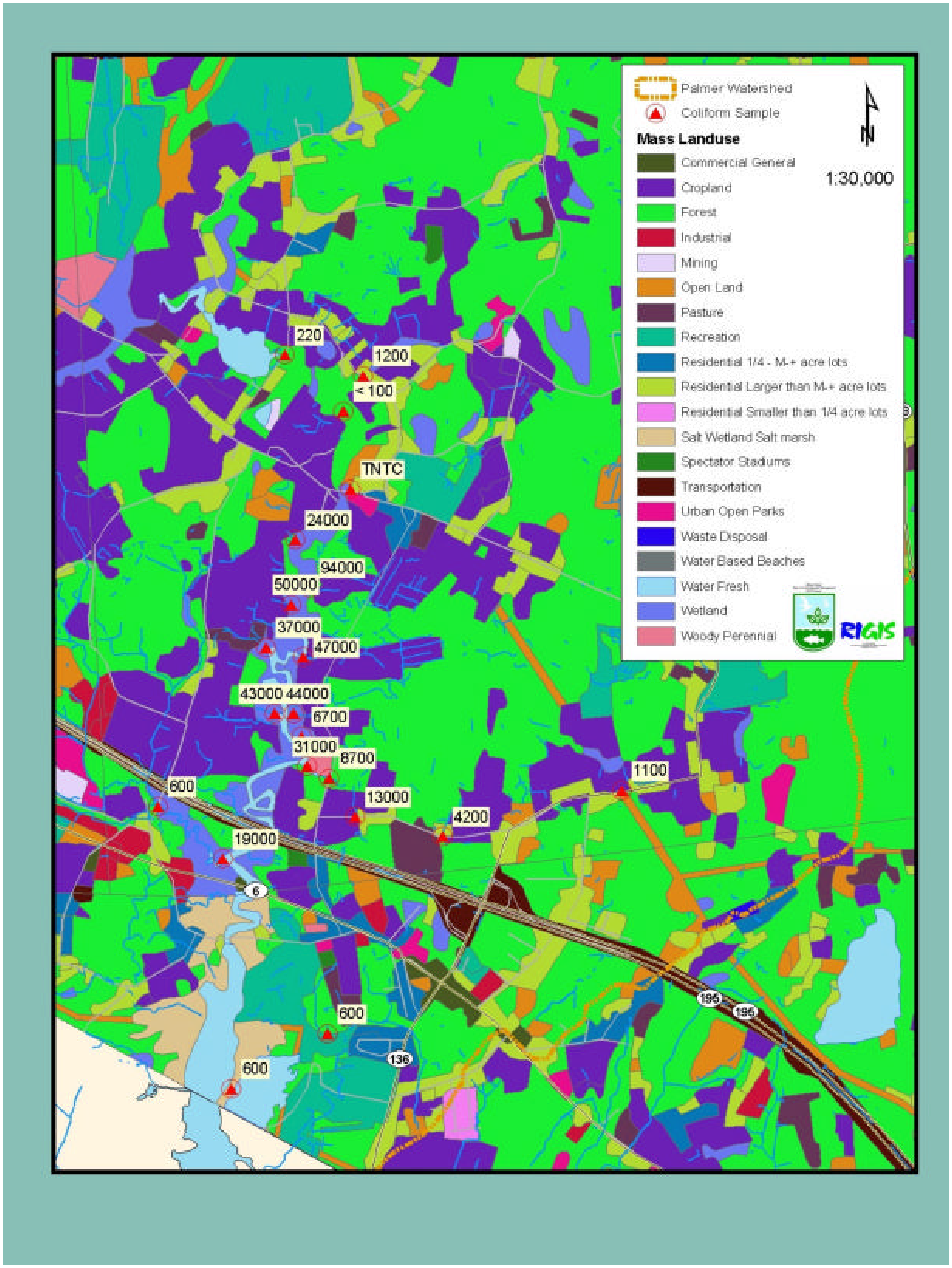


Figure 4.1: Fecal coliform concentrations (fc/100 ml) collected by MADMF and associated land use in the upper Palmer River Watershed.

residential land uses may be present in these and other tributaries in the watershed. The sources may include runoff bearing waste from domestic animals, wildlife, and waterfowl, and failing septic systems. No discharge data were obtained during this study so the significance of these inputs to the water quality impairment of the river is not known. Again, RIDEM recommends that Massachusetts' fecal coliform TMDL for the Palmer River further resolve the significance of these potential sources.

During the October 1998 wet weather event, fecal coliform samples and stage readings were taken at regular intervals at the Rocky Run Mason Street station, and at Bungtown Bridge. Figure 4.2 shows fecal coliform concentrations as a function of time at both stations. The rainfall began at approximately 13:00 EDT on October 14, 1998. Peak concentrations of 7900 fc/100 ml and 14000 fc/100 ml followed peak rainfall at the Bungtown Bridge by 12 and 22 hours, respectively. Concentrations dropped on October 15, 1998 after the first peak, soon after the start of the flood tide began, to 730 fc/100 ml by October 16, 1998. The concurrent fecal coliform concentration in Rocky Run shows a peak at Rocky Run preceding the downstream peak at the Bungtown Bridge by 5 hours (Figure 4.2). An initial peak fecal coliform concentration of 54000 fc/100 ml was observed at 8 PM on October 14 at the mouth of Rocky Run, seven hours after the rainfall began, and two hours after the tide peaked at the mouth of Rocky Run. The peak concentration of 210,000 fc/100 ml occurred at 2 AM on the morning of October 15, 1998 at Rocky Run, approximately seven hours after the time of local high tide at the mouth of Rocky Run, and a similar time after the onset of the period of peak rainfall intensity in the area. If the source of the elevation were assumed to be the farm, the average speed of travel of the stream would be 0.3 ft/sec between Davis and Mason Streets (Figure 4.2)

Peak concentrations in Rocky Run occurred during ebb or low tide pointing to the presence of upstream sources (Figure 4.3). Tidal stage can influence fecal coliform concentrations; high tide brings an influx of water from the Palmer River, diluting the fecal coliform concentration. Concentrations measured at low tide provide a more realistic and protective view of the actual inputs of bacteria into the river. The influence of tide on fecal coliform concentration is clear. These data indicate that high concentrations of fecal coliform are entering the main stem of the Palmer River in Massachusetts from Rocky Run (Table 4.4).

Table 4.4: Upper Palmer River wet weather data, October 1998

Station	Bungtown Bridge	Rocky Run at Mason Street
Geometric mean (fc/100 ml)	2472	7573
% > 400	96%	100%
Maximum (fc/100 ml)	14000	210000
# of samples	16	19

In-stream concentrations along the length of the estuary into Narragansett Bay logically followed a similar pattern with considerable increases on October 15, 1998 and a decrease to acceptable levels after four days (Figure 4.4). The upper reach of the Palmer River peaked at a concentration of 10,200 fc/100 ml, and upper Narragansett Bay reached a peak concentration of 70 fc/100 ml. RIDEM's interpretation of the data presented in section 5 of RIDEM (1999) and in Figure 4.4 is that during the initial phase of the storm, loadings entered the river from areas of the watershed above Bungtown Bridge and the head of Belcher Cove. During the day after the

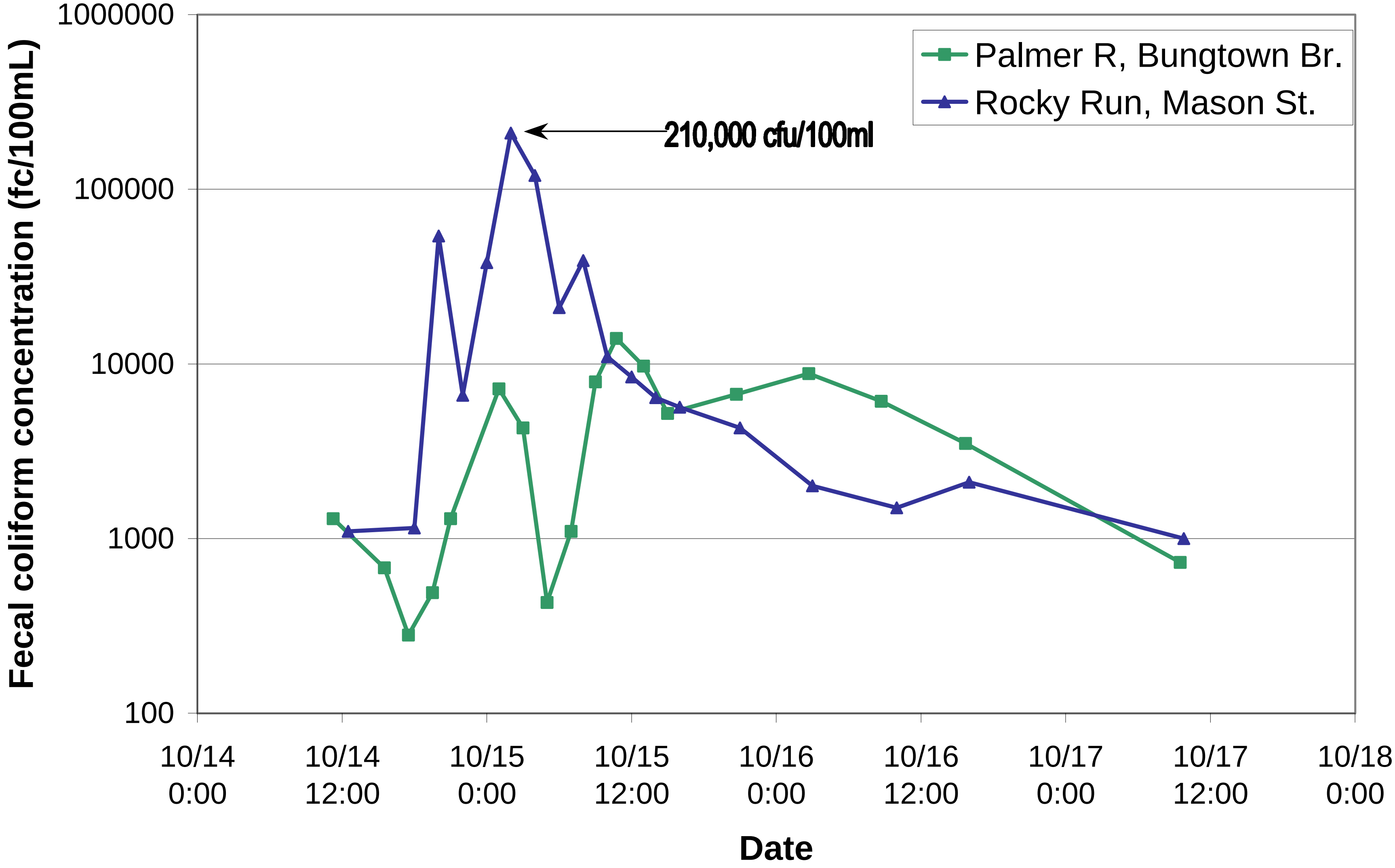


Figure 4.2: Fecal coliform concentrations at the Bungtown Bridge and Mason Street during the 1998 storm.

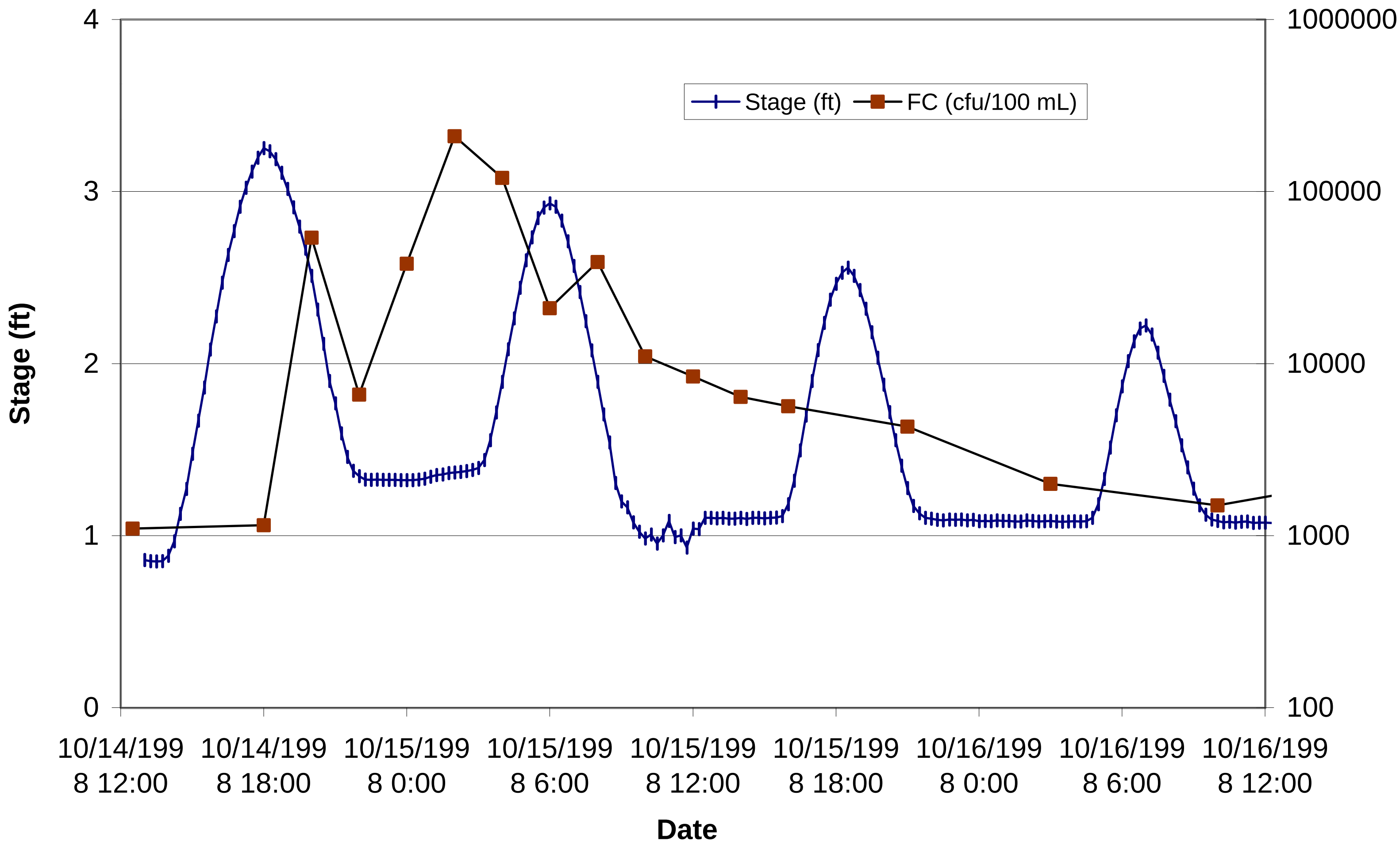


Figure 4.3 Stage and fecal coliform concentrations at Mason Street in Rocky Run, October 1998

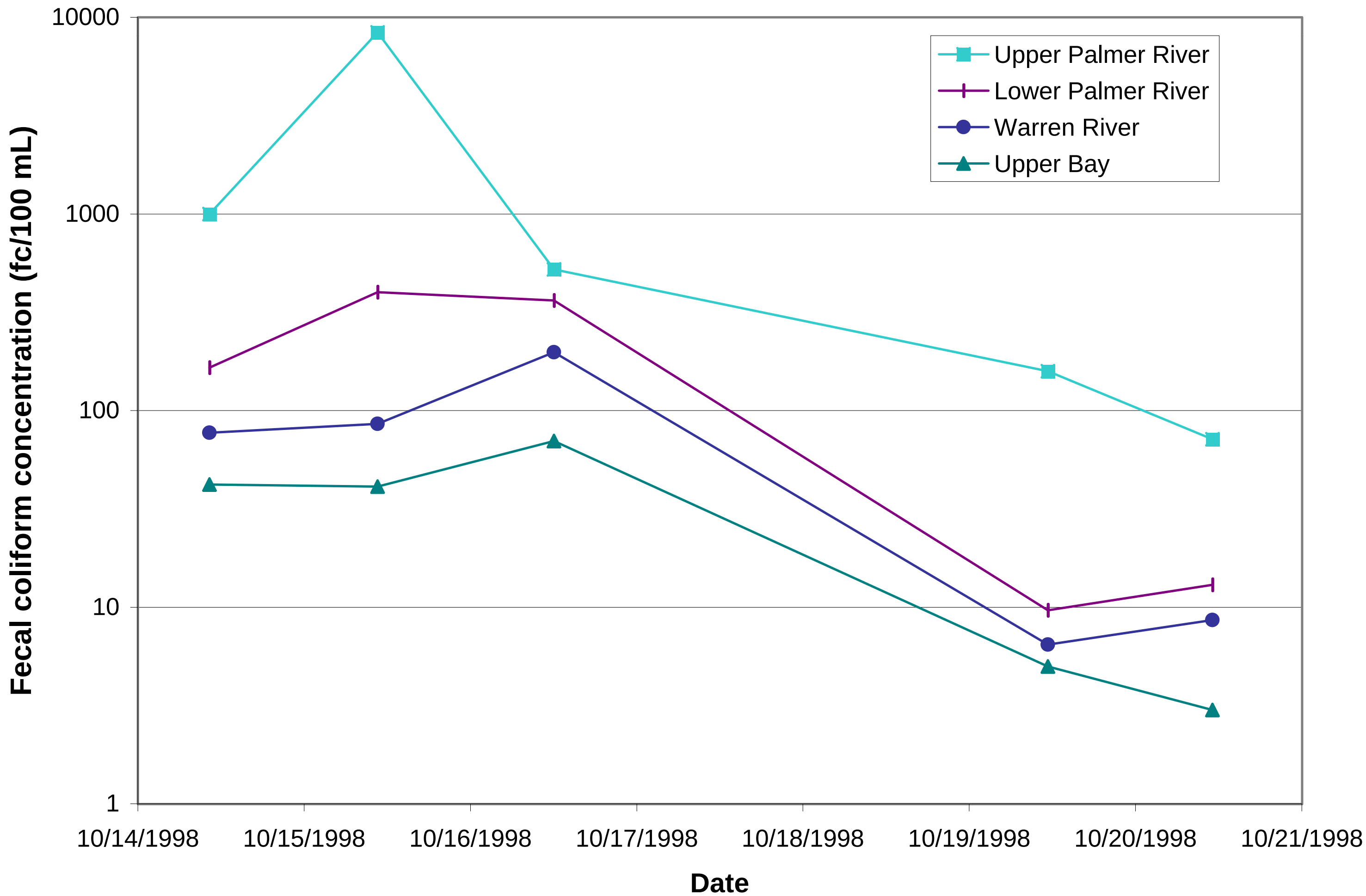


Figure 4.4 Geometric mean concentration of fecal coliform by reach of estuary after the 1998 storm event.

storm, peak concentrations were consequently present at the mouth of Belcher Cove and at the two upstream Palmer River stations. This cloud of peak concentrations continued to move seaward and was mixed longitudinally by dispersion. A day later, concentrations had risen at the mouth of the Palmer River and in the Warren River. Concentrations still remained high at the entrance to Belcher Cove and in the upper river, as loadings from upstream sources continued. At five and six days after the storm, the headwaters sources had not yet abated, particularly from upstream of Bungtown Bridge. Six days after the storm, concentrations remained significantly elevated at the upper Palmer River stations (120 fc/100 ml at station GA2-6A) and to a lesser degree at the entrance to Belcher Cove (24 fc/100 ml at GA2-7A).

4.2 Lower Palmer River Sources

4.2.1 Dry Weather

The Lower Palmer River is influenced by sources upstream in the Palmer River including the waters north of the state line and Belcher Cove. The RIDEM Shellfish Program Shoreline Survey sampled actual and potential dry weather sources along the banks of the Palmer River and found no significant sources of fecal coliform entering directly into the lower Palmer River.

The RIDEM Shellfish Program performed a shoreline survey in 1999 by collecting grab samples at selected locations along the shore (RIDEM, 1999c). Six locations were sampled in the Palmer River (Table 4.5) three of which flow into Belcher Cove; these results are described in the following section 4.3.1. Five locations were sampled in the Warren River (Table 4.6).

Table 4.5: Palmer River pollution sources from the 1999 RIDEM Shellfish shoreline survey.

Source #	Concentration fc/100 ml	Location Description	Actual/ Potential pollution sources	Direct/ Indirect
25	No flow	Opposite 16 Sowams Rd. 12” concrete pipe	Potential	Direct
26	No flow	Opposite 22 Sowams Rd. 12” concrete pipe	Potential	Direct
27	43	Drains Duck Pond Between Commonwealth and Garden St. 12” concrete pipe	Actual	Direct

The three stations sampled in the lower Palmer River were all direct sources to the river. Two of the sources (numbers 25 and 26) were not flowing at the time of collection and are assumed to be potential wet weather contributors to the river. The third station (number 27) sampled had very low flow and drained a small duck pond (A. Charpentier, pers. com.). This flow is assumed to be groundwater induced and is potentially higher during wet weather.

The only station of concern in the Warren River is located on the west bank of the river at Blount Circle. This source had a concentration of 2300 fc/100 ml (Table 4.6), however the pipe was only “dripping” and took some time to get enough water to sample (A. Charpentier, pers. comm.). RIDEM does not consider this a significant source of fecal coliform.

Other bacteria sources may include waste from domestic animals, wildlife, and waterfowl, which enter the river directly in dry weather. No data available during the time of this study indicating that these sources are significant to the water quality impairment of the river, however.

Table 4.6: Warren River pollution sources from the 1999 RIDEM Shellfish shoreline survey.

Source #	Concentration fc/100 ml	Location Description	Actual/ Potential pollution sources	Direct or Indirect
28	4	End of Baker St. 6” concrete pipe.	Actual	Direct
30	No flow	Ferry Ln. & Mathewson Rd. 12” concrete pipe	Potential	Direct
31	No flow	121 Mathewson Rd. 12” concrete pipe.	Potential	Direct
32	No flow	69 Mathewson Rd. 12” concrete pipe.	Potential	Direct
36	2300	Blount Circle 12” concrete pipe.	Actual	Direct

4.2.2 Wet Weather

Wet weather sources directly to the lower Palmer River are negligibly small. The storm water runoff and other sources along the Rhode Island portion of the Palmer River are considered negligible because: a wide wetland buffer borders the majority of the river, fecal coliform concentrations have historically shown a consistent decrease in the downstream direction south from the Massachusetts border, and RIDEM shoreline survey data have indicated that the potential for wet weather impacts from these sources is minimal. The relative impacts of the sources in the upper Palmer River and Belcher Cove to the lower Palmer River are not known, however in RIDEM’s best professional judgment, the upper Palmer River dominates the system. The three stations (Table 4.5) sampled by the RIDEM Shoreline Survey are assumed to be potential wet weather contributors to the Palmer River, however the magnitudes of these sources were not measured.

RIDEM determined that the influence from the Warren and Barrington Rivers is insignificant because their combined contribution to the Palmer River fecal coliform elevation is less than 1 fc/100 ml. This was determined based on water quality modeling performed for the Barrington River TMDL. The model was run using the conditions of the October 1998 storm described in the Barrington River TMDL document (RIDEM, 2000c). The storm event was evaluated with and without bacterial loading releases from the areas in the watershed on both sides of the Warren River and draining directly to the Warren River. The model showed that the mean concentrations at the mouth of the Palmer River over the course of the storm event were elevated by 0.3 fc/100 ml from the influence of the Warren and Barrington Rivers. The estimate of wet weather loadings from storm runoff was made for the area draining to the river from commercial areas in Warren. The runoff coefficient and concentration were based upon results from a similar storm water study in the Runnins River (RIDEM, 2000d).

4.3 Belcher Cove Sources

The two most significant sources of fecal coliform in Belcher Cove are the two streams that flow into Belcher Cove, Belcher Stream West and Belcher Stream East.

4.3.1 Dry Weather

The RIDEM Shellfish Program performed a shoreline survey in 1999 by collecting grab samples at selected locations along the shore (RIDEM, 1999c). Three locations in the Belcher Cove streams were sampled (Table 4.7). The highest fecal coliform concentration (4300 fc/100 ml) was found in Belcher Stream West, one of the two streams emptying into Belcher Cove. This stream runs along a park, as well as several businesses including a cleaner and an auto body shop where a dog is penned up alongside the stream. The other stream, Belcher Stream East, had a fairly high dry weather concentration of 750 fc/100 ml. This stream drains an area upstream that is predominantly a mix of agricultural and residential uses.

The RIDEM TMDL program sampled the two tributaries feeding Belcher Cove during the summer of 2000. Samples were collected at five sites along Belcher Stream West and at one site along Belcher Stream East (Figure 4.5). Upstream measurements were made at station BC05 located behind a house at the end of Ward Street. The next downstream station, station BC02, was alongside J. J. Cleansers upstream of the penned-up dog. Station BC04 was downstream of the dog and Market Street, and station BC01 was located near the mouth of the stream along Jamiel Park.

Table 4.7: Palmer River pollution sources in Belcher Cove from the 1999 RIDEM Shellfish shoreline survey.

Source #	Concentration fc/100 ml	Location Description	Actual/ Potential pollution sources	Direct/ Indirect
22	750	Rt. 136 & Market St. Belcher Stream East	Actual	Direct
23	4300	Market St. at J. J. Cleaners Belcher Stream West	Actual	Direct
24	3	NE area of Jamiel Park, Market St. mouth of Belcher Stream West	Actual	Direct

All stations in Belcher Stream West exceeded both parts of the water quality standard for Class A waters (Figure 4.6). The data are shown in Table 4.8. During dry weather, fecal coliform concentrations increased in the downstream direction with a concentration of 413 fc/100 ml at BC05 increasing to 3201 fc/100 ml downstream at station BC01. Upstream of the dog at station BC02 the geometric mean concentration was 1264 fc/100 ml and just downstream of the dog and Market Street the geometric mean was 3201 fc/100 ml. These results indicate a problem in two areas along Belcher Stream West. Residents regularly use Jamiel Park at the mouth of the stream to walk dogs. Although signs are posted in the area stating the law requires people to pick up after their dogs, a good deal of dog waste was found along the stream bank. It was apparent to RIDEM staff that rain events would wash the waste into the stream.

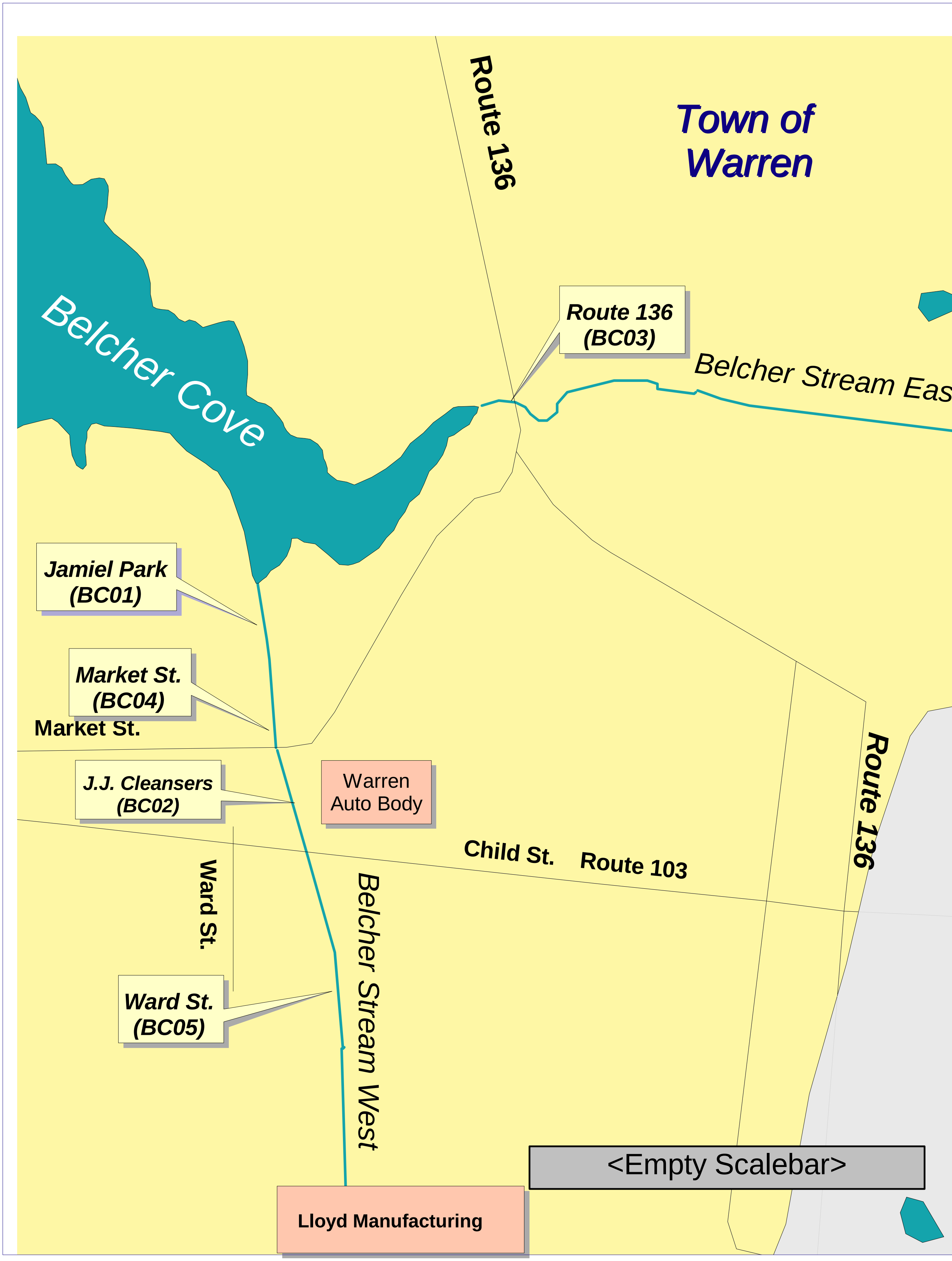


Figure 4.5 Belcher Cove Streams sampling stations

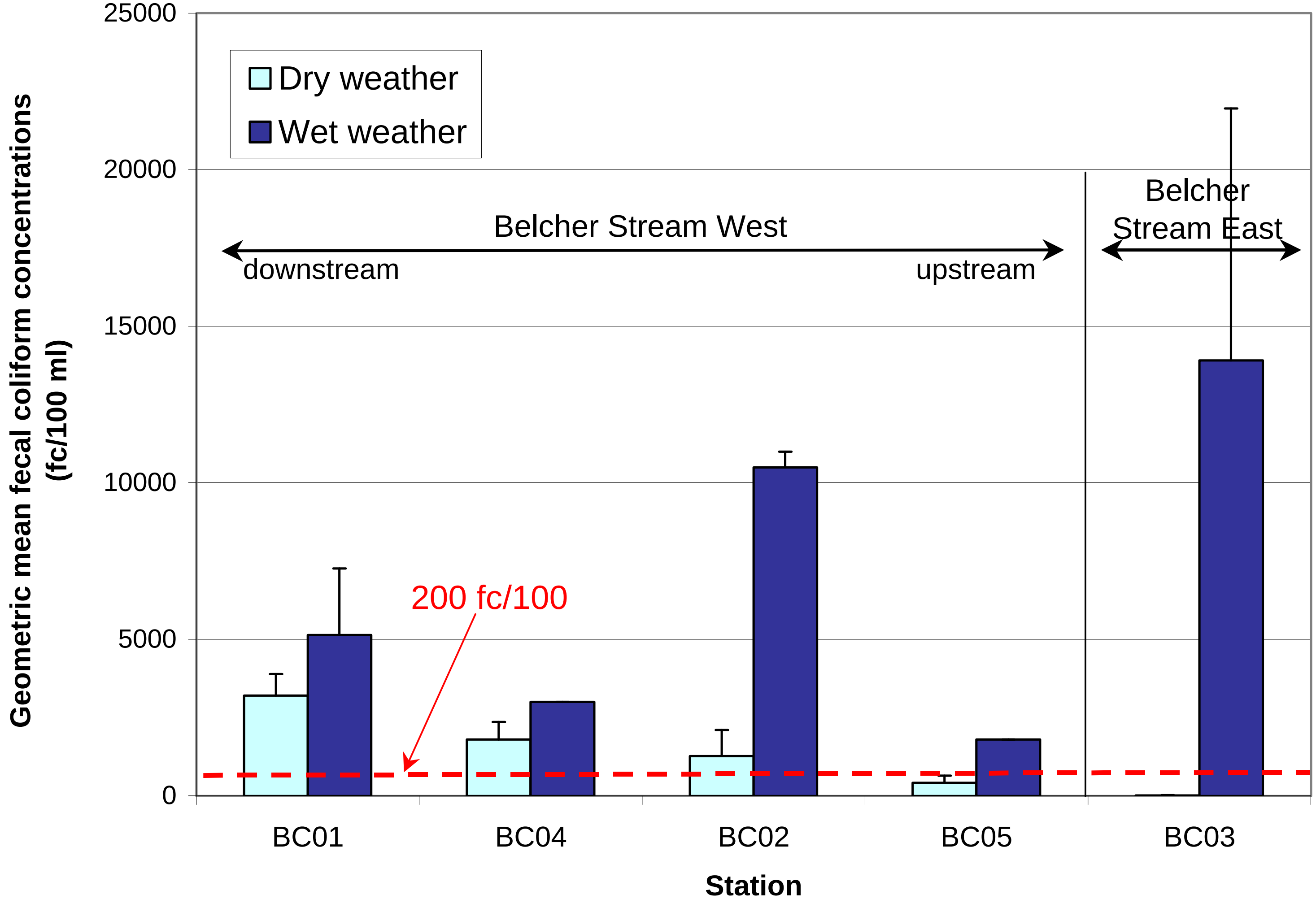


Figure 4.6 Fecal coliform concentrations in Belcher Cove Streams (+/- standard error)

Table 4.8 Dry Weather data for Belcher Cove Streams.

Station	Belcher Stream West Ward St. (BC05)	Belcher Stream West J.J. Cleansers (BC02)	Belcher Stream West Market St. (BC04)	Belcher Stream West Jamiel Park (BC01)	Belcher Stream East South of Rte 136 (BC03)
Geometric mean fc/100 ml	413	1264	1801	3201	9.7
% > 200	100%	100%	100%	100%	0%
# samples	4	4	3	3	4

Upstream of Market Street, a dog is penned behind an auto body repair shop located upstream of the park and directly along the stream. The pen area is paved and pitches directly toward the stream. RIDEM personnel observed that the dog's waste was not cleaned up on a regular basis and will flow directly into the stream when it rains.

Station BC03 was located in Belcher Stream East below the Route 136 overpass. In dry weather the fecal coliform concentrations met both parts of the water quality standard (Table 4.8). The geometric mean fecal coliform concentration was lower than the 20 fc/100 ml required by the first part of the standard and 100% of the samples were less than the 200 fc/100 ml concentration required by the second part of the standard.

4.3.2 Wet weather

RIDEM wet weather sampling during the summer of 2000 and fall of 2001 determined that the Belcher Cove streams had high fecal coliform concentrations in wet weather (Table 4.9). In Belcher Stream West the concentrations were highest during wet weather at the station next to J. J. Cleansers just upstream of the dog (Figure 4.6). The concentrations at the mouth of the stream were also high possibly because of runoff from the road and from dog waste in the park.

Wet weather concentrations were highest at Belcher Stream East (BSE), which meets water quality criteria in dry weather (Figure 3.4). The south fork of the upstream portion of BSE includes a small cattle farm and a residential area. In September 2001 RIDEM personnel conducted a wet weather study of Belcher stream east to bracket sources along the south fork of the stream and determine concentrations in the north fork of the stream. Results indicate that the dominant fecal coliform source in the subwatershed is the farm pond with a maximum concentration of 1,500,000 fc/100 ml during the first hour of the storm (RIDEM, 2001). High concentrations from the farm pond were found to persist downstream up to a day after the rain began. Other sources along the south fork of the stream include a storm drain that enters the stream just downstream of the farm pond, runoff from streets, wildlife, waterfowl and domestic animals. No septic systems are present in the south fork of Belcher Stream East.

The north fork of Belcher Stream East was sampled at one station, which peaked at 71,000 fc/100 ml during the first hour and decreased to 39,000 after three hours. Successive samples decreased in concentration to 22,000 fc/00 ml after six hours and 9,800 fc/00 ml after 18 hours. Concentrations that start out high and decrease rapidly point to nearby fecal coliform sources. Sources along this stream may include possible failing septic systems, a small farm operation, which occasionally grazes 5-10 head of cattle, a garbage transfer station, wildlife, waterfowl, and domestic animals.

Table 4.9: Wet weather fecal coliform concentrations in the Belcher Cove Streams.

Station	Belcher Stream West Ward St. (BC05)	Belcher Stream West J.J. Cleansers (BC02)	Belcher Stream West Market St. (BC04)	Belcher Stream West Jamiel's Park (BC01)	Belcher Stream East South of Rte 136 (BC03)
Geometric mean fc/100 ml	1800	10488	3000	5130	16143
% > 200	100%	100%	100%	100%	100%
# samples	1	2	1	2	8

4.4 Weighted average calculation

The present condition in the Belcher Cove streams was determined based on a "weighted average" calculation. This formula considers the probability of dry and wet days that occur in the watershed on an annual basis and calculates a value that would approximate the true condition of the area if it were sampled intensively. Incorporated into this approach is the time needed for the stream to return to a steady state condition after a rainfall. The weighted average is compared to the water quality standard to determine if a violation of the standard exists. If a violation does exist, a percent reduction is calculated. The weighted average equation is as follows:

Weighted Avg. Geometric Mean=

(% Dry days) x (Dry weather Geometric Mean)+ (% Wet days)x (Wet weather Geometric Mean)

The weighted average approach was first used in the Hunt River TMDL (RIDEM, 2000b). The percentage of wet weather days used for the Palmer River TMDL sources reflect those for the wet weather calculation in the Hunt River TMDL document because of the similarity of the two areas. The Hunt River TMDL determined that the amount of precipitation required to produce runoff was 0.20 inches, and any rain event producing 0.20 inches of rain or greater was considered wet weather. The frequency of occurrence of wet weather events on a yearly basis was determined in the Hunt River TMDL document by using 15 years of rainfall data from T. F. Green Airport (Warwick, RI). It was determined that wet weather days occurred 17.8% of the year. Recovery time for the streams to return to pre-storm conditions required an additional day in the Hunt River. To incorporate the day of recovery into the calculation, the percentage was doubled to 35.6% making the percentage of the year that dry weather is occurring 64.4%.

For the Belcher Cove streams the weighted average geometric mean is calculated:

Weighted Avg. Geometric Mean for Belcher Cove streams=

(64.4 %) x (Dry weather Geometric Mean) + (35.6 %) x (Wet weather Geometric Mean)

The results of this calculation are shown in Table 4.10. The Belcher Stream East station and the station at the mouth of Belcher Stream West were used to determine the geometric means for their respective streams. Data for the other stations in BSW were used to determine the causes of the high concentrations.

Table 4.10: Weighted average geometric means in the Belcher Cove Streams.

Location	Dry weather geometric mean fc/100 ml	Sample count, dry weather	Wet weather geometric mean fc/100 ml	Sample count, wet weather	Weighted average geometric mean fc/100 ml
Belcher Stream West	3201*	5	5130*	3	3888*
Belcher Stream East	9.7	4	16143*	9	5753*

** indicates violation of water quality criteria for fecal coliform bacteria*

4.5 Calculation of the percent exceedence value

In order to determine if a waterbody meets the requirements of this part of the standard the wet and dry weather data sets from the Belcher Cove streams were combined. The 90th percentile value presented in Table 4.11, was determined for each station from the combined data set.

Table 4.11: Percent exceedence values in Belcher Cove Streams

Location	Calculated 90th percentile value of combined data sets fc/100 ml
Belcher Stream East	37208*
Belcher Stream West	7273*

** indicates violation of water quality criteria for fecal coliform bacteria*

4.6 RIPDES Sources

The current waste load concentrations for point sources in the Palmer and Warren Rivers are presented in Table 4.12. The only point source discharging directly into the Palmer River is the Lloyd Manufacturing Company, which discharges into Belcher Cove via Belcher Stream West (RIPDES permit number RI000074). The Lloyd Manufacturing Company makes rubber sheeting and thread and discharges cooling water and boiler blow down in its manufacturing process to a limit of 0.3 million gallons per day (MGD) into Belcher Stream West. Lloyd Manufacturing Company's mean discharge during 1999 was 0.04 MGD.

Two facilities discharging to the Warren River may be pertinent to the Palmer River because the effeluent may be carried into the Palmer River on the flood tide. These are the Town of Warren Waste Water Treatment Facility (WWTF) and the Blount Seafood Corporation processing plant. The Warren WWTF was built in 1981 and is operated on a full-time basis. Recent improvements to the plant include upgrades to instrumentation, dissolved oxygen control with aerators, and dechlorination. In addition, the Town of Warren is investigating inflow and infiltration (I/I) reductions. The current permit limit is 2.01 MGD with an average monthly fecal coliform concentration of 200 MPN/100 ml. In 1999 the average daily flow was 1.6 MGD with an average effluent fecal coliform concentration of 7 MPN/100 ml. Blount Seafood discharges effluent from its seafood processing facility. Blount's current permit limit is 0.2 MGD with an average monthly fecal coliform concentration of 200 MPN/100 ml from April 1 – October 31 and 3100 MPN/100 ml November 1 - March 31. Blount Seafood's average daily flow for1999 was 0.05 MGD.

Dye dilution studies have been used to establish mixing zones and effluent concentration limits for RIPDES permits for the Warren Waste Water Treatment Facility (WWTF), permit number RI0100056, and Blount Seafood, permit number RI0001121, which both discharge to the Warren River. From examining the dye studies, RIDEM has concluded that increasing or decreasing loadings from these sources has very little impact on water quality in the Palmer River.

Table 4.12 Waste load allocations (geometric means) to point sources.

Point Source	Present Load (fc/100 ml)
Lloyd Manufacturing Company	0
Warren Wastewater Treatment Facility	10.1[1]
Blount Seafood	29.3[1]

[1] 1998-2000 data

The Warren WWTF dye study established the size of the acute zone as a circle with a radius of 50 feet. The minimum observed dilution in this zone was 35:1. The chronic zone was assigned a lateral dimension of 300 feet and a longitudinal dimension of 500 feet centered on the outfall. The minimum dilution factor for this zone was 100:1. The dye study demonstrated that the monthly average fecal coliform discharge limits of 200 fc/100 ml for Warren WWTF are reduced to a maximum observable value of 5.7 fc/100 ml above background within the boil. The maximum area of impact associated with this elevation is within a ten foot distance of the outfall. Assuming an ambient concentration of 6 fc/100ml for the Warren River the maximum local concentration in the vicinity of the Warren WWTF outfall is 11.7 fc/100 ml, well below the SB limit. Additional dilution occurs between the boundary of the mixing zone and the mouth of the Palmer River (a distance of approximately 4300 feet).

The 1994 RIPDES development document for Blount Seafood (RIDEM, 1994) used EPA guidance to establish an acute mixing zone radius of ten feet and a chronic mixing zone radius of 100 feet. The minimum dye dilution observed in the acute zone (i.e. minimum of observed raw values in the top two meters of the water column at the boil) during a dye study performed at the outfall was 290:1 in the outfall boil. The minimum dilution 100 feet from the outfall was 370:1.

The RIPDES permit issued to Blount Seafood on June 14, 1994, included seasonal permit limits for fecal coliform. Summer limits (April 1 - October 31) for Blount Seafood were established at the state treatment performance standard of 200 MPN/100 ml. Since the state applies performance standards statewide for secondary sanitary facilities and Blount does not discharge sanitary waste, their RIPDES permit included higher winter limits. When the plant is operating at the summer limit, the maximum concentration elevation within the ten foot radius of the boil would be 0.7 fc/100 ml. Winter limits (November 1 - May 31) of 3,100 MPN/100 ml were based on an analysis of instream mixing, which demonstrated that the receiving water quality criteria of 50 MPN/100 ml would be met within a very short distance of the outfall and the discharge would not impact the Warren Town Beach. The dilution study indicated that within a ten foot radius of the outfall concentration would be reduced from 3,100 to 17 MPN/100 ml. Other factors which contributed to the determination that the winter limit would not impact existing or designated uses included: Blount does not discharge treated sanitary waste and large amounts of chlorine were being utilized to meet the limit of 200 MPN/100 ml. In November 1998 Blount Corporation received approval to eliminate the use of chlorine and at that time switched to pasteurization to disinfect their effluent.

Both of these point sources dilute to a sufficient degree that their contribution to fecal coliform concentrations in the Palmer River may be neglected. However, RIDEM will be proposing a change in the fecal coliform standard for SB1 waters, which would include that stretch of the Warren River. The change would raise the SB1 fecal coliform standard from a geometric mean of 50 fc/100 ml to 200 MPN/100 ml.

5.0 PALMER RIVER FECAL COLIFORM CHARACTERIZATION

5.1 Dry weather

5.1.1 TMDL Watershed surveys

In 1996-97, the RIDEM TMDL program collected the dry weather in-stream fecal coliform data summarized in Table 5.1. Duplicate, deep, and shallow samples have been averaged into a single value for each station. All stations met water quality standards for geometric mean concentration at high and low tide. Station 5, located in the central lower reach of the Palmer River, had the highest geometric mean concentrations at low tide, with a mean of 9.4 fc/100 ml. The highest fecal coliform concentration, of 550 fc/100 ml, occurred at station 5.1. This was the only sample taken at this station at low tide. Fecal coliform concentrations were lower at high tide for most stations. Dilution during high tide at station 5 drops the fecal coliform concentration to an average of 32% of the low tide concentration. These observations indicate the presence of significant sources upstream of station 5.

A summary of the data at high and low tide is shown in Figure 5.1, with results presented by station and survey. Fecal coliform concentrations were highest during the months of June and July. During those months the concentration in the Palmer River was higher at the more northern station (station 5) with a peak value of 70 on June 13, 1996. Additional sampling was carried out at high and low tide on July 11, 1996 at station 5.2 (see Figure 3.3 for station locations). The low tide fecal coliform concentration was 550 fc/100 ml. From this we can deduce that the most significant fecal coliform source to the Palmer River during dry weather conditions in 1996 is the headwaters to the Palmer River, north of the state line. The northern most station consistently sampled in the river was station 5; station 4 was located in Belcher Cove and station 3 was located in the confluence of the Palmer and Barrington Rivers.

Table 5.1: Dry weather fecal coliform data at low and high tide in the Palmer River.
Shaded areas are measurements taken at high tide.

Reach	Mouth of Palmer River	Belcher Cove	Lower Palmer River	Upper Palmer River	Mouth of Palmer River	Belcher Cove	Lower Palmer River	Upper Palmer River
Station	3	4	5	5.1	3	4	5	5.1
Count	6	6	6	1	6	6	6	1
Geometric mean fc/100 ml	4.5	3.1	9.4	550*	5.9	2.4	3.8	8*
%>49	0%	0%	17%	-	17%	0%	0%	-
Min	2	1	2	-	0.5	1	0.5	-
Max	11.5	17	70	-	185	16	17	-

*Only a single sample was taken.

5.1.2 RIDEM Shellfish program monitoring

The water quality monitoring procedures used by the RIDEM shellfish program are largely dictated by the National Shellfish Sanitation Program (NSSP) requirements. The eighteen shellfish growing areas in Rhode Island waters are sampled for fecal coliform once a month. NSSP requires that the most recent fifteen samples be utilized when compiling and reviewing monitoring data for shellfish classification each year. Two Class SA fecal coliform standards must be met. The geometric mean of all samples must be less than 14 MPN/100 ml and 10% of the samples must not exceed 49 MPN/100 ml. If these standards are not met a decision is made

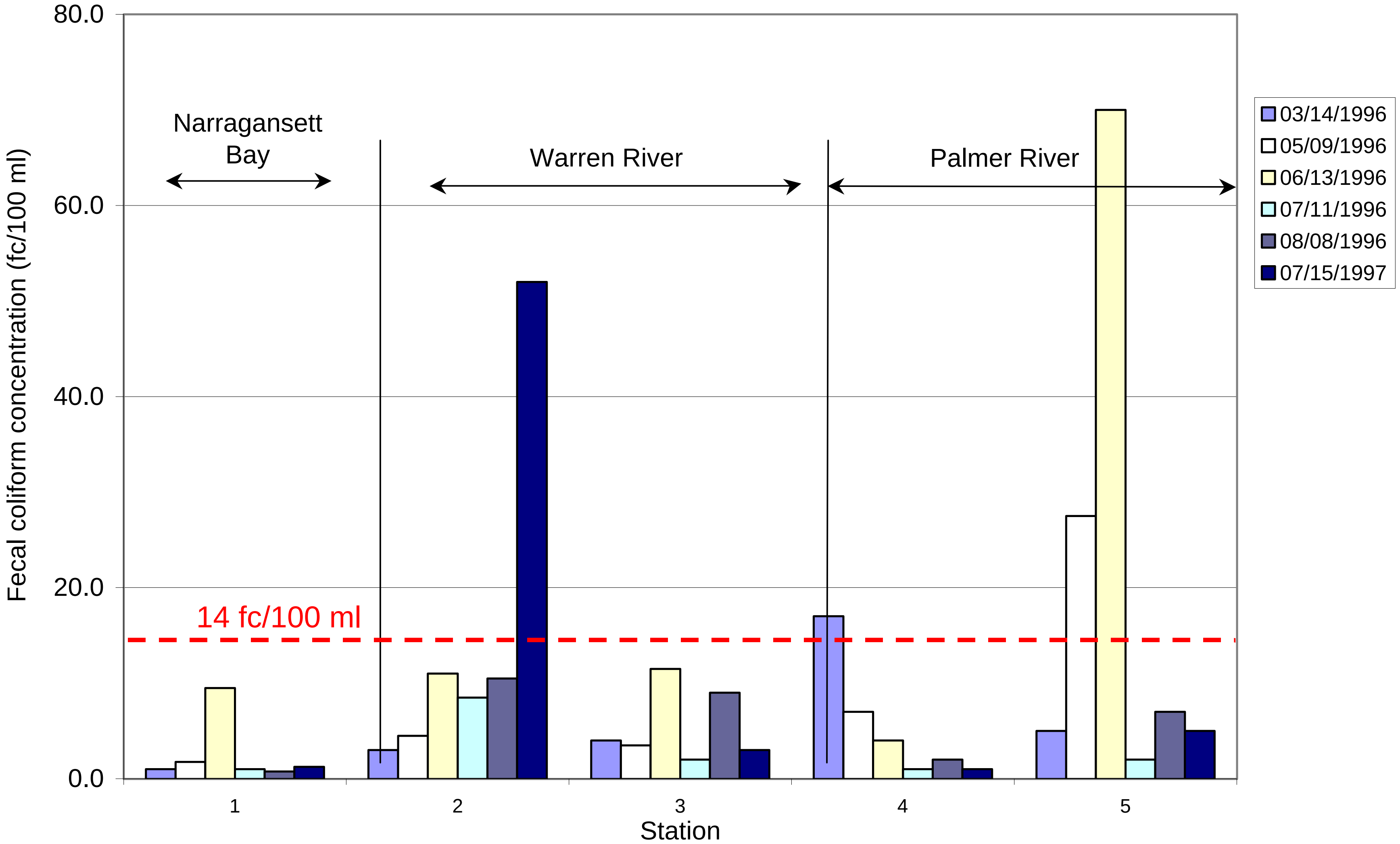


Figure 5.1. High tide in-stream fecal coliform concentrations in the Palmer River (RIDEM,1999)

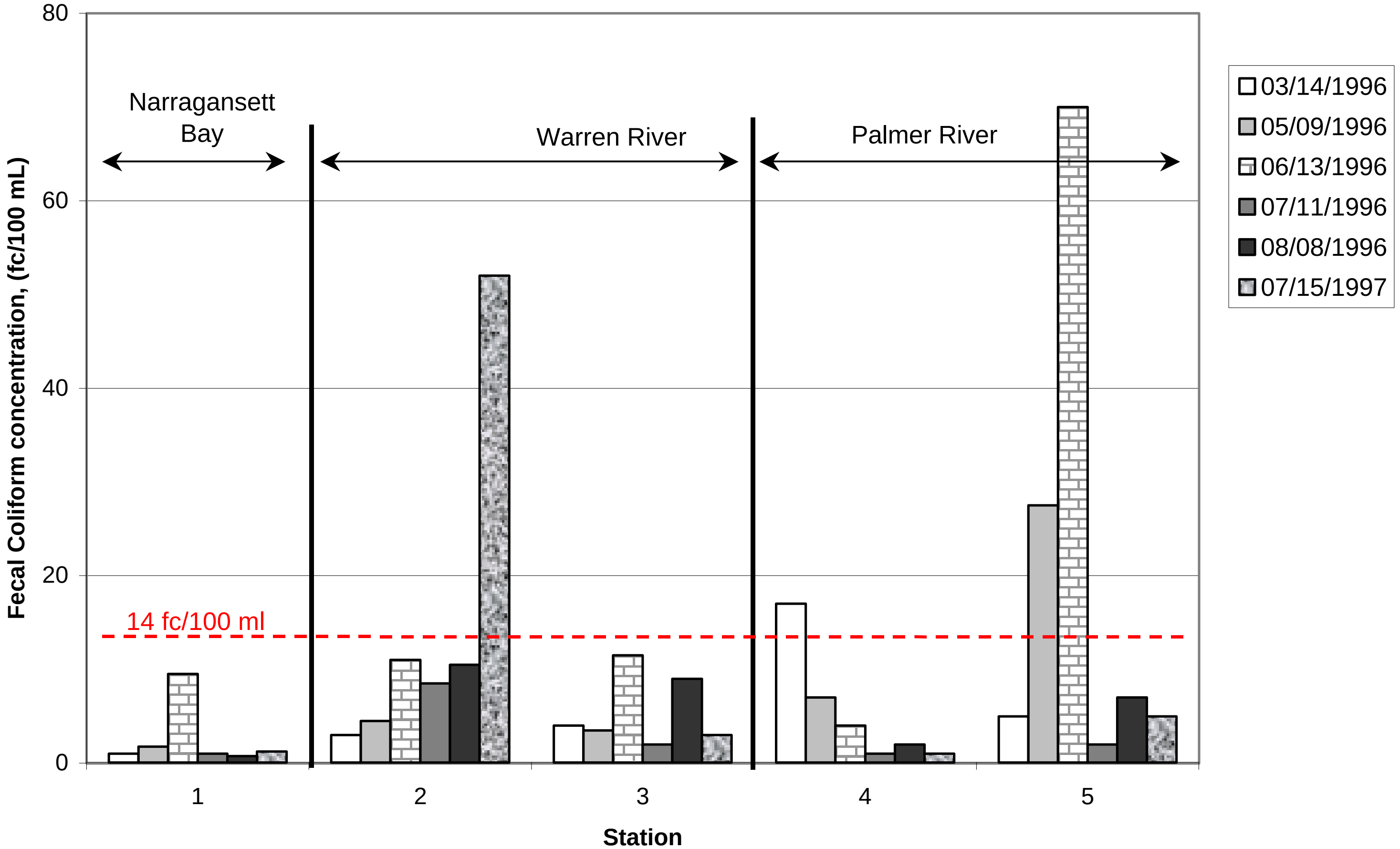


Figure 5.2. Low tide in-stream fecal coliform concentrations in the Palmer River (RIDEM,1999)

to either close the area permanently or open it on a conditional basis (after a certain amount of time has passed since the last rain event). The information used by the Shellfish Program to make the most recent determinations for 1996, 1997, 1998, and 1999 included monthly surveys conducted during dry weather between September 1995 though December 1999 (RIDEM, 1997a; RIDEM, 1998a; RIDEM, 1999a, RIDEM 2000a). The Palmer River is part of shellfish Growing Area 2. The data collected by the shellfish monitoring program in Growing Area 2 will be considered part of the dry weather data for the Palmer River.

During 1990, the Palmer River was conditionally approved for shellfishing north to the state line, and Belcher Cove was closed up to station 7A. From 1991 through 1994, Belcher Cove and the north end of the River south from the state line to sampling station 6 were closed. The north end of the river continued to be closed during 1995, and the closure line in Belcher Cove was moved north to include station 7A. The entire Rhode Island portion of the Palmer River has been permanently closed to shellfishing since 1996. Since that time stations 6A and 6, which are located in the northern end of the main part of the river, have continually exceeded the SA water quality standard. Since 1997 station 7A has exceeded the SA standard for fecal coliform.

Data for the years 1996 through 1999, from the RIDEM shellfish program illustrates that a deteriorated condition exists (Table 5.2). Since the Palmer River was closed to shellfishing in June 1996, at least three out of the five stations (see Figure 3.1 for shellfish station locations) in the Palmer River have exceeded one or both of the water quality criteria (Figure 5.3). Consistently, during the four years, stations 6 and 6A produced fecal coliform levels above the geometric mean standard of 14 fc/100 ml and greater than 10% of the time exceeded an MPN of 49/100 ml standard for variability. For the years 1996 through 1999, station 6A had fecal coliform geometric mean values of 52 fc/100 ml, 52 fc/100 ml, 96 fc/100 ml and 49 fc/100 ml, respectively. The percent exceedences for those years were 33%, 36%, 67%, and 44%, respectively. In 1996, the percent exceedence was 20% at station 7 exceeding the variability standard. From 1997 to 1999, the variability standard was exceeded at station 7A with percentages of 15%, 33% and 13%, respectively. The other stations in the Palmer River (Stations 7, 7A and 8 depending on the year) were near or just at the limit of compliance. During 1998 the data showed all but one of the stations (Station 8) in the Palmer River exceeding either one or both of the fecal coliform standards.

Table 5.2: Summary of dry weather fecal coliform data from RI Shellfish Survey 1996-1999.

Reach	Upper Palmer River Source	Upper Palmer River	Lower Palmer River	Belcher Cove	Mouth of Palmer River
Station	6A	6	7	7A	8
Count	44	54	55	53	62
Geometric mean fc/100 ml	62	18	10	14	10
% > 49	49%	23%	9%	17%	2%
Maximum fc/100 ml	430	2300	230	150	93

In a summary of the Shellfish Program data from 1996-1999 (Table 5.2), fecal coliform concentrations were highest upstream with a geometric mean of 62 fc/100 ml at station 6A, with almost half of the samples exceeding 49 fc/100 ml. Bacterial concentrations decreased

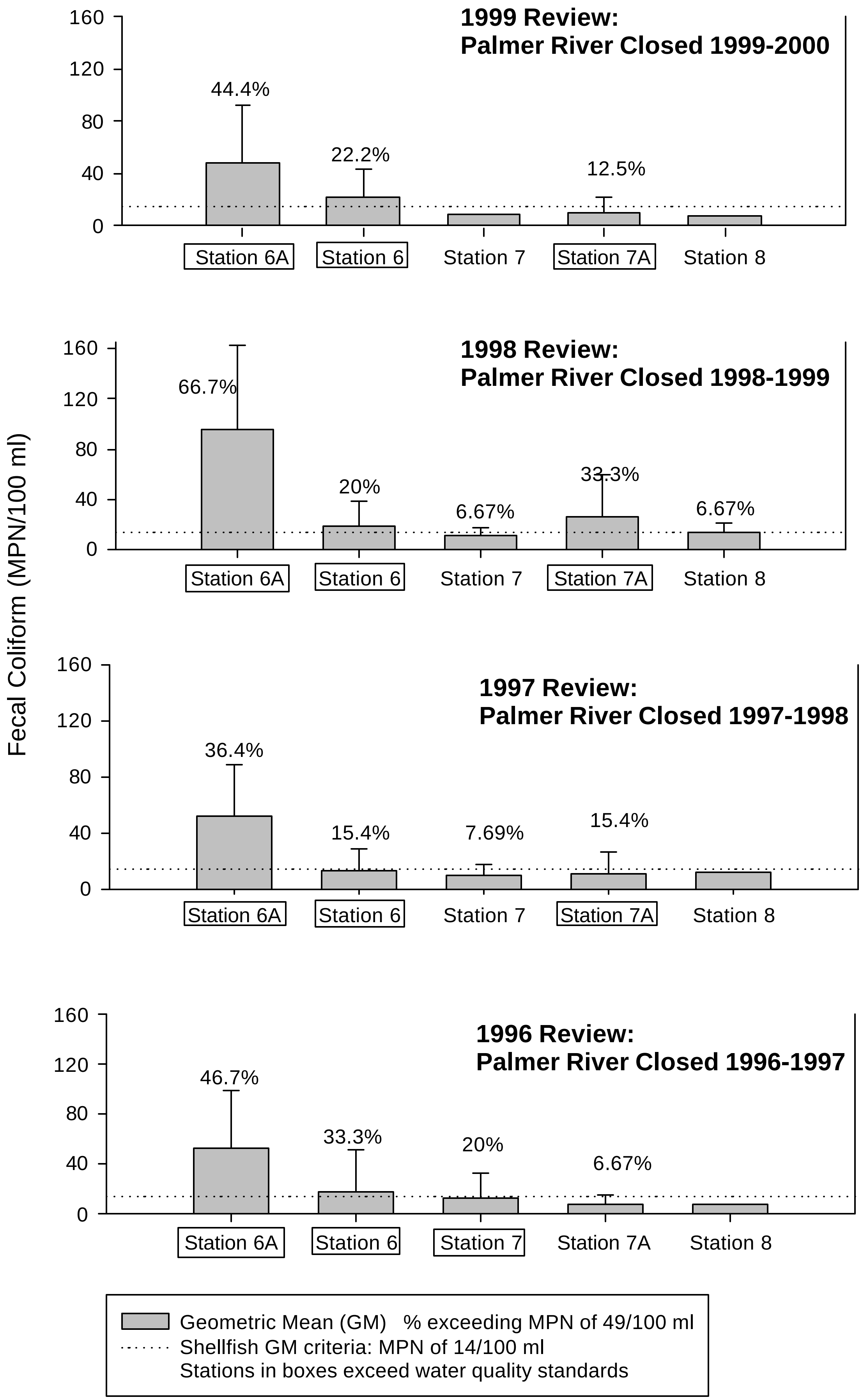


Figure 5.3 Summary of shellfish data for 1996-1999

downstream with stations 7 and 8 meeting water quality criteria. The only downstream station not meeting the 10% exceedence criterion was station 7A, located in Belcher Cove.

5.2 Wet Weather

As part of this TMDL, RIDEM sampled the sixteen shellfish stations in Growing Area 2 (GA2) during ebb tide prior to and during the wet weather event on August 13, 1997. The data show elevated fecal coliform levels in the upper river increasing from 230 and 20 fc/100 ml during the pre-storm survey (Figure 5.4) to 2300 and 230 fc/100 ml after the storm (Figure 5.5) at stations GA2-6A and GA2-6 respectively. The dry weather data collected prior to this storm are consistent with the yearly means calculated by the Shellfish Monitoring Program with stations 6, 6A and 7A exceeding water quality standards.

Fecal coliform samples were collected during one pre-storm and four post-storm surveys during October 1998. The sixteen RIDEM shellfish stations in Growing Area 2 were sampled during low tide conditions on each date. The sequence of results by survey is shown in Figures 5.6 through 5.10, beginning with the pre-storm condition on October 14. The pre-storm survey was conducted before the start of rainfall. The figures show concentrations relatively high at the start of the storm, with values in the Palmer River, ranging between 120 fc/100 ml at the mouth to 1000 fc/100 ml at station GA2-6 near the head of the river in Massachusetts. No data were collected at station 6A during the initial survey because of low water depths above station 6. The elevated concentrations were apparently residual from a rainstorm of 1.9 inch on October 10.

On October 15, 1998, the day after the storm, concentrations were highest in the upper Palmer River at 16000 fc/100 ml and 4400 fc/100 ml at stations 6A and 6, respectively (Figure 5.7). Measurements range from 240 to 850 fc/100 ml in the lower Palmer River and the upper Warren River. Two days after the storm, Figure 5.8 shows a peak concentration located near the Warren WWTF in the central Warren River. Concentrations declined to 120 fc/100 ml in the Barrington River. The October 19 and 20 surveys (Figures 5.9 and 5.10) show the area returned to below the pre-storm condition and with the exception of station 6A at the head of the Palmer River, all stations dropped to single digit or low double-digit values. In-stream fecal coliform concentrations in the Palmer River reach peak values on October 15, the day after the storm (Figure 5.7). Concentrations peak a day later in the Palmer River and in the central Warren River then decrease to values which meet water quality standards except for the upper Palmer River.

The Palmer wet weather data show that highest fecal coliform concentrations are consistently at station 6A in the upper part of the River (Table 5.3). Fecal coliform concentrations decrease downstream with the lowest concentrations at the mouth of the Palmer River. This result indicates that principal fecal coliform sources are located in Massachusetts, and affect the river downstream in Rhode Island. The data also show that concentrations at one station (station 7A) in Belcher Cove concentrations are slightly higher than the upstream station (station 7) and the downstream station (station 8). This result indicates the presence of sources in Belcher Cove

Figure 5.4 Low tide fecal coliform levels (fc/100 ml), one day before storm August 13, 1997

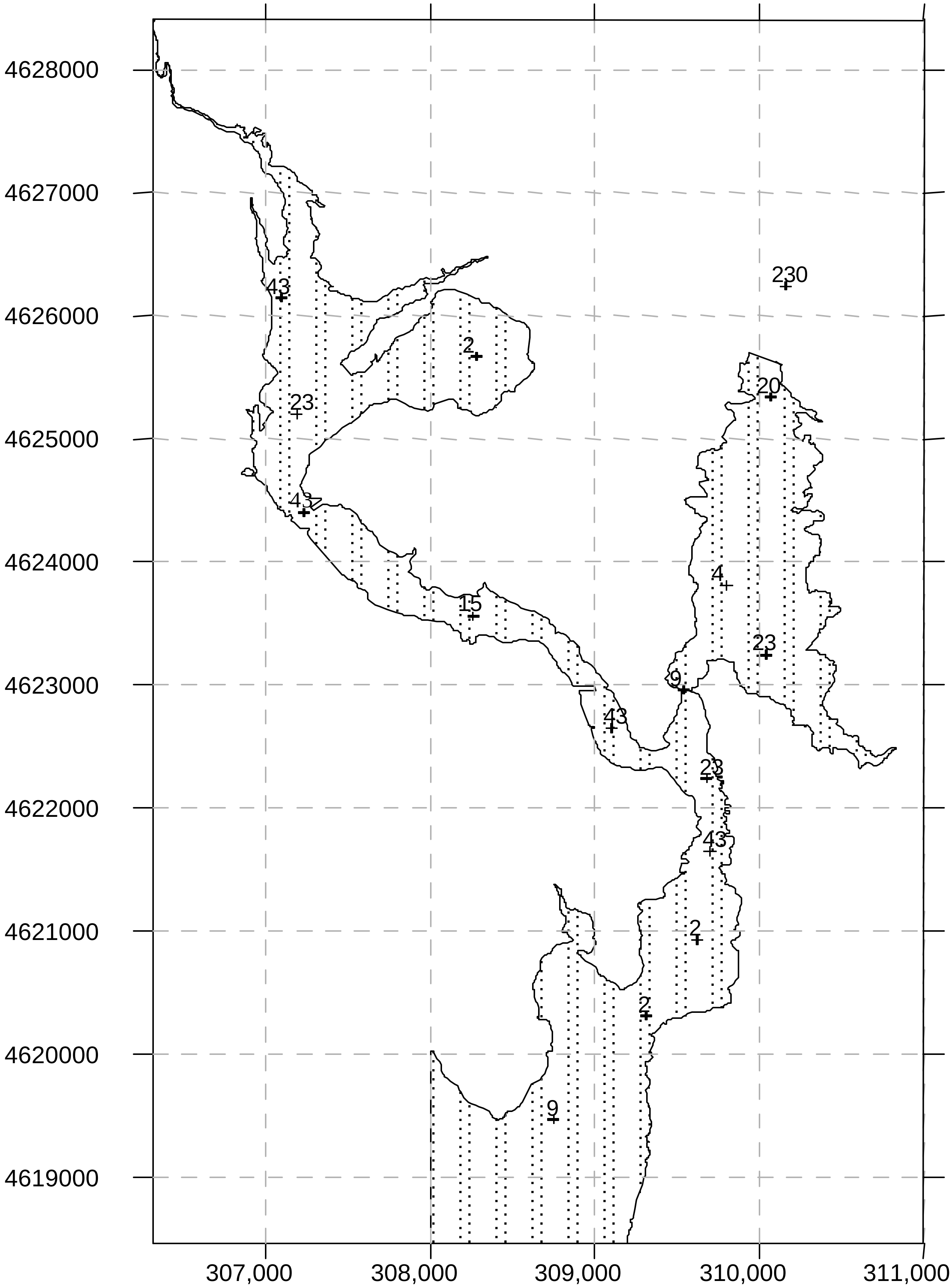


Figure 5.5 Low tide fecal coliform levels (fc/100 ml), one day after storm August 14, 1997

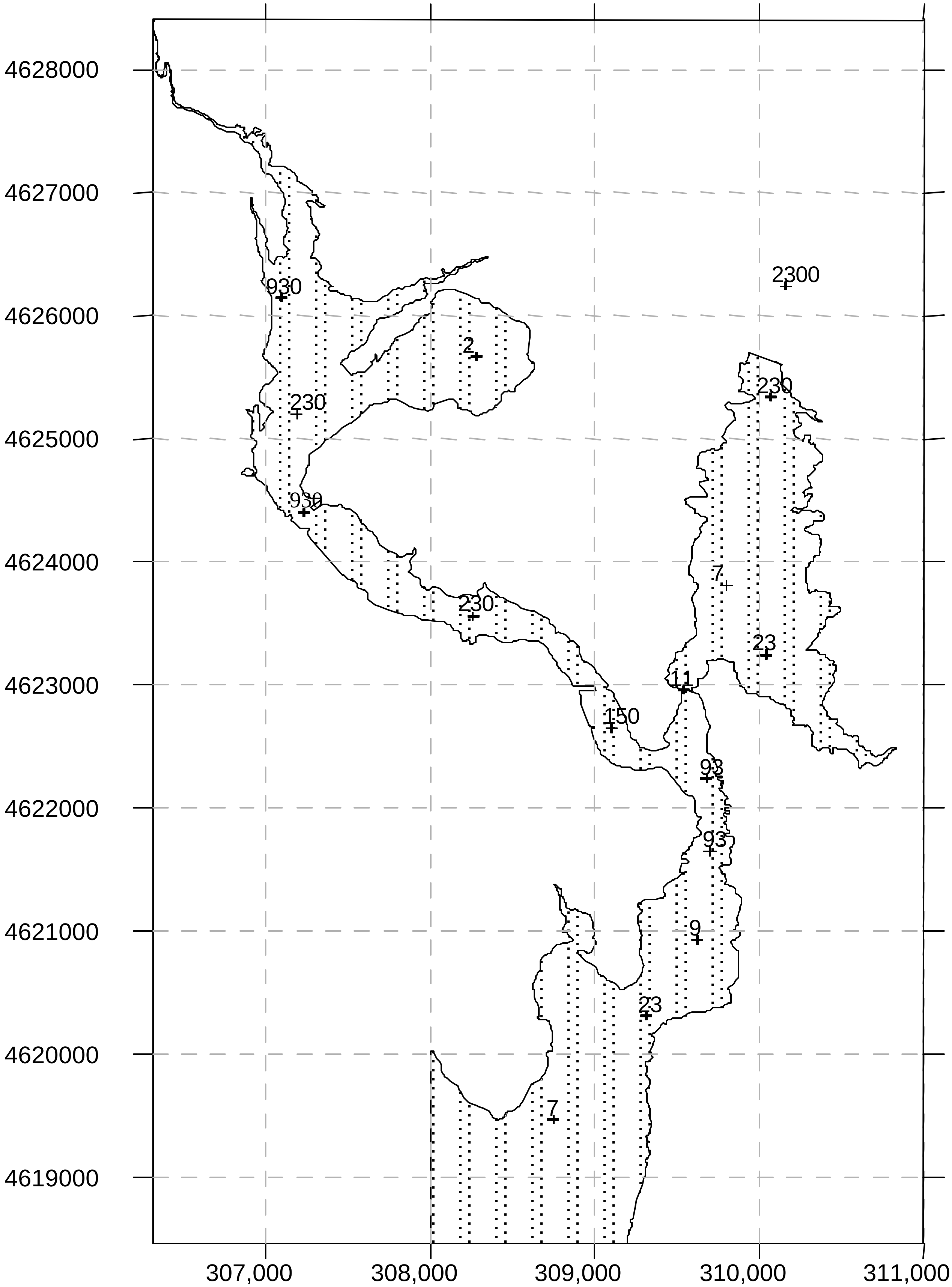


Figure 5.6 Pre-storm low tide survey fecal coliform levels (fc/100 ml), October 14, 1998

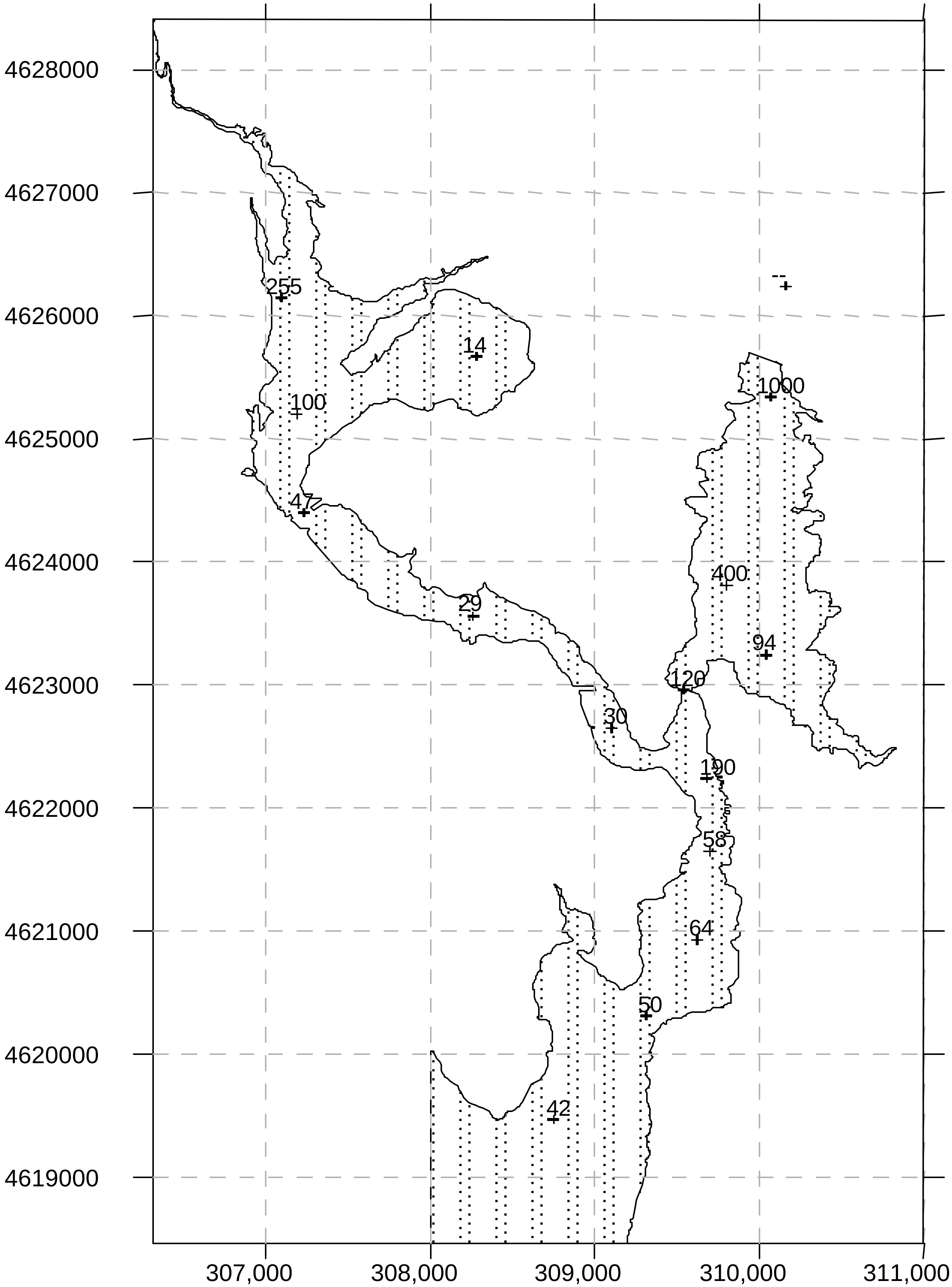


Figure 5.7 Low tide fecal coliform levels (fc/100 ml), one day after storm October 15, 1998

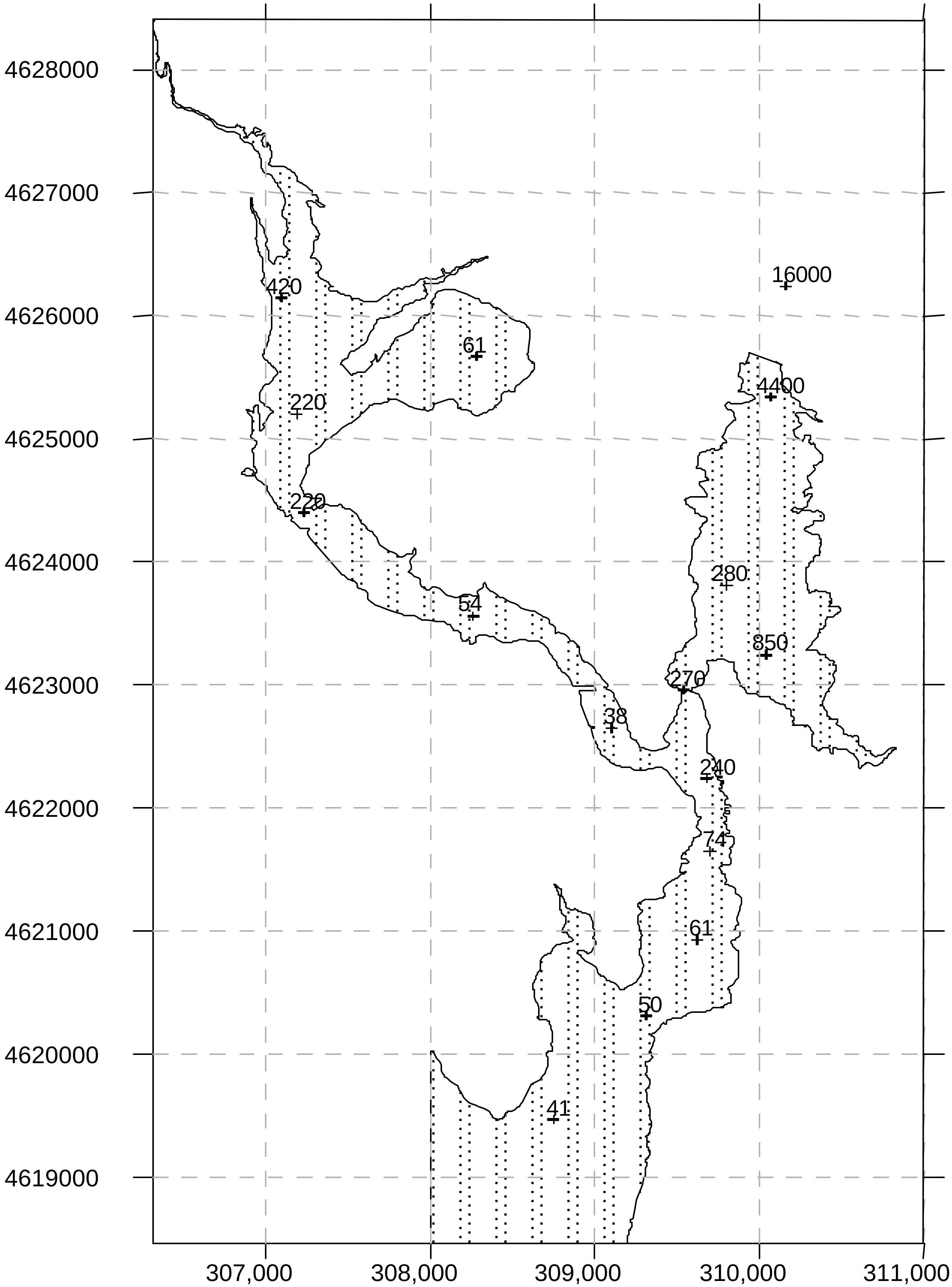


Figure 5.8 Low tide fecal coliform levels (fc/100 ml), two days after storm October 16, 1998

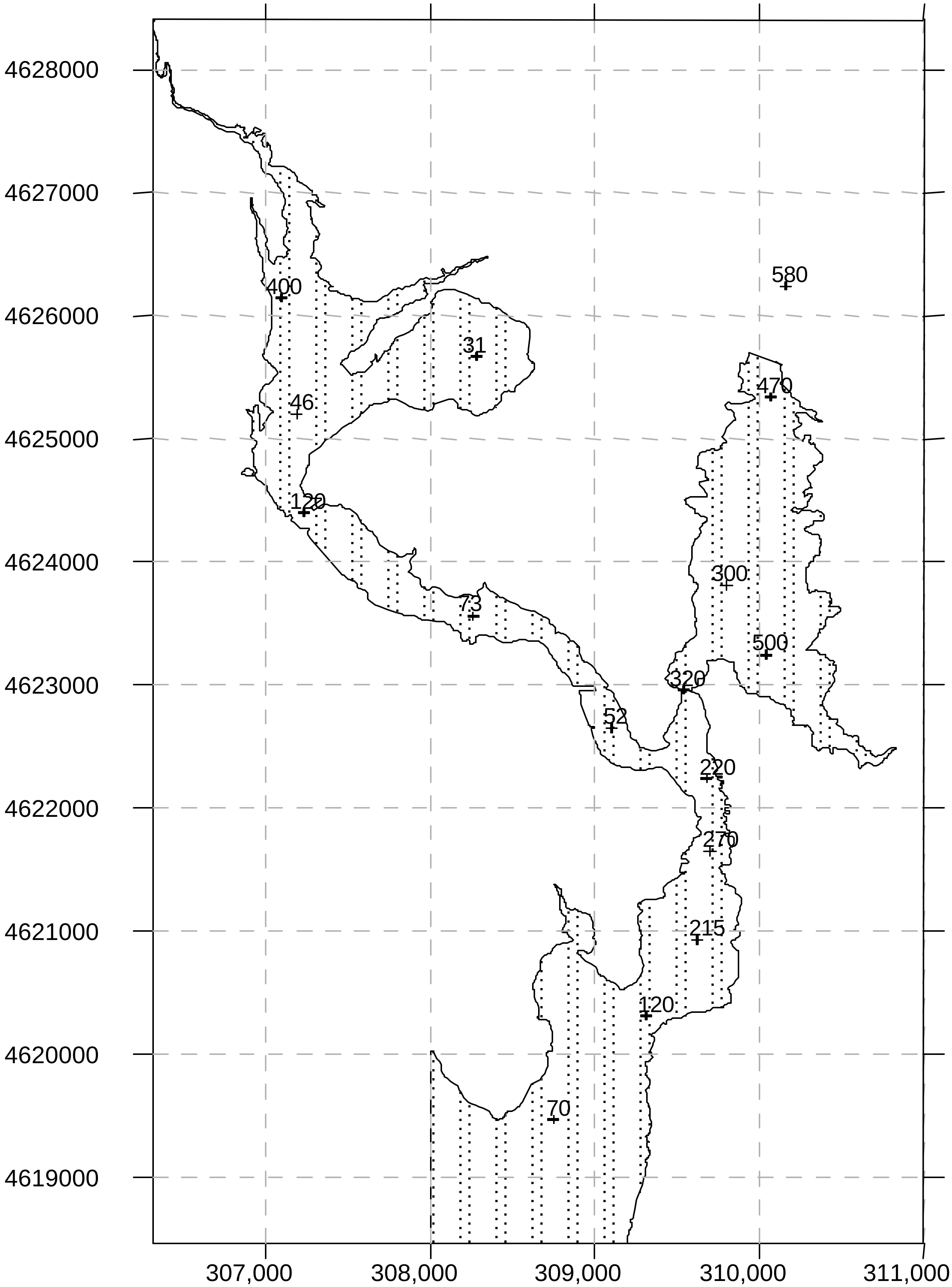


Figure 5.9 Low tide fecal coliform levels (fc/100 ml), five days after storm October 19, 1998

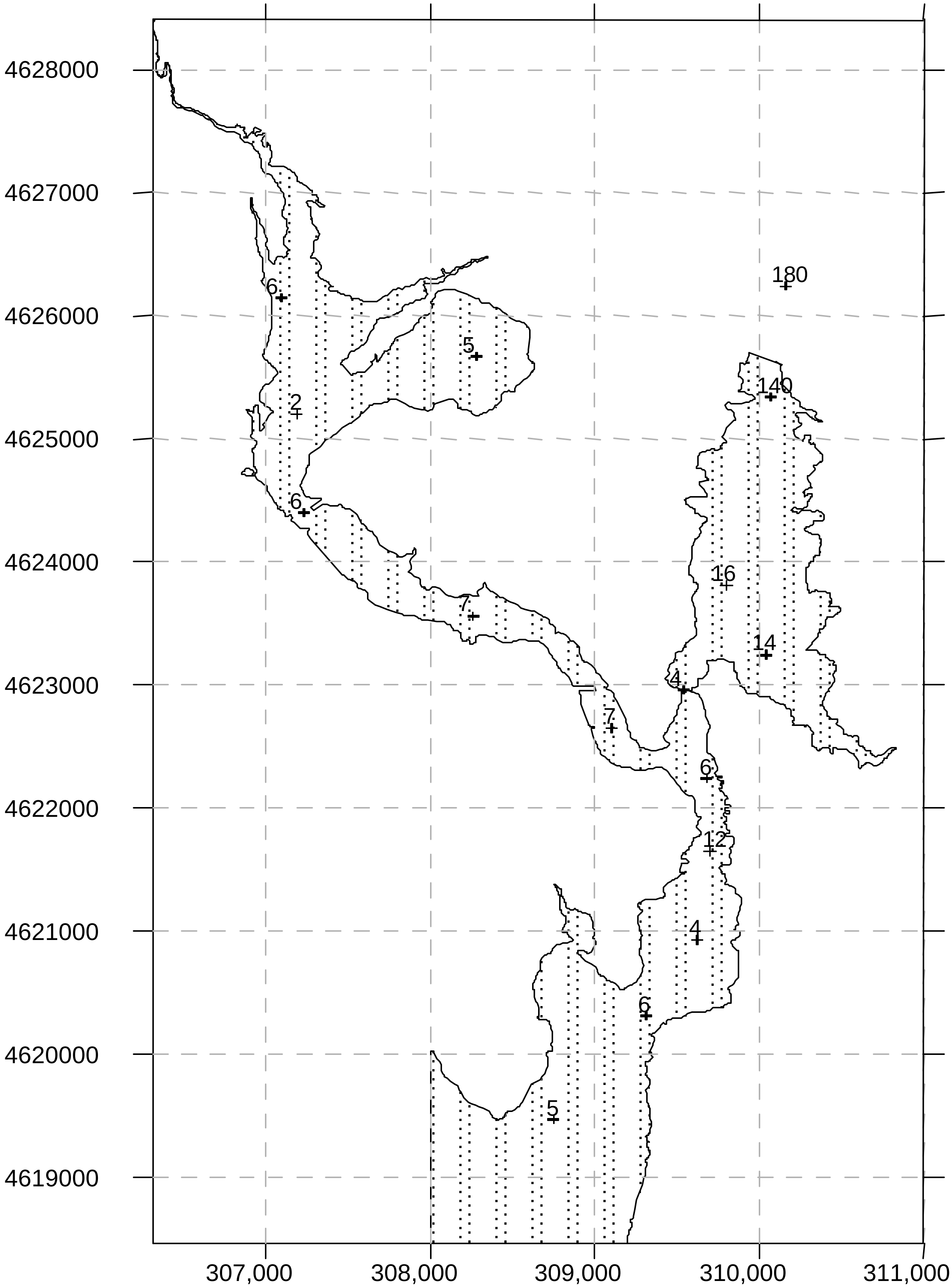


Figure 5.10 Low tide fecal coliform levels (fc/100 ml), six days after storm October 20, 1998

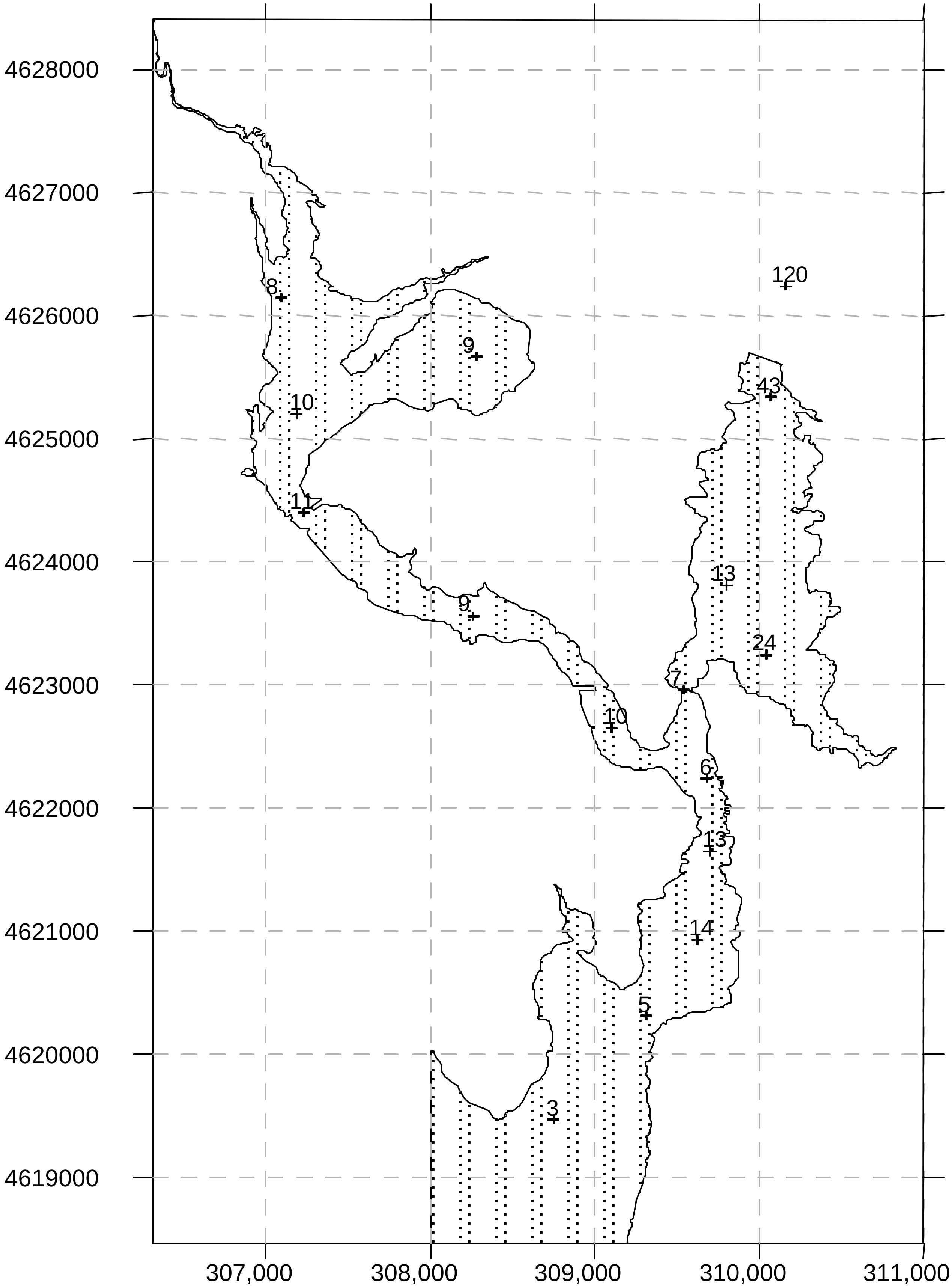


Table 5.3: Wet weather fecal coliform data, August 1997 and October 1998 in the Palmer River.

Station	6A	6	7	7A	8
Count	4	5	5	5	5
Geometric Mean	1400	582	82	105	54
%>49	100	100	50	50	50
Maximum	16000	4400	300	850	320

5.3 Weighted average calculation for Palmer River receiving waters

The present condition in the Palmer River was determined based on the "weighted average" calculation, outlined in section 4.4, that considers the probability of dry and wet days that occur in the watershed on an annual basis to calculate the representative condition of the area. The data set used for the dry weather portion of the weighted average calculation is the data collected for the RIDEM shellfish survey because this data is more conservative.

The percentage of wet weather days used to calculate the weighted geometric mean of the Palmer River waters follows the method used by the RIDEM's Shellfish Program. In conditional shellfishing areas, a rain event of 0.5 inches or greater within 24 hours causes a closure of the area to shellfishing for seven days. The 1998 RIDEM TMDL sampling indicated that at least 6 days are needed for the river to recover from a rain event (Figures 5.6-5.10). The assumption of a seven day closure is therefore appropriate for the Palmer River. Over the last ten years, the conditional areas in Growing Area 2 (GA-2) have been closed between 55 and 77 percent of the time. The Palmer River is in a wet weather condition, meaning it is raining or recovering from a rain event, for 75% of the time. During the remaining 25% it is considered to be in its dry weather condition.

For the Palmer River in-stream stations, the weighted average geometric mean is calculated:

Weighted Avg. Geometric Mean for Palmer River=

(25 %) x (Dry weather Geometric Mean) + (75 %) x (Wet weather Geometric Mean)

The results of this calculation are shown in Table 5.4 for each of the five in-stream stations. Once the weighted average is calculated it can be compared to the water quality standard to determine if either portion of the standard for fecal coliform is violated.

Table 5.4: Weighted average geometric means in the Palmer River

Station	Dry Weather Geometric Mean (fc/100 ml)	Number of samples, dry weather	Wet Weather Geometric Mean (fc/100 ml)	Number of samples, wet weather	Weighted Average Geometric Mean fc/100 ml	Percent of values > 49 fc/100 ml
6A	62	44	1400	4	1066*	59%*
6	18	54	582	5	441*	30%*
7	10	55	82	5	64*	17%*
7A	14	53	105	5	82*	8%
8	10	62	54	5	43*	6%

**indicates violation of water quality criteria for fecal coliform bacteria*

5.4 Calculation of the percent exceedence value

State water quality standards for Class SA waterbodies require that not more than 10% of the samples shall exceed a value of 49 fc/100 ml. To determine when a waterbody meets the requirements of this part of the standard, the wet and dry weather data sets from the in-stream stations were combined. The 90th percentile value was then determined for each station from the combined data set. The results are presented in Table 5.5.

Table 5.5: Summary of 90th percentile values for Palmer River stations.

Station	Water quality limit (fc/100 ml)	90th Percentile of combined data set (fc/100 ml)
6A	49	580*
6	49	230*
7	49	93*
7A	49	94*
8	49	50*

**indicates violation of water quality criteria for fecal coliform bacteria*

Table 5.4 and 5.5 show weighted geometric mean values for stations 6A and 6 that are greater than the 90th percentile values. This discrepancy is a result of the number and conditions represented by the samples taken. The weighted average geometric mean is derived from wet (75%) and dry (25%) weather samples. For example, at station 6A, 4 samples were collected during wet weather and the resulting geometric mean was 1400 fc/100 ml. In dry weather, 44 samples were used in the geometric mean calculation and the resulting geometric mean was 62 fc/100ml. The weighted average of these two numbers is 1066 fc/100 ml. When the weighted average is calculated, wet weather is given more importance because it is assumed to exist 75% of the time. The 90th percentile value is controlled by the large fraction of low concentration dry weather samples.

6.0 WATER QUALITY IMPAIRMENT OF THE PALMER RIVER

This section characterizes the fecal coliform impairments to the Palmer River, waterbody RI0007022E-01, and specifies violations of designated uses and water quality criteria. Three different reaches of the Palmer River are addressed, the upper Palmer River, the lower Palmer River and Belcher Cove (Figure 6.1). Both dry and wet weather data were used to assess the water quality impairment in the Palmer River. Dry weather data from the RIDEM Shellfish Monitoring program were used to assess the steady state condition when the waters would most likely be used for shellfishing and other primary and secondary recreational activities. Wet weather data were used to determine a worst case scenario and to identify sources of nonpoint pollution.

6.1 Upper Palmer River

Water Quality Impairments

Station 6 is the most northerly station in RI, located 400 m south of the MA state line and approximately 900m south of station 6A located in Massachusetts waters. Dry weather geometric mean fecal coliform values (Table 6.1) decrease from 62 fc/100 ml at station 6A in Massachusetts to 18 fc/100 ml at station 6 in Rhode Island. Wet weather geometric mean fecal coliform values decreased from 1400 fc/100 ml at station 6A to 582 fc/100 ml at station 6. The resulting weighted average geometric means are 1066 fc/100 ml at station 6A and 441 fc/100 ml at station 6.

Table 6.1: Percent reductions for fecal coliform concentration and 90th percentile value at Station 6.

	Present condition	Water quality standard	Percent reduction
Weighted average geometric mean fc/100 ml	441	14	97%
90th percentile fc/100 ml	230	49	79%

Pollution Source identification

RIDEM has identified the upper Palmer River in Massachusetts as the major dry and wet weather source of fecal coliform bacteria impacting the northerly reaches of the Palmer River in Rhode Island. This is evident from the concentration difference between station 6 and station 6A upstream in Massachusetts. The Rhode Island SA water quality standard must be met at the RI- MA state line. Based on the assumption that concentration varies linearly with distance between stations 6A and 6, the concentration at the state line would be 719 fc/100 ml. The percentage reduction in existing loads from the upstream MA sources is assumed to correspond directly to the percentage change in the geometric mean concentration at the state line and the 90th percentile concentration at RI Shellfish Program station GA2-6. The necessary upstream source load reductions are presented in Table 6.2.

RIDEM has identified one significant controllable source in the upper Palmer River, a farm along the Rocky Run tributary where cows were allowed to roam in and out of the water at will. Fecal matter deposited in the river by cattle in dry weather and additionally washed off the land during wet weather contributes significantly to the bacterial pollution the Palmer River. RIDEM

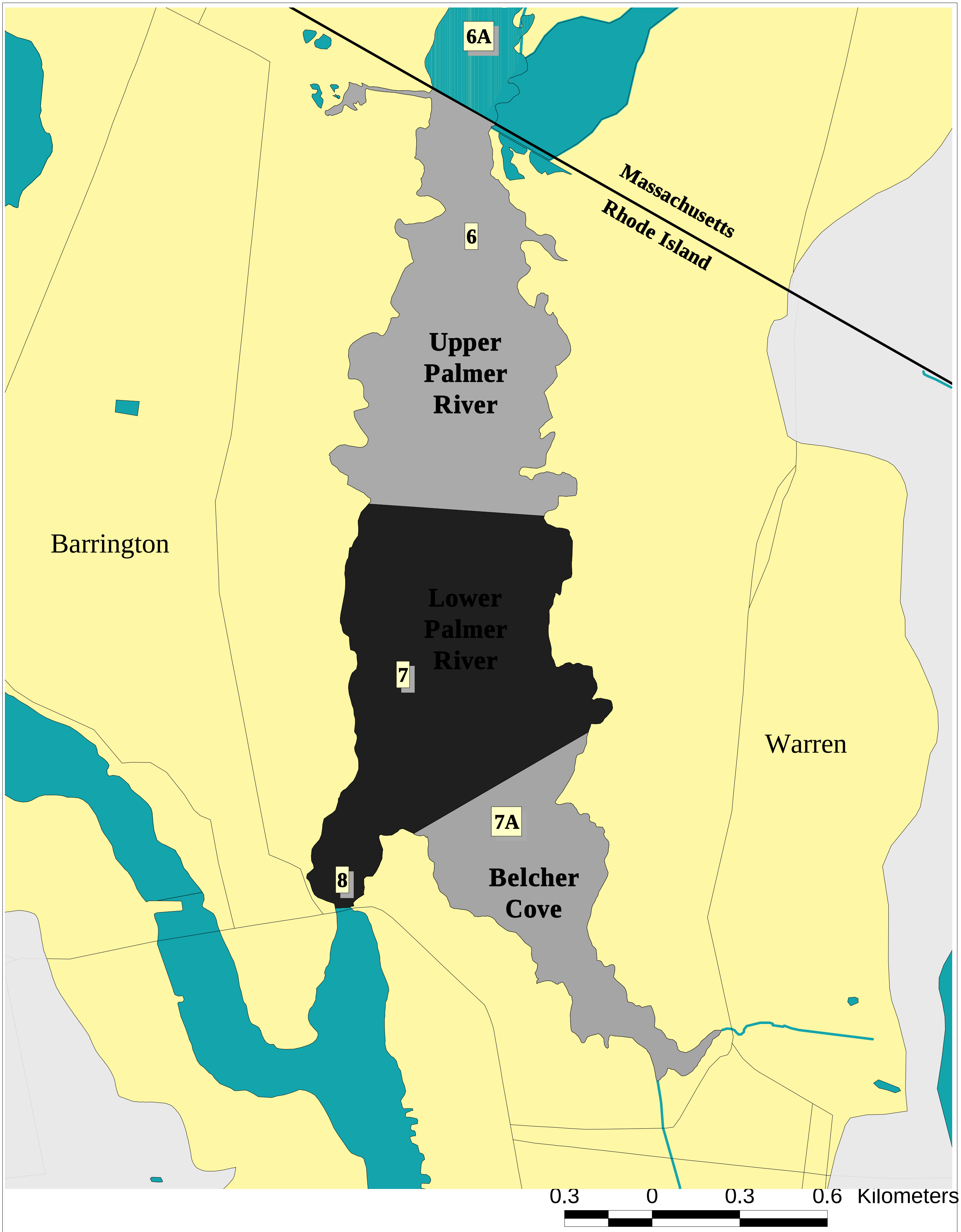


Figure 6.1 Segments of the Palmer River including survey station numbers.

Table 6.2: Percent reductions for geometric mean and 90th percentile fecal coliform concentration values needed to meet RI water quality fecal coliform standards.

	Present condition (fc/100 ml)	Location	Water quality standard (fc/100 ml)	Percent reduction
Weighted average geometric mean concentration	719	RI-MA state line	14	98%
90th percentile concentration	230	RI Shellfish station GA2-6	49	79%

has identified at least one other farm along the main stem of the Palmer River where a similar condition has existed and may continue in the future if the farm is worked. The Massachusetts Division of Marine Fisheries data indicate that storm runoff from other agricultural uses along the upper river contain high bacterial concentrations. These sources should be investigated and actions taken to reduce loads where possible.

6.2 Lower Palmer River

The two water quality stations in the lower Palmer River are stations 7 and 8. Station 7 is located 1.9 km from the Massachusetts State line, and station 8 is located 2.8 km from the state line. The dry weather geometric mean fecal coliform concentration at station 7 is 10.2 fc/100 ml and at station 8 is 10.4 fc/100 ml. Wet weather geometric mean fecal coliform concentration at station 7 is 82 fc/100 ml and at station 8 is 54 fc/100 ml. The weighted geometric mean for station 7 is 64 fc/100 ml and for station 8 is 43 fc/100 ml. The 90th percentile value for station 7 is 93 fc/100 ml and for station 8 is 50 fc/100 ml. The present condition and percent reductions for stations 7 and 8 are presented in Table 6.3.

<u>Pollution source identification</u>

RIDEM has identified conditions existing upstream of station 6 and in streams emptying into Belcher Cove to be the sources of bacterial pollution at stations 7 and 8. RIDEM considers the pollution sources affecting the upstream stations including station 7A in Belcher Cove to be also contributing to elevated fecal coliform levels at station 8. It is RIDEM's judgment, due to the extensive buffer areas along the river, and because RIDEM shellfish surveys found only

Table 6.3: Percent reductions for geometric mean and 90th percentile fecal coliform concentration values in the Lower Palmer River.

	Station	Present Condition (fc/100 ml)	Water quality standard (fc/100 ml)	Percent Reduction
Weighted average geometric mean	7	64	14	78%
	8	43	14	67%
90thPercentile	7	93	49	47%
	8	50	49	2%

minor sources, other dry and wet weather sources along the lower Palmer River are negligibly small. The sources identified in the lower Palmer River by RIDEM's Shoreline Survey are assumed to be potential wet weather contributors to the river. The drainage areas of these sources are small, the historical data show a consistent trend of decreasing concentration downstream from the head of the Palmer River, and the instream station data do not show increases near these sources. Once upstream sources are mitigated, the local exceedences may be detectable. The influence of downstream sources on the lower Palmer River cannot be separated from ambient background levels, or from the influence of earlier upstream loading. The influence of downstream sources therefore cannot be considered to influence in-stream conditions in the lower Palmer River. In RIDEM's judgment, resolving the upper Palmer River and Belcher Cove pollution sources will eliminate water quality violations at station 7 and 8.

6.3 Belcher Cove

Water Quality Impairment

Station 7A is located in Belcher Cove. The dry weather geometric mean fecal coliform value at station 7A is 14 fc/100 ml. The wet weather geometric mean value is 105 fc/100 ml. The weighted geometric mean value is 82 fc/100 ml. The 90th percentile value is 94 fc/100 ml. The present condition and percent reductions are presented in Table 6.4.

Pollution source identification

RIDEM has identified the two streams that flow into Belcher Cove as sources of bacterial pollution. The present conditions of Belcher Stream East (BSE) and Belcher Stream West (BSW) are presented in Table 6.5. The Belcher Cove streams are Class A streams, which have a water quality limit of 20 fc/100 ml and not more than 10% of the samples shall exceed 200 fc/100 ml. In the absence of data to determine if each tributary discharging at the Class A criteria will provide water quality sufficient to meet appropriate uses in the Palmer River, the

Table 6.4: Percent reductions for geometric mean and 90th percentile fecal coliform concentration values in Belcher Cove (Station 7A).

	Present condition (fc/100 ml)	Water quality standard (fc/100 ml)	Percent reduction
Weighted average geometric mean	82	14	83%
90th percentile	94	49	48%

TMDL requires that each tributary meet the Class SA standard at the point of discharge. The percent reduction needed is in excess of 99% for both BSE and for BSW (Table 6.5). These streams affect the water quality at station 7A, which is the closest water quality monitoring station in the Palmer River. If the water quality targets for these streams are met, along with those in the upper river as described above, it is RIDEM's judgment that the standard will be met at station 7A.

High fecal coliform concentrations are present in both streams, particularly in wet weather. The watersheds of both streams have intensive residential and commercial development. In addition, RIDEM staff discovered that waste from a penned-up dog located directly along Belcher Stream West (BSW) was not cleaned on a regular basis and was entering the stream directly. This situation poses a source during dry weather because fecal material could enter the stream directly, as well as a wet weather source. RIDEM also determined that a grass area in Jamiel Park at the mouth of this stream is regularly used for walking dogs. RIDEM staff observed that significant amounts of pet waste were present on the grass near the water's edge. This condition represents a likely wet weather source to the stream and Belcher Cove.

Dry weather fecal coliform concentrations meet water quality standards in Belcher Stream East (BSE). BSE was found to contain significant fecal coliform concentrations during wet weather, however. Preliminary site visits by RIDEM staff indicated that the elevations could be attributed to several possible causes: septic systems, periodic failures of the sewage collection systems on St. Teresa Street and Metacom Avenue, agriculture, wildlife (i.e. Canada Geese), and storm runoff from the developed areas adjacent to the stream. Septic systems and sewage overflows were eliminated as possible causes upon further evaluation by RIDEM because no septic systems were identified in the area and only one failure of a sewage pumping station was identified in the last four years. This failure occurred on St. Teresa Street on January 20, 1999, and resulted in a discharge of 500 gallons to the stream.

Belcher Stream East was sampled before and after a storm in September 2001. The sampling effort and results are documented in Appendix B. The study found very high concentrations in the pond used as a water source for cattle before, during, and after the storm. Concentrations in the pond were 210,000 fc/100 ml before the storm, peaked at 1,500,000 fc/100 ml during the storm, and tapered off to 37,000 fc/100 ml 42 hours after the storm. The event mean concentration for the pond station was 626,167 fc/100 ml. Runoff from a drain serving a nearby neighborhood was also sampled during the storm. The event mean concentration from the drain was 22,750 fc/100 ml. Concentrations at downstream stations generally declined in the downstream direction, from 38,000 fc/100 ml at the first in-stream station below the pond to 27,500 fc/100 ml where the stream empties into Belcher Cove. From this information, RIDEM has concluded that the farm is the dominant source to the stream. Other sources may convey

Table 6.5: Percent reductions for fecal coliform concentration and 90th percentile value in Belcher Cove Streams.

	BSE (BC03)			BSW (BC01)		
	Present condition	Water quality standard	Percent Reduction	Present condition	Water quality standard	Percent Reduction
Weighted average geometric mean fc/100 ml	5753	14	99.8%	3888	14	99.6%
90th percentile fc/100 ml	37208	49	99.9%	7273	49	99.3%

bacterial loadings to the stream, however, these only tend to dilute the high upstream loading. Results of this study have been sent to the RIDEM Division of Agriculture, which will work with the farmer to implement best management practices for the pond.

7.0 TOTAL MAXIMUM DAILY LOAD ALLOCATIONS

7.1 TMDL definition

The TMDL identifies the greatest amount of a pollutant that can be assimilated by a waterbody while still achieving water quality standards. TMDLs are normally expressed in units of mass loading (e.g. pounds per day), but may also be expressed in terms of concentration (number of organisms per 100 milliliters). This TMDL will be expressed in concentration units.

7.2 Loading Capacity

As described in EPA guidelines, a TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards. (40 C.F.R. 130.2). The loadings are to be expressed as a mass loading, toxicity, or other appropriate measures (40 C.F.R. 130.2[I]). The loading capacity for this TMDL is expressed as a concentration set equal to the state water quality standard. It is justifiable to express a bacteria TMDL in terms of concentration. Rationale for this approach is provided below.

1) Expressing a bacteria TMDL in terms of concentrations provides a direct link between existing water quality and the numeric water quality target.

2) Using concentration units in a bacterial TMDL is more relevant and consistent with the water quality standards, which apply for a range of flow and environmental conditions.

3) Follow-up monitoring will compare concentrations, not loadings, to water quality standards.

Required reductions represent an overall reduction goal that is applicable to the composite of all tributary, point and nonpoint sources contributing to the water quality impairment.

7.3 Targeted Water Quality Goal

One of the major components of a TMDL is the establishment of in-stream water quality targets. These targets are used to evaluate the process of achieving acceptable water quality and are usually based on either the narrative or numeric criteria required by state water quality standards. The Class SA fecal coliform standard is used as the target for the Palmer River.

7.4 Point Sources

Allocations for the point sources discharging to the Palmer and Warren Rivers are the same in dry and wet weather and have been set to their current permit limits as listed in Table 7.1. The only point source discharging directly into the Palmer River is the Lloyd Manufacturing Company, which discharges into Belcher Cove via Belcher Stream West (RIPDES permit number RI000074). Dye dilution studies have been used to establish mixing zones and effluent concentration limits for RIPDES permits for the Warren Waste Water Treatment Facility (WWTF), permit number RI0100056, and Blount Seafood, permit number RI0001121, which both discharge to the Warren River. From examining the dye studies, RIDEM has concluded that increasing or decreasing loadings from these sources has very little impact on water quality in the Palmer River. Both of these point sources dilute to a sufficient degree that their contribution to fecal coliform concentrations in the Palmer River may be neglected.

Table 7.1 Waste load allocations (geometric means) to point sources.

Point Source	Present Load (fc/100 ml)	Allocated Load (fc/100 ml)	Percent Reduction
Lloyd Manufacturing Company	0	0	0 %
Warren Wastewater Treatment Facility	10.1[1]	200	0 %
Blount Seafood	29.3[1]	200 summer/ 3100 winter[2]	0 %

[1] 1998-2000 data
[2] As described below, the allocated winter limit for Blount Seafood is 3100 fc/100 ml.

7.5 Nonpoint Sources

The load allocations were determined for each water quality station by comparing current conditions to the water quality standard and then calculating the percent reduction needed to meet the standard. Since there are two parts to the water quality standard, two calculations must be made at each station to determine the reductions necessary to meet both parts of the standard. The TMDL will be based on the greater, or more conservative of the two reduction levels. The weighted average geometric mean values and the resulting percent reductions to meet the water quality standard are presented in Table 7.2. As stated previously, storm water pipes although technically considered point sources were included in the loading allocation due to a lack of detailed site specific information.

Table 7.2: Weighted average geometric means and reductions needed at Palmer River stations to reach the water quality limit of 14 fc/100 ml.

Station	Weighted Average Geometric Mean (fc/100 ml)	Percent reduction required to reach 14 fc/100 ml
State Line	719	98 %
6	441	97 %
7	64	78 %
7A	82	83 %
8	43	67 %

The 90th percentile values of the combined data set of wet and dry weather fecal coliform concentrations for the water quality stations in the Palmer River are presented in Table 7.3. Percent reductions necessary to meet the water quality standard of not more than 10% of the samples shall exceed 49 fc/100 ml are also included.

The difference between the weighted average geometric mean concentration and the concentration determined by the 90th percentile is a result of the number of samples taken. The weighted average geometric mean is a combination of wet (75%) and dry (25%) weather concentrations. For example at station 6A six samples were collected in wet weather. The resulting geometric mean was 1400 fc/100 ml. In dry weather, 38 samples were used in the geometric mean calculation and the resulting geometric mean was 62 fc/100ml. The weighted average of these two numbers is 1066 fc/100 ml. When the weighted average is calculated, wet weather is given more importance because wet weather concentrations are relatively high and the wet weather condition is assumed to occur during 75% of the year. The geometric value at the RI-MA state line was calculated by averaging the value at station 6A north of the border with that at 6 south of the border, inversely weighted by their distance to the border. When the 90th percentile is calculated the numbers are weighted the same and the result depends upon the number of samples collected and the corresponding weather condition (wet/dry). The 90th % value at the state line was assigned the value at station 6.

Table 7.3: Percent reductions at Palmer River stations required to reach the water quality limit of 49 fc/100 ml.

Station	90th Percentile of combined data set (fc/100 ml)	Percent reduction required to reach 49 fc/100 ml
State Line / 6	230	79 %
7	93	47 %
7A	94	48%
8	50	2 %

Required Load Reductions

The TMDL is based upon the more conservative (the greater) of the two reduction values in the two tables above. The required load reductions presented below in Table 7.4. are the TMDL bacterial pollutant load reduction goals for the Palmer River.

Table 7.4: Required load reductions at Palmer River stations

Palmer River Station	Percent reduction required
State Line	98 %
6	97 %
7	78 %
7A	83 %
8	67 %

7.6 Margin of Safety

There are two basic methods for incorporating the margin of safety (MOS) into the TMDL. One can implicitly incorporate the MOS using conservative assumptions to develop the allocations or explicitly specify a portion of the TMDL as a portion of the final TMDL allocation. An implicit margin of safety is designed into the weighted average and the loading allocation prior to the final TMDL calculations. Throughout the TMDL process conservative assumptions were made and are described below.

- Conservative estimates of both the amount of rainfall needed to produce runoff and recovery time were used in the weighted average geometric mean calculations.
- The weighted average calculation emphasizes wet conditions because the wet weather period was determined using the 90th percentile value of ten years of weather data ranging from 55-77% of wet days in any given year.

7.7 Seasonal Variation

The Palmer River TMDL is protective of all seasons. Historically the highest fecal coliform levels in the Palmer River occur during the summer season from July through October. Most of the data used in the analysis were collected during the summer months. Any TMDL endpoint established for the summer months will therefore provide protection during the winter months.

8.0 IMPLEMENTATION

Fecal coliform bacteria levels in the Palmer River are related principally to conditions and loadings introduced by the upper Palmer River, Rocky Run and the Belcher Cove Streams. The high bacterial levels in the upper Palmer River result from loadings from farms and other nonpoint sources. Problems also exist in the Rhode Island section of the watershed specifically in the two streams feeding Belcher Cove. In all cases, the significant sources are nonpoint in nature and the improvements achieved by implementing the measures outlined below cannot be predicted. Section 9 contains recommendations for the continued monitoring of Palmer River to ensure that the in-stream numeric targets are met. Some of these recommendations can be used to partially satisfy Phase II storm water requirements, which are outlined in section 8.4.

8.1 Upper Palmer River

The upper Palmer River lies in the Commonwealth of Massachusetts. High dry and wet weather fecal coliform concentrations enter the Palmer River in Rhode Island from upstream in Massachusetts. As outlined in this TMDL, Massachusetts will need to meet the water quality standard of 14 fc/100 ml at the Rhode Island State line in order to avoid impacting Rhode Island shellfishing waters. RIDEM studies in the MA portion of the Palmer River watershed have determined that significant loads were associated with agricultural operations adjacent to the Palmer River and Rocky Run (RIDEM, 1999b). A summary of current and proposed work in the upper Palmer River is presented in Table 8.1.

Table 8.1: Summary of current and proposed work in the upper Palmer River

Known (K) or Potential (P) pollution source	Jurisdiction	Abatement measure	Status
Davis Street. Farm (K)	MADFA	Install fence to remove cows from stream	Farmer installed fence. Needs continuous maintenance
Mason Street & I-195 Farm (K)	MADFA	-Manure management -Cement base for milking area -Culvert into stream needs cement base with side wall and vegetative buffer	Completed March 2000
Mason Street Farm (P)	MADFA	Buffer cattle from stream that flows directly into Palmer River	Fence installed keeping cows from stream completed 2001.
Other potential sources (P)	MADEP	Investigate and mitigate other potential sources of fecal coliform. For specific locations see Figure 4.1	MADEP is currently conducting preliminary TMDL sampling for other potential sources of fecal coliform in the watershed.

For the three farms located on Davis and Mason Street listed in Table 8.1 RIDEM recommends that the Commonwealth of Massachusetts Department of Environmental Protection (MADEP) conduct confirmatory sampling to evaluate the effectiveness of the pollution control measures in reducing bacteria concentrations. This confirmatory sampling should include samples taken upstream and downstream of the farms during dry weather and also during storms. Additionally, RIDEM recommends that MADEP conduct additional investigations into identifying and mitigating other bacterial sources. Investigations should focus on areas upstream of stations with high fecal coliform concentrations as seen in Figure 4.1. Other areas to focus on should include streams flowing through and runoff from agricultural areas, runoff from golf courses, and failing septic systems.

Lastly, Massachusetts Department of Food and Agriculture is encouraged to continue its work with local farmers to implement Best Management Practices (BMPs) including development of nutrient management plans. The work that the Massachusetts Department of Food and Agriculture has completed is very promising for the future of the Palmer River and the continuation of this work will ensure a cleaner Palmer River.

8.2 Belcher Cove Streams

A summary of known and potential fecal coliform sources to the Belcher Cove streams is presented in Table 8.2. RIDEM has found several problems in Belcher Stream West that relate to pet waste entering into the stream. The public regularly uses Jamiel Park at the mouth of Belcher Stream West for dog walking. Signs at the park state that the law (Town ordinance 3-35.1) requires picking up after dogs, however, RIDEM has encountered dog waste on the ground each time it has sampled at that location. Additional education, plastic bags and permanent waste cans should be provided in the area to make clean up as easy as possible. Also the town's ordinance (3-35.1) for pick up of dog waste should be enforced. In a letter addressed to the Warren Town Manager on December 12, 2000, RIDEM outlined the pet waste problem and requested Town assistance in coming up with a solution to this issue.

A short distance upstream at Market Street, a dog is penned up next to the stream on Warren Auto Body property. A complaint has been filed with RIDEM's Office of Compliance and Inspection (OCI) for enforcement action. OCI issued a notice to the owner on October 18, 2000, requesting that the site be cleaned on a daily basis so that the dog waste does not cause a water pollution problem. If the owner fails to comply with the notice further enforcement action, which may include the assessment of penalties, may be taken.

Two major roadways, Market Street and Child Street, cross over Belcher Stream West. Runoff entering the stream from these two crossings should be addressed in the Town of Warren's Storm Water Management Program Plan (SWMPP) as part of the Storm water Phase II permit program. We encourage the Town of Warren to consider installing structural BMPs at these crossings to reduce the amount of direct runoff into the stream. For more information on the Storm water Phase II permit program see section 8.4.

High fecal coliform concentrations have been found in Belcher Stream East during wet weather. Belcher Stream East rises from a pond on a small cattle farm adjacent to Serpentine Road. Wet weather sampling by RIDEM staff has led to the conclusion that the pond is the predominant cause of the wet weather bacterial impairment of the stream. Most of the grazing and loafing areas on the farm drain to the pond that forms the source of the stream. The RIDEM Division of Agriculture will provide technical support to the farmer to implement appropriate management practices, such as improved manure management, and managed access of cattle to the pond.

The stream flows through a sewered residential area below the farm. During an assessment of the area by RIDEM Division of Agriculture personnel, local residents reported that flooding and sewage backing up at the end of the three streets occur after heavy rains. The issue was referred to RIDEM's Office of Compliance and Inspection (OCI) on 11/16/00. Office of Water Resources staff determined that failures of the sewage collection system in this area are uncommon. One known incident allowed 500 gallons to overflow into the stream on January 20, 1999, at the St. Teresa Street pump station.

RIDEM/OWR staff investigated the flooding issue and concluded that the storm sewer system at the end of Metacom Avenue appears to be partially blocked. A culvert connecting one drain appears to be blocked. Sand spread on the road has washed into the drain system and is apparently partially blocking the main culvert under Metacom Avenue. Some of this sand has also washed into the open channel area downstream of Metacom Avenue, effectively forming a dam that causes water to back up onto neighborhood lawns and Metacom Avenue during and after storms. The impoundment of water in this area may reduce infiltration of pollutants in the flooded area, exacerbating the wet weather impairment of this reach. RIDEM recommends that the storm drain system be inspected and repaired by the Town of Warren as necessary. To prevent road sand from obstructing the flow of runoff, the Town should increase the size of catch basins along Metacom Avenue and clean out the drain system on an annual basis to prevent the buildup of sand in the system.

High fecal coliform concentrations were also found in the north fork of Belcher Stream East. Source identification was not conclusive so additional investigations must be made in the area. The urbanized area in the Belcher Stream East subwatershed contains the north fork of Belcher Stream East up to and including School House Road. RIDEM recommends that the entire north fork of the Belcher Stream East subwatershed be included in the Storm Water Phase II permit developed by the Town of Warren.

The Town of Warren is encouraged to combine some or all of these recommendations into its Phase II Storm Water Management Program Plan (SWMPP). All towns with designated urban areas are required to apply for Phase II SWMPP permits by March 10, 2003. Urban areas in the Palmer River watershed are shown in Figure 8.1.

Other sources in the lower Palmer River (Table 4.5) were undetectable in the presence of the upstream source.

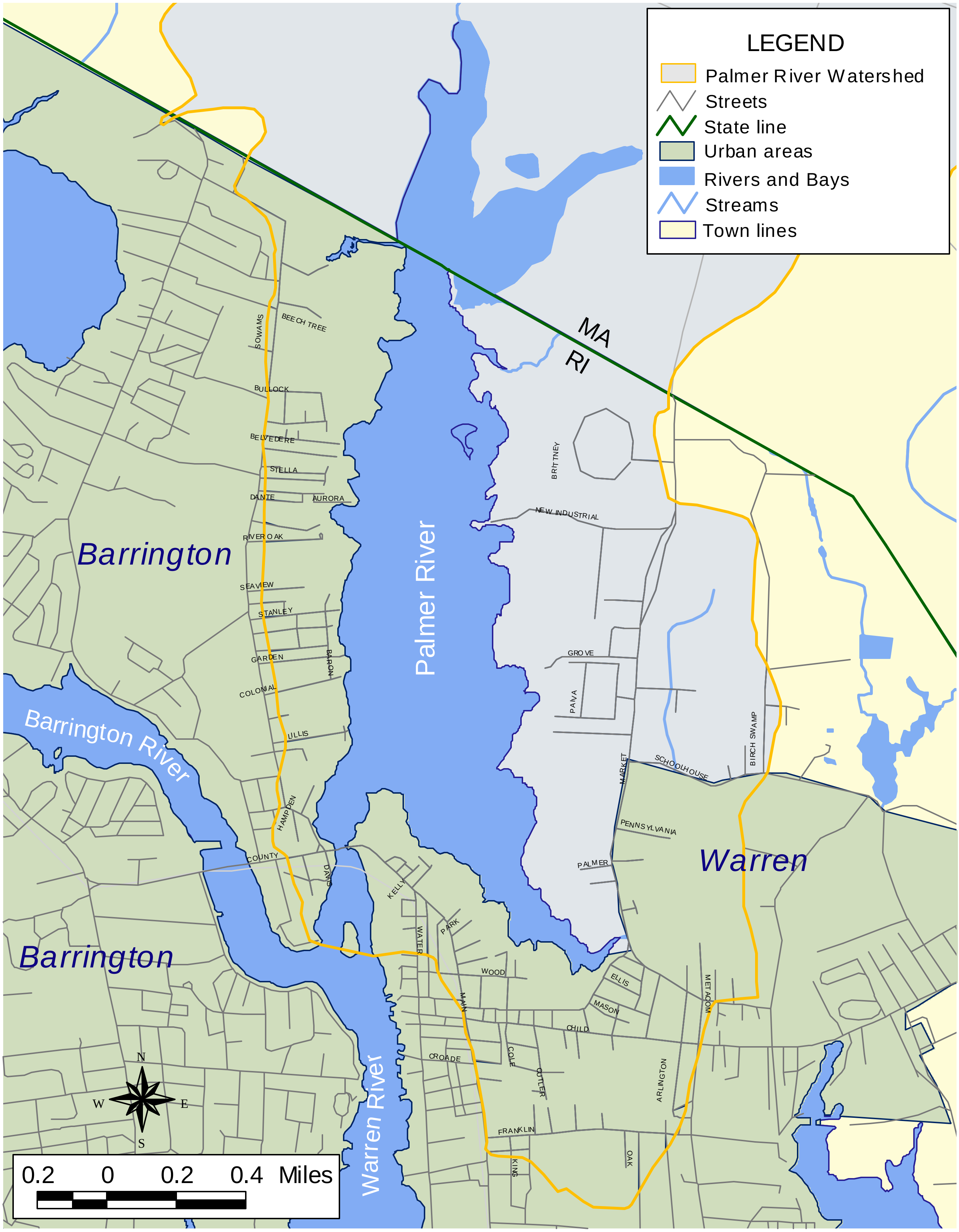


Figure 8.1: Urban areas in the towns of Warren and Barrington identified for March 10, 2003 Phase II storm water permits.

Table 8.2: Summary of current and proposed work in the Belcher Cove streams.

Known (K) or Potential (P) pollution source	Jurisdiction	Abatement measure	Status
Jamiel Park Dog waste Belcher Stream West (K)	Town of Warren	Install additional signage, baggies and waste bins to encourage pick up and disposal of dog waste. Enforce town ordinance 3-35.1 for pick up of dog waste	Town has installed temporary trash receptacles.
Warren Auto Body dog waste along Belcher Stream West (K)	RIDEM	Daily pick up of dog waste	RIDEM sent letter requiring disposal of waste 10/18/00 indicating a fine will be issued if owner found to be non-compliant
Kickamuit Road Cattle Farm (K) Belcher Stream East	RIDEM Division of Agriculture	Manure control / manage access of cattle to pond	RIDEM Division of Agriculture working with farmer.
Roadways at crossings of Market Street and Child Street with Belcher Stream West (K)	RIDOT (Phase II)	Install structural BMPs to reduce contribution of fecal coliform of roadways to Belcher Stream East, Phase II	A plan for addressing this source should be included in the Town of Warren's Storm Water Management Program Plan (SWMPP) and submitted by March 10, 2003 (see section 8.4)
Upstream sources along north fork of Belcher Stream East (P)	Town of Warren (Phase II)	Investigate potential sources in the urbanized area up to School House Road.	A plan for addressing this source should be included in the Town of Warren's Storm Water Management Program Plan (SWMPP) and submitted by March 10, 2003 (see section 8.4)
Catch basins along and culvert under Metacom Avenue (K)	Town of Warren (Phase II)	Increase size of catch basin and clean out the culvert and drainage system on a yearly basis.	Should be done as soon as possible and also a plan for maintenance at this source should be included in the Town of Warren's Storm Water Management Program Plan (SWMPP) and submitted by March 10, 2003 (see section 8.4)
St. Teresa St. (K)	Town of Warren (Phase II)	Install structural BMP at end of storm drain flowing into wetland.	A plan for addressing this source should be included in the Town of Warren's Storm Water Management Program Plan (SWMPP) and submitted by March 10, 2003 (see section 8.4)

8.3 Warren Waste Water Treatment Facility

The Warren WWTF experiences occasional exceedences of the daily maximum fecal coliform concentration limit. Investigation thus far has not found the cause, however equipment failures have been ruled out. The timing of the exceedences suggests that the problem may be tied to excessive infiltration and inflow (I/I) in the Warren collection system. The Warren WWTF has been issued a Compliance Order to address excessive I/I, and the plant has completed implementation of corrective actions for inflow sources. The plant also recently submitted the results of an infiltration identification study along with a schedule for implementing corrective actions.

8.4 Storm water Phase II Permit Program

RIDEM is amending the existing Rhode Island Pollution Discharge Elimination System (RIPDES) regulations to include Phase II Storm Water Regulations. The new regulations will become effective in early 2002. As specified by the regulations, municipalities must develop a storm water management program plan (SWMPP) that describes the Best Management Practices (BMPs) for each of the following minimum control measures:

1. a public education and outreach program to inform the public about the impacts storm water on surface water bodies,
2. a public involvement/participation program,
3. an illicit discharge detection and elimination program,
4. a construction site storm water runoff control program for sites disturbing more than 1 acre,
5. a post construction storm water runoff control program for new development and redevelopment sites disturbing more than 1 acre and
6. a municipal pollution prevention/good housekeeping operation and maintenance program.

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

Operators of municipal separate storm sewer systems (MS4s) within urbanized areas (UAs) or densely populated areas (DPAs) will be required to develop a SWMPP and obtain a permit (for those portions within the UA or DPA) by March 10, 2003. Operators of MS4s located outside of UAs and DPAs and that discharge to Special Resource Protection Waters (SRPWs), or impaired waters will also be required to obtain a permit (or expand permit coverage throughout the jurisdiction) by March 10, 2008, unless the operator has demonstrated effective protection of water quality to the satisfaction of the Director. The Director will also require permits for MS4s that contribute to a violation of a water quality standard, are significant contributors of pollutants to waters of the State or that require storm water controls based on waste load allocations (WLAs) determined through a TMDL.

The MS4s that discharge to the Palmer River are owned and operated by the Towns of Barrington and Warren, or by the Rhode Island Department of Transportation (RIDOT). Areas within Rhode Island adjacent to the Palmer River, with the exception of the area along the eastern shore of Belcher Cove and the Palmer River are in a UA. Accordingly, the Towns of Barrington and Warren, and RIDOT will be required to apply for RIPDES permits for those portions of their MS4s located within the UA by March 10, 2003. The Palmer River is designated as an SRPW in the state's Water Quality Regulations. As a result, any storm sewer outfalls part of MS4s that are not located in the UA found subsequent to this TMDL to discharge significant loadings to the Palmer River will be required to obtain a RIPDES permit (or expand coverage of an existing permit). This action is required by the Phase II regulations because these loadings contribute to a violation of a water quality standard, and because it has been determined through this TMDL that storm water controls are necessary to restore water quality.

RIDEM will continue to work with the Coastal Resources Management Council (CRMC), RIDOT, and the local municipalities to identify funding sources and to evaluate locations and designs for storm water control BMPs throughout the watershed. In accordance with the requirements of this phased TMDL, monitoring of the Palmer River will continue so that the effectiveness of ongoing remedial activities can be gauged.

9.0 MONITORING PLAN

Continued monitoring, whether through local volunteer organizations or via RIDEM will be the only means of confirming that the desired water quality standards have been accomplished. Sampling should occur once the recommended implementation measures are put in place. The Palmer River sampling should include a station at the Bungtown Bridge on Old Providence Road in Swansea during the months of June through October to better track trends in loadings entering the upper Palmer River. This sampling should occur near the time of low tide, accompanying the sampling of the Runnins River and Hundred Acre Cove by the Pokanoket Watershed Alliance. The mouth of each of the Belcher's Cove streams should be monitored on a monthly basis.

The RIDEM Shellfish Program limited its sampling of the Palmer River in 2001 since the area is designated as closed to shellfishing and the Food and Drug Administration does not require sanitary surveys in closed areas. RIDEM received information from MADFA prior to the start of the public comment period in January 2002 that corrective measures had been completed at each of the three farms in Massachusetts. Given this information, the RIDEM Shellfish Program will resume sampling in Growing Area 2 on a systematic random basis. Sampling would therefore be conducted six times a year under randomly selected, weather and tidal conditions.

RIDEM is currently working on a TMDL for the Palmer River for nutrients and dissolved oxygen. The Massachusetts Department of Environmental Protection has hired Environmental Science Services to sample for nutrients and bacteria in the Palmer River watershed in Massachusetts. Additionally, Save the Bay is monitoring the watershed in both Massachusetts and Rhode Island in an effort to assist the two states and their respective communities toward the common goal of a clean Palmer River.

Sampling of the streams that feed Belcher Cove is recommended on a monthly basis to allow RIDEM to determine whether recommended actions have reduced instream concentrations.

10.0 PUBLIC PARTICIPATION

Public participation in this TMDL has taken place in two forums. The New England Interstate Water Pollution Control Commission (NEIWPCC) established a steering committee comprised of members of local municipalities, state agencies, EPA, and the Pokanoket Watershed Alliance, in 1993. The Pokanoket Watershed Alliance holds bimonthly meetings that are open to the public.

The second element of public involvement for this TMDL is the presentation of this plan at two public meetings during January 2002. The two public meetings were held at the Barrington Public Library in Barrington, Rhode Island on January 9, 2002 and at the Beckwith School in Rehoboth, Massachusetts on January 10, 2002. During these public meetings, RIDEM solicited public comment on the content and recommendations of the TMDL. The public comment period was from January 9, 2002 through February 10, 2002. RIDEM has prepared responses to all the comments received in a separate document that will be submitted along with the TMDL document to the EPA.

11.0 REFERENCES

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APPENDIX A: BELCHER COVE STREAM SAMPLING DATA, 2000

BELCHER COVE STREAMS FECAL COLIFORM DATA							
Date	6/8/00	6/29/00	7/13/00	7/18/00	7/25/00	7/26/00	8/22/00
Weather/tide	wet/low	dry/low	dry/low	dry/high	dry/low	wet/low	dry/low
Station*	Concentration (fc/100 ml)						
BC01	4500	2800	4800	27	4100	10000	1000
BC01R	3000		6100				
BC02	10000	2600	590	600	3400	11000	490
BC02R				650			
BC03	4200	28	2	60	4	20000	41
BC03R						32000	
BC04		2200			3700	3000	680
BC04R		1900					
BC05			240	2400	700	1800	420
BC06			570	2700	3200	12000	
BC06R						9000	
BC07			100				
BC08			90				
BC09					3000		

* The R suffix denotes a duplicate sample at that station.

Station locations:

BC01 – Mouth of Belcher Stream West at Jamiel Park.
BC02 – Belcher Stream West, upstream of dog (Warren Auto Body) behind J. J. Cleansers.
BC03 – Belcher Stream East just downstream of Route 136, by gas station.
BC04 – Belcher Stream West at entrance to Jamiel Park, just downstream of Market Street.
BC05 - Belcher Stream West behind last house on Ward Street, main stream.
BC06 – Belcher Stream West behind last house on Ward Street, small eastern fork flowing into main stream.
BC07 – Belcher Stream West, in woods behind Gob Shop studios, 30 Cutler Street.
BC08 – Belcher Stream West, in Phragmities just downstream of Lloyd Manufacturing Company.
BC09 – Belcher Stream West, upstream of J. J. Cleansers next to Dodge Body Shop in Phragmities.

Location of stations BS01-BS05 is also presented in Figure 4.5.

APPENDIX B: FINAL DATA REPORT FOR PALMER RIVER BELCHER STREAM EAST WET WEATHER FECAL COLIFORM STUDY, 2001

1.0 INTRODUCTION

The results of water quality monitoring conducted by Rhode Island Department of Environmental Management (RIDEM) in support of the Pathogen Total Maximum Daily Load (TMDL) report for the Palmer River indicated Belcher Stream East in the Belcher Cove area of the Palmer River has high fecal coliform concentrations during wet weather and low fecal coliform concentrations in dry weather. It was determined that additional sampling of the stream at several locations during wet weather was necessary to identify the fecal coliform sources in Belcher Stream East for subsequent action. A farm is located at the source of this stream. Several residential developments and an area of wetland are downstream of the farm. This project was designed to determine the wet weather sources of fecal coliform in this area of the Town of Warren so that the source(s) can be eliminated or reduced to acceptable levels.

1.1 Goals and objectives

TMDLs are required under Section 303(d) of the Clean Water Act and USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130). The goal of the Palmer River TMDL study was to quantify existing loadings from nonpoint sources and to establish the impact that these loadings have on instream fecal coliform concentrations. At the conclusion of the study, the load reductions needed to achieve water quality standards were established, however, not enough specific information was collected in Belcher Stream East. The goal of this project is to differentiate between sources in Belcher Stream East in order to make specific recommendations to improve water quality in the Palmer River fecal coliform TMDL.

1.2 Study area - The Belcher Stream East subwatershed

The Belcher Stream East subwatershed is located in the Town of Warren in the eastern portion of the State of Rhode Island (see Figure A). Belcher Stream East is a subwatershed of the larger Palmer River watershed. Belcher Stream East generally flows from east to west through the Town of Warren. It and its sister stream Belcher Stream West flow into Belcher Cove in the Palmer River. Belcher Cove is a very shallow cove, which opens up to the Palmer River just east of the mouth of the River.

A large part of this small watershed is wetland. The stream rises from a man-made pond in a small farm and flows through a small wet and wooded area. Storm water from St. Teresa Street flows into the wet wooded area and a stormdrain also empties here behind the last house on the east side of the street. This wetland ends at the end of North Cornell Avenue and the stream is funneled into a ditch which takes a sharp turn to the right and flows behind houses on the East side of Metacom Avenue. Three houses from the end of the street, the stream enters a culvert and runs under Metacom Avenue, then emerges behind a house on the opposite side of the street at the edge of a dense stand of *Phragmites*. The stream then flows through a salt marsh until it reaches Route 136. It flows under the Route 136 overpass passing a small used car dealership, liquor store and gas station finally arriving at the Palmer River.

Several residential streets slope downhill toward the stream, and a storm drain located along the edge of the farm property flows into the stream. Homes along St. Teresa Street, North Cornell Avenue and Metacom Avenue are connected to the Warren sewerage system. St. Teresa Street and Metacom Avenue have sewage collection systems located at the end of the street, which pump waste uphill to the beginning of the street where they connect with the town sewer system serviced by the Warren Waste Water Treatment Facility. These pump stations are checked regularly by the Warren Sewage Authority to make sure they are functioning properly.

A second stream enters from the North and merges with Belcher Stream East a short distance upstream of Route 136. This stream passes a commercial manufacturer, a garbage transfer station, under two residential streets and past a large farm. This farm is only used minimally with the farmer renting fields out periodically for grazing small numbers of cattle. The commercial facility and several of the houses in the area are connected to the Warren sewer system, however, some of the homes are not sewered and might have failing septic systems.

1.3 Background

The Palmer River Pathogen Total Maximum Daily Load (TMDL) found elevated fecal coliform concentrations at the one sampling site in Belcher Stream East (RIDEM, 2001). This site is located just downstream of the Route 136 overpass. This study also indicated that fecal coliform concentrations violate the Class A standard in Belcher Stream East. A list of applicable studies is presented in Table A.

Table A: Pathogen studies conducted in the Palmer River watershed

Primary Organization	Title	Date of Report	Approximate Date of Study
RIDEM, Office of Water Resources	Draft Fecal Coliform TMDL for the Palmer River, Rhode Island	2001	Spring 1999
RIDEM, Office of Water Resources	Characterization Studies to Support TMDL Development for the Barrington, Palmer and Warren River Watershed.	1999	1996-1998
RIDEM, Office of Water Resources	Barrington, Palmer and Warren Rivers Shoreline Survey Report	1996	1996

Belcher Stream East (BSE) was found to contain significant fecal coliform concentrations during periods of wet weather. A preliminary investigation by RIDEM pointed to several possible causes: septic systems, periodic failures of the sewage collection systems on St. Teresa Street and Metacom Avenue, agriculture, wildlife (i.e. Canada Geese), and storm runoff from the developed areas adjacent to the stream. Septic systems and sewage overflows were eliminated as possible causes upon further evaluation by RIDEM because no septic systems were identified in the area, and only one failure of a sewage pumping station on St. Teresa St. (500 gallons on January 20, 1999) could be documented after interviews with local residents and Town officials. The remaining potential causes are runoff from residential areas, domestic animals, wildlife and agriculture.

A Quality Assurance Project Plan (QAPP) was designed to address the questions raised in the Palmer River Fecal coliform TMDL. The Belcher Stream East Quality Assurance Project Plan was approved by the US EPA on September 10, 2001

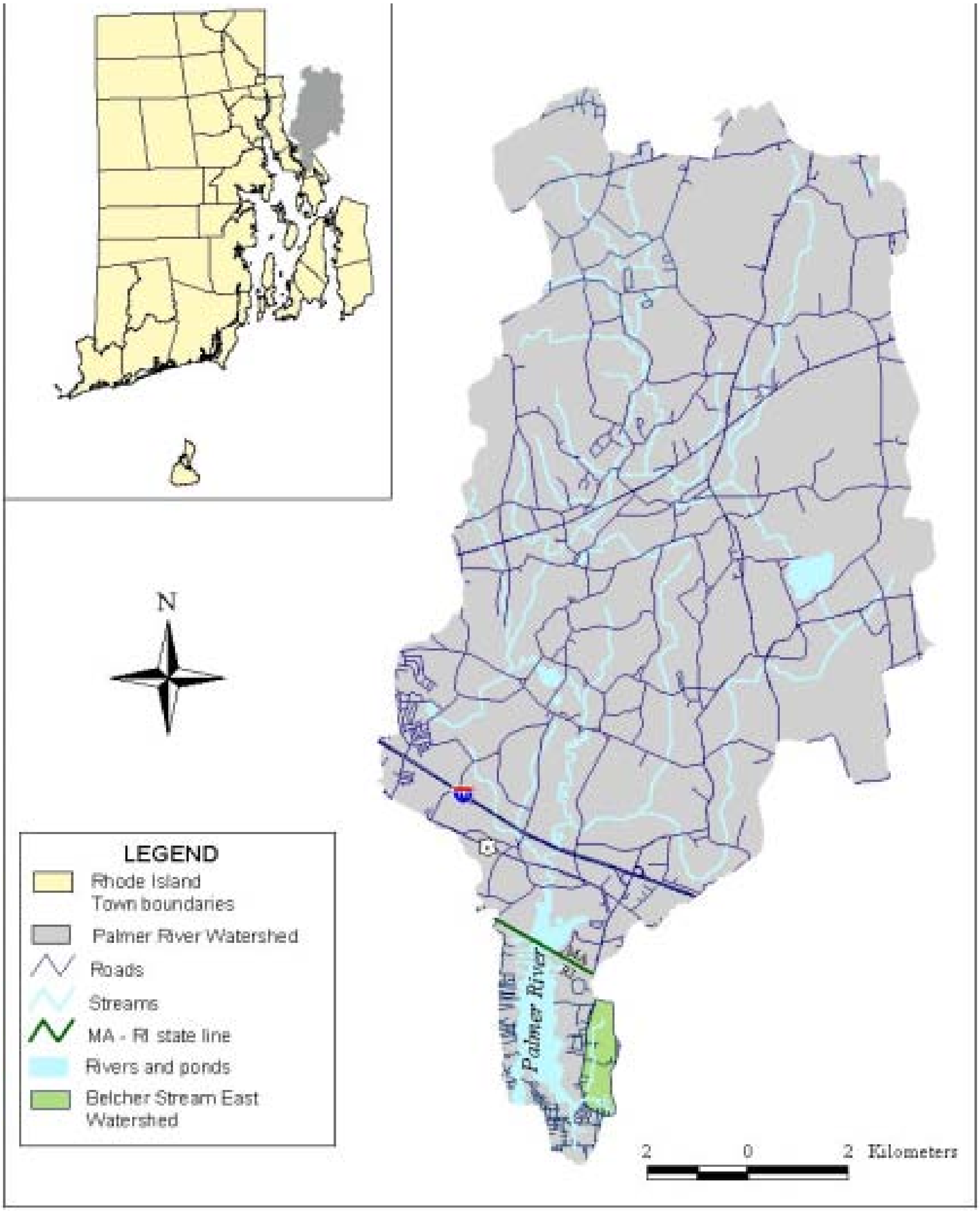

Figure A: Location of the Belcher Stream East subwatershed in the Palmer River watershed.

2.1 Methods

Sample stations were set up at six locations in the watershed (Figure B). Station BSE01 was located at the intersection of the stream and Route 136 on the downstream side of the street and was selected to establish conditions within wetland and residential area upstream including runoff from Route 136. Station BSE02 was located at the pond on the farm at the headwaters of the southern branch of the stream and was intended to sample the farm runoff entering the pond. Station BSE03 was located at the end of a pipe draining residential lands and roadways behind a house on St. Teresa Drive and was intended to characterize storm runoff from that residential area adjacent to the farm that combines with runoff from the farm pond. Station BSE05 was located at the end of North Cornell Avenue downstream of the pond where the stream emerges from a wetland into a ditch behind houses located on the east side of Metacom Avenue. Station BSE06 was located where the stream emerges from the culvert under Metacom Avenue behind the houses on the west side of the street. BSE-05 and BSE-06 were intended to characterize conditions downstream of points where other storm runoff had entered the stream. Station BSE08 was located along the northern fork of the stream in the wetland at the end of John Street and was selected to characterize inputs from the northern portion of the Belcher Stream East drainage area. Two of the eight stations mentioned in the QAPP were eliminated because access to the sites was difficult, and it was decided that the necessary information could be gathered using the six remaining stations.

Bacteria samples were to be collected at each site that was flowing. Samples were collected pre-storm, during the first hour of the storm, then at three hours, six hours, eighteen hours, and 42 hours.

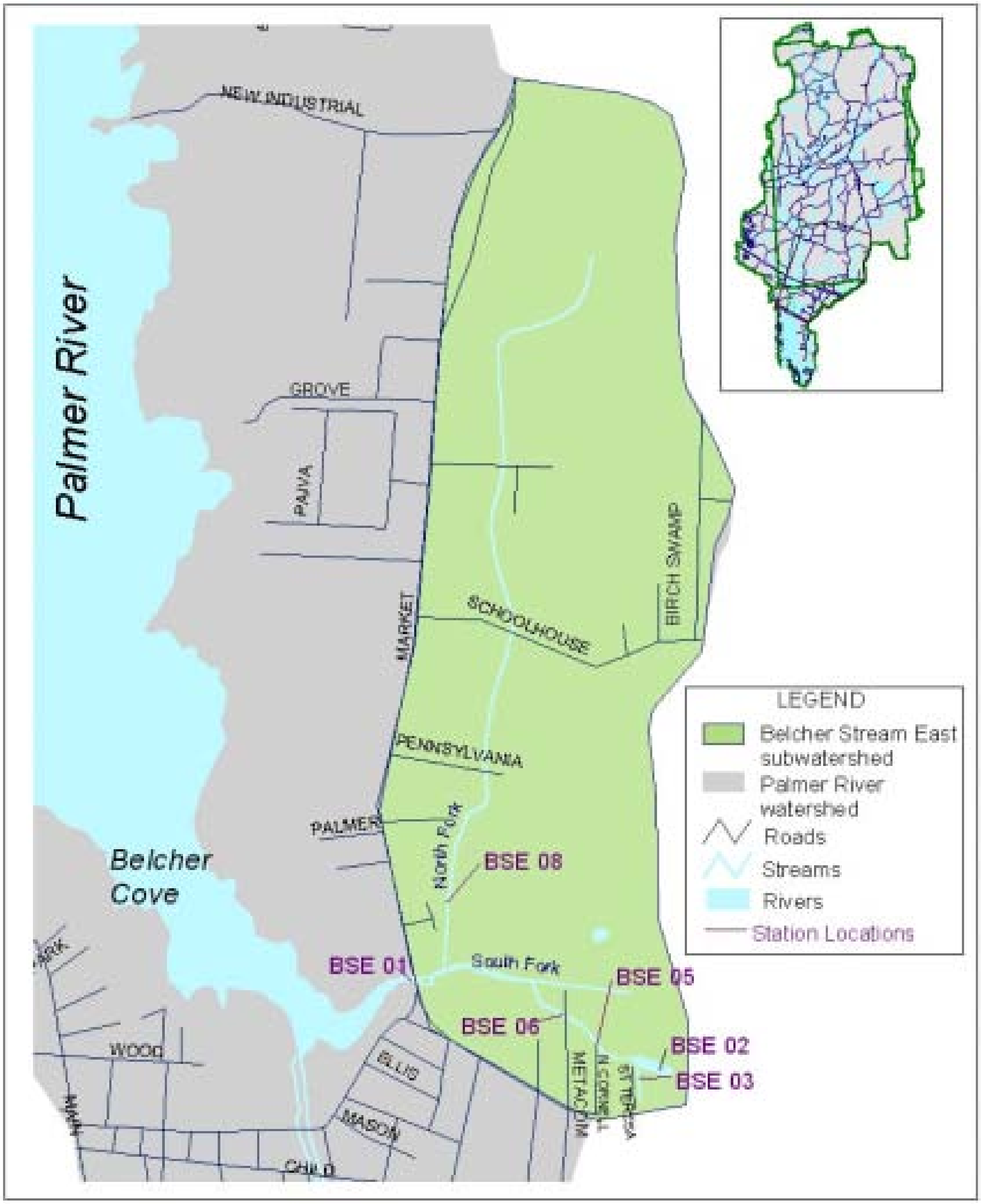

Figure B: Sampling locations in the Belcher Stream East subwatershed.

3.0 Results

Sampling in the Belcher Stream East subwatershed took place September 24-27 2001. Prestorm sampling was begun on September 24, 2001. Four stations were sampled on September 24, 2001 including BSE01, BSE05, BSE06 and BSE08. BSE03 was not sampled prior to the storm because it was not flowing. The farm pond (BSE02) was sampled on the morning of September 25, 2001. The storm began at approximately 1:30 pm on September 25, 2001. Samples were collected at all six stations during the storm at hours 1, 3, 6, and 18. Sampling was begun at 1:56 pm on September 25, 2001 and continued using the schedule above until 8:28 am on September 27, 2001. Samples were collected after 42 hours at every station except station BSE03 because there was no flow.

3.1 Rainfall data

Storm totals for September 25, 2001 varied widely over the state of Rhode Island. Rainfall in the Belcher Stream East subwatershed was not specifically measured however the daily rain data from NOAA's Forecast Systems Laboratory online at Taunton (http://precip.fsl.noaa.gov/hourly_precip.html) measured 0.74 inches of rainfall for that day. Other NOAA stations in Rhode Island included totals for September 25, 2001 of 0.22 inches in Middletown, 0.33 inches in Warwick and 0.42 inches in North Smithfield. At RIDEM in Providence rainfall for September 25, 2001 measured 0.20 inches and the University of Rhode Island in Kingston recorded 0.33 inches of rainfall The Warren Water Treatment Facility measured 1.47 inches of rain on that date.

Prior to the September 25 storm, rainfall was recorded at RIDEM in Providence on September 20, 2001 (0.26") and September 22, 2001(1.26"). University of Rhode Island at Kingston measured 1.52" on September 21, 2001 and 0.97" on September 22, 2001.

3.2 Summary of Wet weather water quality data

Fecal coliform data are presented in Table B and Figure C. The highest concentrations in the farm pond (BSE02) were one to two orders of magnitude higher than peak concentrations elsewhere in the small watershed. Stations BSE02, BSE03, and BSE08 peaked during the first hour. Stations BSE01, BSE05 and BSE06 farther downstream peaked at 6 to 18 hours. The high concentrations appeared to move through the system from 6 to 18 hours, then returned to prestorm levels after 42 hours. The prestorm fecal coliform levels may have been somewhat elevated due to rain three days prior to this storm event.

Maximum fecal coliform concentrations of 1,500,000 fc/100 ml and 1,300,000 fc/100 ml were found at station BSE02 located in the pond on the farm during the first two sampling runs (hours 1 and 3) after the beginning of the storm. Station BSE03 located at a storm drain just off of St. Teresa Street had concentrations ranging from 23,000-32,000 fc/100 ml. Station BSE05 peaked at hour 6 with a concentration of 74,000 fc/100 ml and station BSE06, located about 120 meters downstream, peaked at hour 18 with a concentration of 78,000 fc/100 ml.

At BSE08 on the north fork, the peak concentration of 71,000 fc/100 ml occurred during the first hour. The station at the mouth of the stream (Station BSE01) at Route 136 peaked at hour 6 with a concentration of 80,000 fc/100 ml.

Table B: Results from the Belcher Stream East wet weather study, September 2001.

Station	Pre-storm (fc/100 ml)	Hour 1 (fc/100 ml)	Hour 3 (fc/100 m)	Hour 6 (fc/100 ml)	Hour 18 (fc/100 ml)	Hour 42 (fc/100 ml)
BSE02	210,000	1,500,000	1,300,000	490,000	220,000	37,000
BSE03	No flow	32,000	23,000	26,000	10,000	No flow
BSE05	450	12,000	49,000	74,000	65,000	2,700
BSE06	910	10,000	42,000	64,000	78,000	2,900
BSE08	600	71,000	39,000	22,000	3,900	3,100
BSE01	1,800	33,000	39,000	80,000	9,800	1,700
Replicates		46,000	1,000,000	75,000	77,000	1,700
Replicate locations		BSE08-1	BSE02-3	BSE06-6	BSE05-18	BSE01-42

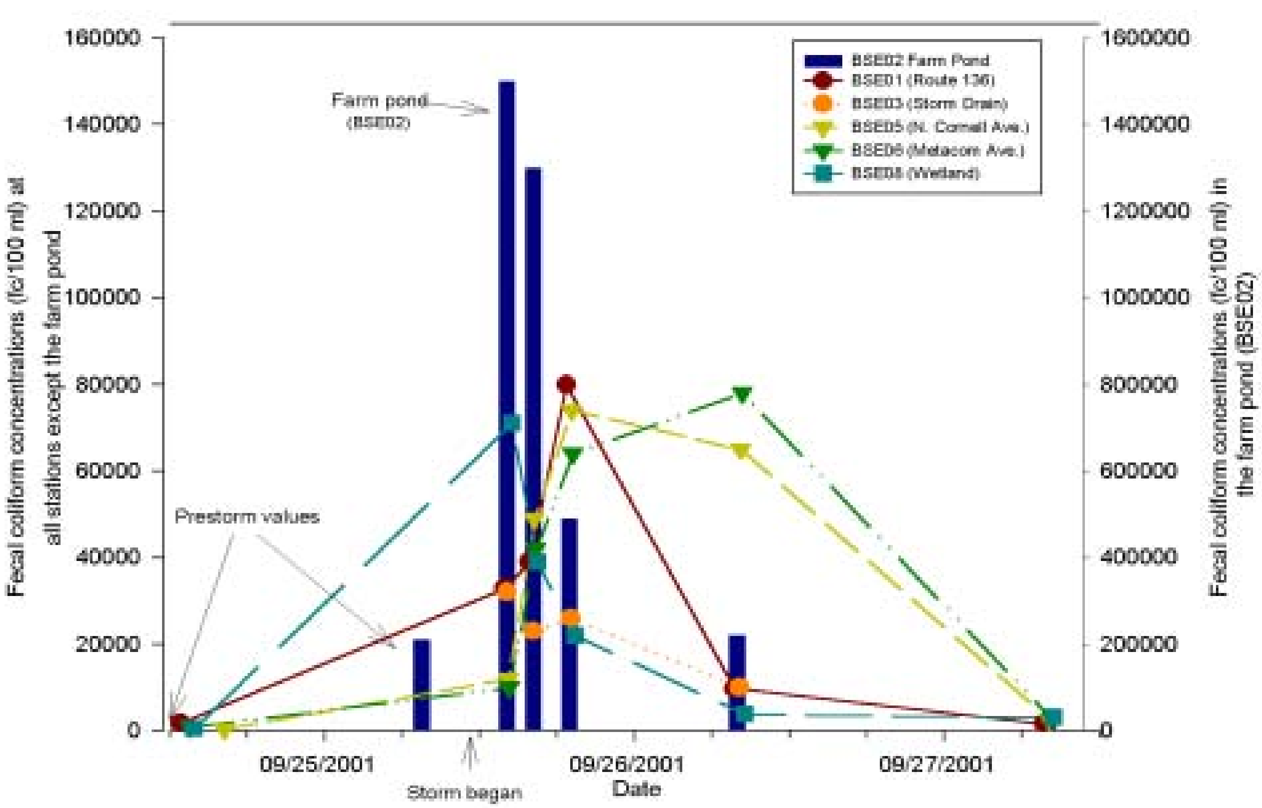

Figure C: Results from Belcher Stream East wet weather fecal coliform sampling study.

3.3 Evaluation of data quality

Replicates were taken at one station per sampling run so that a replicate was collected at each of the stations once by the end of the study excluding station BSE03. BAL Laboratories also analyzed a laboratory split sample for station BSE08-1. The precision of the mTEC membrane filtration technique for fecal coliforms is 35% at the 95% confidence interval. (Rippey et al., 1987). Replicates collected in this study (one during each sampling run) were compared to the confidence interval criteria mentioned above using a 95% confidence interval of 35% above and below the mean of the two values to assess data reliability. The results are presented in Table C. All of the replicates fell within their respective confidence intervals indicating that the data are of adequate quality.

Table C: Confidence intervals for the replicate data collected in Belcher Stream East.

Station	Initial fecal coliform concentration (fc/100 ml)	Replicate fecal coliform concentration (fc/100 ml)	Mean Fecal coliform concentration (fc/100 ml)	95% Confidence interval (fc/100 ml)	Does the data fall within the confidence interval?
BSE01-42	1,700	1,700	1,700	1105-2295	Yes
BSE02-3	1,300,000	1,000,000	1,150,000	747500-1,552,500	Yes
BSE05-18	65,000	77,000	71,000	46,150-95850	Yes
BSE06-6	64,000	74,000	69,000	44,850-93,150	Yes
BSE 08-1	71,000	46,000	58,500	38,025-78,975	Yes
BSE08-1 (lab duplicate)	71,000	57,000	64,000	41,600-86,400	Yes

4.0 Data discussion, source identification and analysis

The data clearly indicate that the pond on the farm is a significant source of fecal coliform. Concentrations varied between 210,000 fc/100 ml prestorm to 1,500,000 fc/100 ml during the peak of the storm. The data show other sources of fecal coliform are also present in the watershed. These include a storm drain (station BSE03), runoff from streets and runoff from residential areas (stations BSE05, BSE06, and BSE08). Causes that are consistent with loadings from these sources include wildlife, waterfowl, domestic animals and failing septic systems. There are no known septic systems in the area between stations BSE02 and BSE01 and until further study indicates the presence of failing septic systems these will be ruled out as sources in this area of the watershed.

Peak concentrations of fecal coliform dropped from 1,500,000 fc/100 ml in the farm pond during the first hour to 74,000 fc/100 ml at hour 6 at station BSE05, the next downstream sampling site. A peak concentration of 78,000 fc/100 ml occurred at BSE06, the next station downstream at hour 18. This suggests that the impact of high fecal coliform concentrations from the farm pond were persistent for at least a day even after other concentrations decreased. Decreases in concentration between the farm pond (station BSE02) and station BSE05 was approximately 20:1, indicating that dilution was occurring in the wetland area as a result of runoff from the storm drain (Station BSE03) and runoff from the street. Even though the impact of the farm pond was somewhat reduced, the fecal coliform concentrations from the farm continued to affect the system longer than other sources.

Runoff from the streets and residential areas also contain comparatively high concentrations of fecal coliform when compared to the water quality goal of the stream (20 fc/100 ml). Station BSE03 runs underground and behind houses on the east side of St. Teresa Street. The flow from this storm drain comes from the back of these properties and the neighborhood along Kickemuit Road, which is not located in the Belcher Stream East watershed.

Station BSE08 is on the north fork of the Belcher Stream East tributary and runs parallel to Route 136 from the northern part of the watershed. The initial fecal coliform concentration at station BSE08 of 71,000 fc/100 ml, decreased to 39,000 fc/100 ml two hours later. High initial fecal coliform concentrations usually indicate that the source or sources are nearby. Sources in the area draining to BSE08 include possible failing septic systems, domestic animals, wildlife, waterfowl, runoff from streets, residential areas and the local garbage transfer station. Although this area is mostly sewered, preliminary inquiries indicate that not all homes in the area upstream of station BSE08 are connected to sewer service. A large boat building facility in the watershed is connected to the sewer. Another farm is located in this subwatershed. Most of this farm drains into the Kickemuit watershed however portions of the farmland drain to station BSE08. This farm does not own cattle but rents land for grazing other cattle. The numbers of cattle are usually between 5 and 10 heads (personal communication E. Pepper). This farm has land just upstream of Station BSE01, which can be seen from the intersection at Market Street and Kickemuit Road. This field has a small swale that drains into the stream between stations BSE06 and BSE01. During the prestorm survey 5 cows were seen in this area. Other possible contributors of fecal coliform in this area include but are not limited to domestic animals, and wildlife and failing septic systems. The high initial fecal coliform concentrations (71,000 fc/100 ml at hour 1) concentrations could be contributing to the elevated concentrations at station BSE01.

During the first hour of the storm a concentration of 33,000 fc/100 ml was measured at station BSE01. Initial fecal coliform concentrations are usually representative of more localized sources. Fecal coliform concentrations were highest at station BSE01 (the station closest to the Palmer River) at hour 6. The concentration at this time was 80,000 fc/100 ml. The peak concentration at hour 6 was most likely caused by a number of upstream sources. The farm pond was determined to affect the stream (Stations BSE05 and BSE06) with high fecal coliform concentrations from hours 3 through 18. Given the distance between the farm pond and station BSE01 (approximately 0.41 miles), it is most likely that these concentrations also affected station BSE01.

5.0 Source ID and Conclusions

The highest fecal coliform concentrations were found in the farm pond. Although some detention and dilution occurs in the small wetland area just downstream of the farm, this pond appears to be the dominant fecal coliform source. The storm drain is a less significant source to the stream however, storm drains and runoff from the streets did contribute to the fecal coliform concentrations elsewhere along the stream. In the area draining the northern section of the watershed failing septic systems could be contributing to the fecal coliform violations. A farm in that area has fewer cattle that could also be another contributor of fecal coliform. Other potential sources of fecal coliform not specifically identified in the watershed were runoff from streets and residential areas, wildlife, waterfowl and domestic animals. The influence of the farm pond persisted longer than the other sources would be expected to last

6.0 References

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