FECAL COLIFORM TMDL DEVELOPMENT

FOR

HUNT RIVER, RHODE ISLAND

FINAL REPORT

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Description of Waterbody

The Hunt River Basin is centrally located in Rhode Island on the westerly side of Narragansett Bay (Figure 2.1). The watershed drains approximately 25 square miles (15,445 acres) and includes parts of seven Rhode Island communities: Exeter, North Kingstown, East Greenwich, West Greenwich, Coventry, West Warwick, and Warwick. The watershed includes Hunt River, Potowomut River, and four major tributaries. The major tributary sub-watersheds are Sandhill Brook (2,352 acres), Frenchtown Brook (4,487 acres), Scrabbletown Brook (1,653 acres), and Fry Brook (1,986 acres). TMDLs are also under development for the latter two tributaries, Scrabbletown Brook and Fry Brook.

Based on recent land use information (URI 1997), land use in the 25 square mile watershed is 37.6% forest, 16.3% wetland, 6.2% agriculture, 4.3% commercial-industrial, 1.7% roads, 24.1% medium density residential, 0.5% high density residential, and 2.0% low density residential. The majority of the commercial and medium density residential areas are in the eastern half of the watershed.

As reported in the state's 1998 303(d) list of impaired waterbodies, the Hunt River was listed for being impacted by fecal coliform bacteria for a length of approximately 8.82 miles, Scrabbletown Brook for a length of approximately 3.2 miles, and Fry Brook for a length of approximately 6.2 miles. The majority of bacteria violations in the watershed were found to occur during wet weather conditions.

Priority Ranking

The Hunt River, Fry Brook, and Scrabbletown Brook are listed as Group 1 (highest priority) waterbodies on the State of Rhode Island's 303(d) list of water quality impaired waterbodies.

Pollutant of Concern

The Hunt River TMDL has been developed for fecal coliform, as measured fecal coliform concentrations have been found to exceed the state's water quality standards. Both dry and wet weather water quality data have been collected in the Hunt River watershed, revealing elevated fecal coliform concentrations at both instream and tributary stations. Based on this data, Hunt River, Fry Brook, and Scrabbletown Brook were placed on the state's 1998 303(d) list of water quality impaired waterbodies.

Pollutant Sources

RIDEM has identified 5 major sources of fecal coliform bacteria in the Hunt River watershed. These include stormwater runoff from highways and residential/commercial areas, a dairy farm, pigeons roosting under Route 4, a horse farm, and resident waterfowl, domestic pets, and wildlife. All sources are summarized below in Table 1. The largest dry weather sources of bacteria are the dairy farm, pigeons roosting under the Route 4 overpass, and domestic pets, resident waterfowl, and other wildlife. The largest wet weather source of bacteria to the watershed is stormwater runoff. Although other sources are significant during wet weather, stormwater runoff has a greater cumulative impact in the watershed. A detailed description of individual sources is presented by stream segment in the Water Quality Impairment Section of this report.

Table 1. Summary of Pathogen Sources in the Hunt River Watershed.

Location	Dry weather sources	Wet weather sources
Hunt River Mainstem	Inputs from Scrabbletown Brook and Fry Brook	Stormwater runoff, inputs from Fry Brook, Pierce Brook, Sandhill Brook, Scrabbletown Brook, and Frenchtown Brook
Hunt River Headwaters	Wildlife, waterfowl contributions	Stormwater runoff, horse farm
Scrabbletown Brook	Contributions from pigeons and waterfowl	Stormwater runoff, contributions from pigeons and waterfowl
Fry Brook	Dairy farm, waterfowl contributions	Stormwater runoff, dairy farm, waterfowl contributions
Frenchtown Brook	Waterfowl, wildlife	Stormwater runoff
Sandhill Brook	Waterfowl, wildlife	Stormwater runoff, waterfowl, wildlife
Pierce Brook	Wildlife	Stormwater runoff, wildlife

Natural Background

Based on field observations and review of land use information, natural background loads from wildlife, especially geese, and other sources are thought to make up a significant portion of the total fecal coliform load in the Hunt River watershed. However, due to the limited amount of data regarding fecal coliform contributions from wildlife, natural background loads were not separated from the overall water quality calculations. Without detailed site-specific information on fecal coliform contributions from wildlife, it is difficult to meaningfully separate natural background from the total nonpoint source load.

2. Description of Applicable Water Quality Standards and Numeric Water Quality Target

State Water Quality Standard

The regulatory standard for the Hunt River and tributaries upstream of Frenchtown Road, including Mawney, Frenchtown, and Scrabbletown Brooks is Class A (freshwater). These waters are designated as a source of public drinking water supply, primary and secondary contact recreational activities, and fish and wildlife habitat. Class A waters shall also be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses.

The regulatory standard for Fry Brook, Sandhill Brook, Pierce Brook, and the Hunt River from Frenchtown Road to the tidal waters of the Potowomut River (approximately 300 meters south of Forge Bridge) is Class B (freshwater). These waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. Class B waters shall also be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses.

The state's water quality standard for fecal coliform bacteria in Class A waters, is as follows: *"not to exceed a geometric mean value of 20 fc/100ml and not more than 10% of the samples shall exceed a value of 200 fc/100ml."*

The state's water quality standard for fecal coliform bacteria in Class B waters, is as follows: "not to exceed a geometric mean value of 200 fc/100ml and not more than 20% of the samples shall exceed a value of 500 fc/100ml."

Numeric Water Quality Target

One of the major components of a TMDL is the establishment of instream water quality targets used to evaluate the attainment of acceptable water quality. These targets are usually based on either the narrative or numeric criteria required by state water quality standards.

For the Hunt River TMDL, the applicable Class A and Class B fecal coliform standards were used as the applicable endpoints. These standards state that fecal coliform concentrations in Class A waters shall not exceed a geometric mean value of 20 fc/100ml and not more than 10% of the samples shall exceed a value of 200 fc/100ml. The numeric water quality target for Class B waterbodies is a geometric mean of 200 fc/100ml with not more than 20% of the samples exceeding 500 fc/100ml.

Antidegradation Policy

Rhode Island's antidegradation policy requires that, at a minimum, the water quality necessary to support existing uses be maintained. If water quality is better than what is necessary to support the protection and propagation of fish, shellfish, and wildlife, and recreation in and out of the water, the quality should be maintained and protected unless, through a public process, some negative impact to water quality is deemed necessary to allow important economic and social development to occur. In waterbodies identified as having exceptional recreational and ecological significance, water quality should be maintained and protected (RIDEM 1997). Class A waters in the Hunt River watershed are designated as a public drinking water supply. Designated and existing uses for all waterbodies in the Hunt River include fish and wildlife habitat and primary and secondary recreational activities. In addition, all waters in the watershed shall also be suitable for other uses including compatible industrial processes and cooling, hydropower, irrigation, and other agricultural uses. The goal of this TMDL is to restore all existing and designated uses to waterbodies in the Hunt River watershed that are impacted by elevated levels of fecal coliform bacteria.

3. Loading Capacity- Linking Water Quality and Pollutant Sources

Loading Capacity

As described in EPA guidance, a TMDL identifies the loading capacity of a waterbody for a particular pollutant. EPA regulations define loading capacity as the greatest amount of loading that a water can receive without violating water quality standards (40 C.F.R. 130.2). The loadings are required to be expressed as either mass-per-time, 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. For bacteria, it is appropriate and justifiable to express a TMDL in terms of concentration. Rationale for this approach is provided below:

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

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

3) Expressing a bacteria TMDL in terms of daily loads can be confusing to the public and difficult to interpret, especially considering that the magnitude of allowable loads are highly dependant upon flow conditions.

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

Linking water quality and pollutant sources

Knowledge of potential pollutant sources in the Fry Brook watershed and their transportation to the stream was gained from multiple site visits (during both wet and dry weather) and review of aerial photos, topographic maps, land use maps, and other GIS resources. This information was used to link measured fecal coliform concentrations to the pollution sources listed in Table 1.

Supporting documentation for TMDL analysis

A more detailed description of the information used to develop this TMDL is provided in the following sections of this report. Another important supporting document is the final report of the URI water assessment project conducted for the Hunt River (Wright et al. 1999).

Strengths/Weaknesses in the overall analytical process

The Hunt River TMDL was developed using RIDEM-1999 and URI (Wright et al. 1999) water quality and hydrologic data, collected through extensive wet and dry weather field surveys and land use investigations, and utilizing past meteorological records. Numerous site visits to the watershed solidified the link between pollution sources and the high fecal coliform counts identified by RIDEM field monitoring. Site visits to the to the smaller sub-watersheds during wet weather solidified the link between pollution sources and the high fecal coliform counts measured during storm events by RIDEM.

Strengths:
- Approach utilized extensive knowledge of land use in the watershed.
- Made best use of available data.
- Runoff and recovery parameters were derived from extensive databases, validated with field observations, and determined to be appropriate, yet conservative, for this application.

Weaknesses:
- Limited flow data and stage-discharge relationships for tributary streams.
- Much of the dry weather data was collected during drought conditions (i.e. low flow conditions).

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 at their highest during the summer months. We expect that this trend holds true for the Hunt River and its tributaries as well. 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.

4. Wasteload Allocations (WLAs)

As previously mentioned, there are no point sources in the watershed other than municipal storm sewers, which for purposes of this TMDL are considered nonpoint sources because of a lack of detailed pipe specific information. Therefore, the wasteload allocation for all existing and future point sources is zero.

5. Load Allocations

The load allocations were determined for each water quality station (i.e., stream segment or tributary) by comparing current fecal coliform concentration data to the water quality standard and then calculating the percent reduction needed to meet the standard. Since there are two parts to the fecal coliform standard, two calculations must be made at each station. These two calculations are discussed below. In addition, it is also important to note that the load allocations include all natural and background loads. These loads may not come from anthropogenic sources, and may not be controllable.

Comparison of the Weighted Average Geometric Mean to the Geometric Mean Standard
Current bacterial conditions in the Hunt River were determined based on a “weighted average” geometric mean. The weighted average calculation incorporates the probability of occurrence of both dry and wet weather conditions to calculate a weighted average geometric mean value representative of the frequency of occurrence of wet and dry weather conditions in the watershed. (This approach is explained in further detail in the following sections of this TMDL report.) This value is then compared to the geometric mean portion of the applicable Class A or Class B standard to determine whether a violation has occurred.

Comparison of the Combined Sample Dataset's 80th/90th Percentile Value to the Percent Exceedence Standard

The second portion of the fecal coliform standards state that, in class A waters, "*not more than 10% of the samples shall exceed a value of 200 MPN/100ml*" and that, in Class B waters, "*not more than 20% of the samples shall exceed a value of 500 MPN/100ml.*" In order to address this second portion of fecal coliform standard, another calculation must be made. At each water quality station, the combined dataset of wet and dry weather samples was analyzed and the applicable 80th or 90th percentile value calculated. This value was then compared to 200 or 500 fc/100ml, respectively, to determine whether a violation had occurred.

Calculation of Load Reductions

The approach of this TMDL is to calculate the reductions necessary to meet each part of the fecal coliform standard. The more conservative (i.e., the greater) of those two values is the one upon which the TMDL will be based. The load reductions determined for each stream segment are presented below in Table 2.

Table 2. Load Reductions Required for the Hunt River Watershed.

Station	Waterbody	Percent Reduction Needed to Meet Both Parts of the Standard
SC01	Scrabbletown Brook [a]	98
SCh	Scrabbletown Brook [a]	99
HRe	Hunt R. headwaters [a]	99
HR01	Hunt River [a]	92
HR02	Hunt River [a]	22
FB01	Frenchtown Brook [a]	80
HR03	Hunt River [b]	No Violation
FRY03	Fry Brook [b]	97
HR04	Hunt River [b]	93
UB01	Pierce Brook [b]	88
HR05	Hunt River [b]	83
HR06	Hunt River [b]	No Violation
SB01	Sandhill Brook [b]	79
HR07	Hunt River [b]	No Violation

[a] ***denotes Class A waterbody.*** [b] *denotes Class B waterbody.*

The implementation measures needed to reach the required reductions are discussed, in detail, in following sections of the TMDL report.

6 Margin of Safety (MOS)

For this analysis, an implicit MOS is provided. In other words, a separate value is not added to the TMDL "equation" to account for a MOS. Instead, the MOS is incorporated "implicitly" into estimates of current pollutant loadings, the targeted water quality goal (i.e., the instream numeric endpoint), and the load allocation. This is done by making conservative assumptions throughout the TMDL development process. Some of the key conservative assumptions are described below.

- Conservative estimates of both the amount of rainfall needed to produce runoff and recovery time were used in the weighted average geomean calculations.

- For some of the wet weather events included in the weighted average geomean calculation, enough time may not have elapsed since the preceding storm event for pollutant levels to return to the elevated levels represented by the wet weather data. Similarly, other wet weather events may not be large enough, or long enough in duration, to generate the kind of loads represented by the wet weather data.

- RIDEM 1999 Dry weather data was collected during drought conditions.

- The data used to calculate the 80^{th} or 90^{th} percentile values was conservatively biased, since a disproportionate percentage of the data for each station were collected during wet weather conditions.

7 Seasonal Variation

The Hunt River TMDL is protective of all seasons, since most of the fecal coliform data was collected during the summer months when instream fecal coliform concentrations are typically the highest.

8 Implementation Plans

This TMDL addresses the different segments of the Hunt River watershed as defined by the water quality monitoring locations established as part of RIDEM's supplementary monitoring program. Water quality was assessed, and load allocations set, for each of the segments. Similarly, RIDEM has developed recommendations for BMP implementation for each of those sub-watersheds.

The Hunt River TMDL relies upon phased implementation to reach its water quality goals. As BMPs are installed, the corresponding response in fecal coliform bacteria concentrations will be measured. If standards are not met after the BMPs recommended herein are implemented, then additional measures will be set forth.

RIDEM expects BMPs to be implemented on a voluntary basis by the responsible parties. However, if this does not occur, RIDEM may use its permitting authority, or other enforceable means, to require implementation.

Table 3 summarizes the recommendations for BMPs that are made in section 7.0 of this TMDL. Those BMPs recommended for Fry Brook and Scrabbletown Brook are also included in Table 3. All structural BMPs are expected to reduce fecal coliform bacteria loads to the maximum extent practicable (MEP).

Table 3. BMP recommendations for the Hunt River TMDL.

Recommended BMP	Location(s)	Responsible Entity	Station or River Segment Impacted
Structural Stormwater Management BMP(s)	Hunt River intersection with Route 2.	RIDOT	Hunt River headwaters downstream of Route 2.
Discourage the presence of resident waterfowl	Impoundments in Sandhill Brook and Frenchtown Brook	Residents and property owners, Towns of North Kingstown and East Greenwich	Segments in Sandhill Brook and Frenchtown Brook.
Structural Stormwater Management BMP(s)	Frenchtown Brook intersection with Route 2, Woodbridge Drive and Tillinghast Road.	Town of East Greenwich, RIDOT	Downstream of FB01, FB01A, FB03, and FBc.
Structural Stormwater Management BMP(s)	Sandhill Brook intersection with Chadsey Rd, N. Quidnessett Rd, and Briarbrook Dr.	Town of North Kingstown	Sandhill Brook downstream of selected stations.
Agricultural BMPs, including a waste storage structure, a roofed concrete pad, streambank fencing, and stabilized stream crossings.	Dairy Farm	Property owner	From the farm downstream to Fry Brook's confluence with the Hunt River. Also, two unnamed tributaries to Fry Brook (stations FRY04 and FRY05).
Structural Stormwater Management BMP(s) to treat highway runoff	Fry Brook at Fry Corner (intersection of Route 2 and Middle Road). Fry Brook at Route 4, upstream of FRY03.	RIDOT	Downstream of FRY02 and FRY03.
Discourage the presence of resident waterfowl	East Greenwich Golf Course and other areas along Route 2.	Commercial areas, Industrial areas, residents, and property owners.	FRY01, FRY03
Structural Stormwater Management BMP(s)	Fry Brook tributary intersections with Route 2.	RIDOT	Downstream of FRY04 and FRY05.
Agricultural BMPs, including a waste storage structure, roof runoff management.	Horse Farm	Property owner	Downstream of HRa and upstream of HRe.
Structural Stormwater Management BMP(s)	Scrabbletown Brook intersection with Stony Lane.	Town of North Kingstown	Scrabbletown Brook downstream of Stony Lane.
Pigeon Deterrent System	Scrabbletown Brook intersection with Route 4.	RIDOT	Scrabbletown Brook downstream of Route 4.
Discourage the presence of resident waterfowl	Impoundments in Scrabbletown Brook tributary upstream of Route 4.	Residents and property owners, Towns.	Scrabbletown Brook downstream of ponds and Route 4.
Structural Stormwater Management BMP(s)	Scrabbletown Brook tributary intersection with Scrabbletown Road.	Town of East Greenwich	Scrabbletown Brook downstream of Scrabbletown Road.
Structural Stormwater Management BMP(s)	Scrabbletown Brook tributary intersection with Routes 2 and 4.	RIDOT	Scrabbletown Brook downstream of Routes 4 and 2.

In addition to the recommended BMPs in Table 3, RIDEM recommends the implementation of a public outreach program in the Hunt River watershed.

Public Outreach

The public outreach program should be aimed at informing and educating residents in the watershed about the sources of bacteria in streams and ways to eliminate or reduce these sources. The Towns of East Greenwich and North Kingstown would be responsible for carrying out this program.

The public outreach program in the Hunt River watershed should focus on educating the public about the negative water quality impacts that resident waterfowl can have and the potential health risks associated with encouraging the presence of these waterfowl in local ponds, impoundments, and on lawn areas. Additionally, educational information should be distributed concerning the importance of proper ISDS maintenance and pet waste clean-up.

Stormwater Phase II Permit Program

Over the next several years, RI Department of Transportation (RIDOT) and the towns of East Greenwich and North Kingstown will be required to meet Phase II Stormwater Program requirements. Federal program regulations recently adopted by EPA require that permitted municipalities develop stormwater management programs, control runoff from small construction sites, investigate and eliminate illicit discharges, utilize pollution prevention/good housekeeping practices, and educate and involve the public in stormwater related issues. These aspects of the Phase II program should have a positive impact on water quality in the Hunt River watershed. However, it is very difficult to assign a load reduction to these programs.

Since the Hunt River is an impaired waterbody, RIDEM anticipates that special emphasis will be placed on addressing stormwater impacts to this stream from municipal separate storm sewer systems (MS4s). This TMDL identifies major highway crossings and storm sewer outfalls associated with elevated bacteria levels in-stream, and where appropriate recommends structural BMPs to reduce pollutant loads. Actions to achieve the required reductions can be taken voluntarily by the Towns and RIDOT prior to the issuance of Phase II Stormwater Permits, or will be required by the Phase II permits.

Plans are already in place to reduce fecal coliform concentrations in the Hunt River watershed. The areas in which progress is already underway are described below.

Dairy Farm BMPs- Fry Brook

A dairy farm was identified as the largest dry and wet weather source of fecal coliform bacteria to Fry Brook, a major tributary to the Hunt River. The property owner is currently working with NRCS (Natural Resource Conservation Service) and RIDEM's Division of Agriculture to implement BMPs and improve water quality on the farm. We anticipate that RIDEM will be able to provide Section 319 Nonpoint Source Program grant funds to supplement both NRCS and Dairy Farm funding sources to pay for the design and construction of the BMPs. BMP construction is scheduled to begin within the next year, starting with the fencing of riparian and wetland areas. The other proposed BMPs will focus on the heavy-use areas where most of the day-to-day farming operations occur. Subsequent BMPs should focus on the outlying areas of the farm.

Horse Farm BMPs- Hunt River headwaters
A horse farm located in the headwaters of the Hunt River was found to be a significant wet weather source of fecal coliform bacteria. Plans are underway to implement BMPs and improve water quality at the farm. RIDEM has used Nonpoint Source Program (Section 319) grant funds to supplement NRCS, as well as individual funding sources to pay for the design and construction of BMPs on the farm. Construction of these BMPs should begin this year. The proposed BMPs will include a waste storage facility and roof runoff management.

Pigeon deterrent BMP- Scrabbletown Brook
RIDEM will work with RIDOT to install a pigeon deterrent system at the Route 4 overpass. Implementation of the pigeon deterrent BMP should result in a complete removal of roosting pigeons from the Route 4 overpass. The removal of this bacteria source should result in attainment of water quality standards for fecal coliform for this section of Scrabbletown Brook.

9. Monitoring Plan for TMDLs Developed Under the Phased Approach

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to track the response of instream water quality as load reductions are made over time. RIDEM, in coordination with the entities responsible for BMP implementation, will monitor water quality at key locations in the Hunt River watershed in order to assess BMP effectiveness. This monitoring plan is discussed later in the TMDL report. In general, however, RIDEM intends to establish a monitoring program in the watershed that will allow us to track trends in water quality.

10. Public Participation

The public participation associated with this TMDL has two components. An initial meeting was held prior to TMDL development, which included all interested public, private, and government entities. The meeting was held to disseminate information regarding the TMDL issues in the watershed as well as to solicit input regarding pollution sources and/or other concerns.

A second public meeting was held on September 27, 2000 to initiate a 30-day public comment period. RIDEM staff presented the draft TMDL and solicited input, however, no comments were received by the end of the comment period.

THE HUNT RIVER TMDL FOR FECAL COLIFORM

1.0 INTRODUCTION

The State of Rhode Island's 1998 303 (d) List of Impaired Waters identified the Hunt River, Fry Brook, and Scrabbletown Brook as being impaired by pathogens, as evidenced by the presence of high fecal coliform concentrations. The purpose of this report is to establish a Total Maximum Daily Load (TMDL) addressing fecal coliform loads to the Hunt River. This TMDL serves as a restoration plan aimed at abating fecal coliform sources so that bacteria standards can be attained in the river. Separate but complimentary TMDLs address water quality issues in those tributaries to the Hunt River that are also identified as impaired.

1.1 Background

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and management Regulations (40 CFR Part 130) require states to develop TMDLs for waterbodies that are not meeting designated uses. The objective of a TMDL is to establish water quality based loading limits for a given pollutant, for both point and nonpoint sources, in order to restore and maintain the quality of the impacted waterbody.

The TMDL analysis examines point source sources, such as industrial and wastewater treatment facility discharges, as well as nonpoint sources, such as stormwater runoff from agricultural and urbanized areas. Natural background levels are also included in the analysis, along with a margin of safety to account for any modeling or monitoring uncertainties. The ultimate goal of this process is to reduce pollutant loading to a waterbody in order to improve water quality to the point where state water quality standards are met.

1.2 Pollutant of Concern

The pollutant of concern is pathogens, as indicted by the presence of fecal coliform. Fecal coliform concentrations have been found to exceed the state's water quality standards. As reported on the 1998 303(d) list, RIDEM has identified the Hunt River as being impaired by pathogens for a length of approximately 8.82 miles.

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 waterbodies considered impaired, may not represent existing water quality conditions (Water Quality Regulations 1997).

Both Class A and Class B waters are found in the Hunt River watershed. Under RIDEM's recently updated Water Quality Regulations (RIDEM, 1997), the following waterbody segment classifications for the Hunt River watershed apply:

- The Hunt River, from Frenchtown Road to the tidal waters of the Potowomut River, located approximately 1000 feet south of the Forge Bridge, is designated as a Class B waterbody.

- The upper reaches of the Hunt River and tributaries upstream of Frenchtown Road, including Mawney, Frenchtown, and Scrabbletown Brooks are designated Class A waters.

- Fry Brook, Sandhill Brook, and Pierce Brook are designated as Class B waters.

The following excerpts from the Rhode Island section 305(b) report describes Class A and Class B waters:

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 B- These waters are designated for fish and wildlife habitat and primary and secondary contact recreational activities. 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.

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 also are applicable. In particular, Rule 8.D(2) establishes class-specific criterion for fresh and salt waters. For fresh waters of the State that are classified as Class A or Class B, the following fecal coliform criteria, excerpted from Table 1, apply*:*

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

Class B*- Fecal coliform not to exceed a geometric mean value of 200 MPN/100ml and not more than 20% of the samples shall exceed a value of 500 MPN/100ml.*

2.0 DESCRIPTION OF THE HUNT RIVER WATERSHED

The Hunt-Potowomut River Basin is centrally located in Rhode Island on the westerly side of Narragansett Bay. The basin drains approximately 25 square miles (15,852 acres). Seven communities share the watershed, including: East Greenwich, North Kingstown, Exeter, Coventry, West Greenwich, Warwick, and West Warwick.

Tributary streams spread through most of East Greenwich, joining to form the Hunt River at the northern border of North Kingstown. At the southern edge of Warwick, it widens to the Potowomut River and empties into Narragansett Bay just south of Greenwich Bay. The Hunt River watershed includes four major sub-basins: Sandhill Basin (2352 acres), Frenchtown-Mawney Basin (4487 acres), Scrabbletown-Hunt headwaters basin (2646 acres), and Fry-Pierce Basin (2591 acres). Table 2.1 shows area measurements for the Hunt/Potowomut sub-basins and Figure 2.1 shows the sub-watershed boundaries.

2.1 Climate

The climate in the Hunt River basin is variable throughout the year. There are normally no seasonal patterns in the frequency and amount of precipitation during the year, however two major storm patterns exist. Storms that occur between October and May are primarily extra-tropical cyclones. These low-pressure systems typically develop off the North Carolina coast and track north along the Atlantic seaboard, occasionally colliding with colder and drier air in the New England region. This results in the development of heavy rain and/or snow. The second type of storm, occurring between June and October, are primarily tropical cyclones. The biggest storms are hurricanes, which have impacted Rhode Island 71 times during the last 350 years. In the summer, most precipitation results from thunderstorms and smaller convective systems. These typically produce short-duration high-intensity precipitation events.

The average annual precipitation for the basin, as recorded at T.F. Green Airport in Warwick, RI, is approximately 46.3 inches. Precipitation totals ranged from 36.1 to 67.5 inches in the 25-year period 1974-1998. During this period the average annual precipitation was equaled or exceeded about 52 percent of the time.

Watershed response to precipitation events varies according to storm duration, storm intensity, and watershed characteristics such as land use, vegetal cover, and soil characteristics. Changes in land use and vegetal cover are typically accompanied by increases in impervious areas. Of particular concern in the Hunt River watershed is the close proximity of these impervious surfaces to stream channels. This allows for the rapid and efficient transport of runoff, and concomitant pollutants, to the channel during wet weather events.

2.2 Topography

The topography of the basin is generally flat with gently rolling hills, which is typical of coastal low lands of the northeastern United States. Elevations within the watershed range from a few feet above sea level (along the shores of the Potowomut River) to a hill, located south of Carr Pond, which has an elevation of 411 feet above mean sea level. The topography is typically more rugged in the western half of the basin, where many of the tributaries flow through elevations ranging from 200 to 400 feet above sea level.

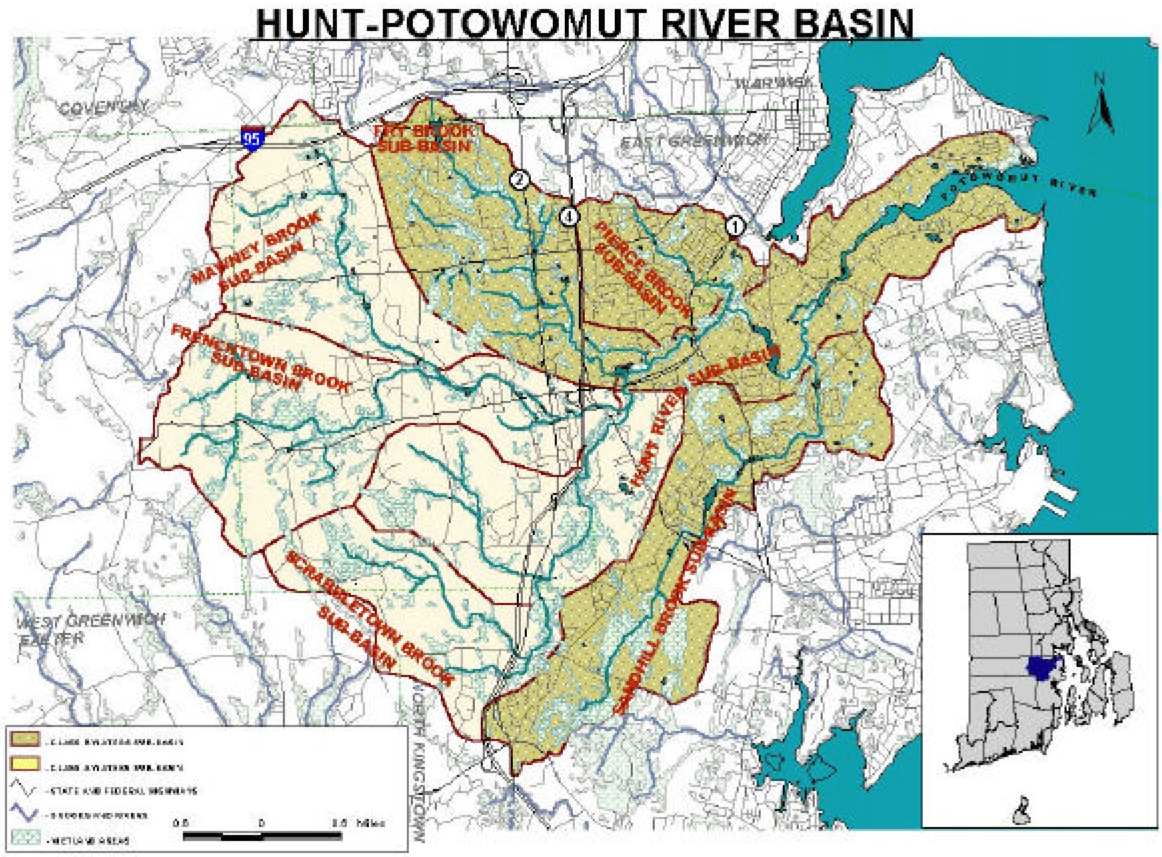


Figure 2.1. Map showing the Hunt River watershed.

Table 2.1 Area measurements for the Hunt-Potowomut sub-basins.

Sub-basin	Area in acres
Mawney-Frenchtown Brook	4,486
Hunt River headwaters	918
Hunt River	2,621
Sandhill Brook	2,351
Fry Brook	1,987
Scrabbletown Brook	1,727
Pierce Brook	604
Hunt-Potowomut Extension	1,156
Total Area:	**15,852**

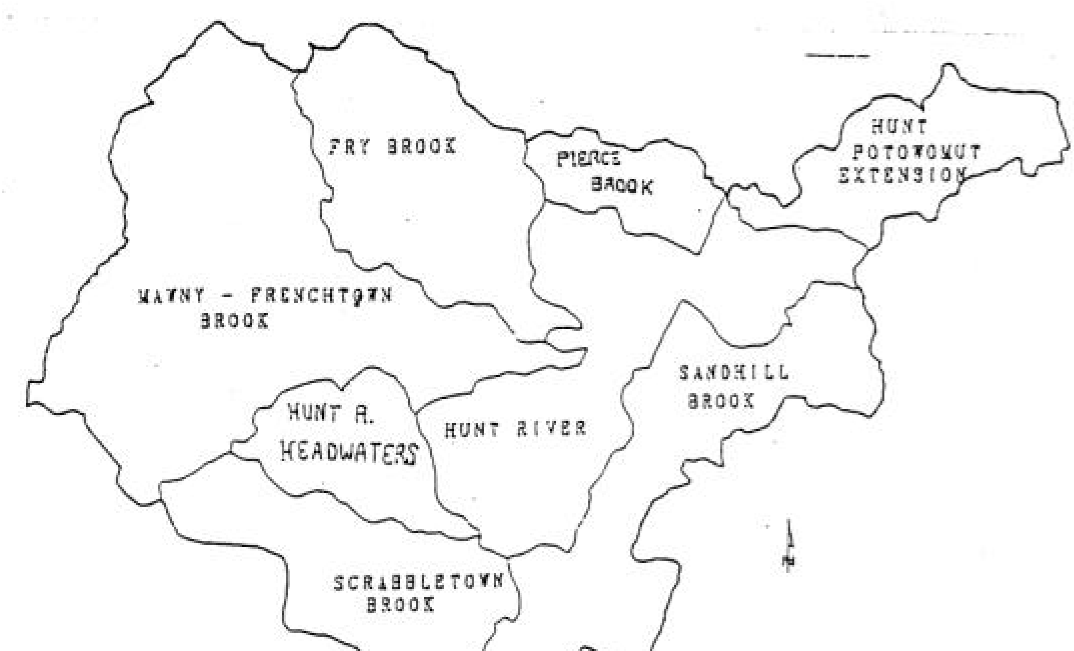


Figure 2.2. Sub-watershed boundaries in the Hunt River watershed.

Topographically, the eastern half of the basin is less varied and streams become more sluggish as they flow through marsh and wetland areas. The Hunt River falls approximately 220 feet from its headwaters in the Bear Swamp to its mouth, at the transition between the Hunt and Potowomut Rivers. The Hunt River watershed has many impoundments. Saw Mill Pond and Sandhill Pond are located in Sandhill Brook and Potowomut Pond is located upstream of the confluence between the Hunt River and Sandhill Brook. Several smaller impoundments occur in the Frenchtown-Mawney sub-basin.

2.3 Soils

Most of the soils in Rhode Island have formed from material that was transported from the site of the parent rock and redeposited at the new location through the action of ice, water, wind, or gravity. Glacial ice was particularly important in transporting and depositing parent materials from which Rhode Island soils, including those in the Hunt River watershed, formed.

The principal parent materials of the Hunt River watershed soils are glacial till and glacial outwash. A small percentage of soils have developed from organic deposits. Organic deposits form the parent materials for peat and muck soils. These organic deposits generally occur in small, very poorly drained depressions and are particularly thick in large lowland swamps such as those along the Hunt River.

2.4 Surface-Subsurface Hydrology

The high drainage density (0.97 km/km^2) of the Hunt River watershed indicates that the drainage system is very efficient in transporting water from the watershed to the outlet. The drainage density of a watershed affects the rapidity by which water is transported to the channel. Drainage density increases with an increase in the amount of impervious surfaces (roads, parking lots, etc.). This has implications for pollutant transfer from impervious surfaces to the stream channel, as most roadways paralleling waterbodies are designed to channel runoff directly to that waterbody.

Much of the Hunt River watershed contains ponds and marshes. Many of the streams are controlled to some degree by small impoundments. These impoundments are the result of previous mill operations, agricultural uses, and other smaller industrial uses. Small quantities of water are generally diverted from the streams and ponds and in low-flow periods these diversions may constitute a sizable part of the total discharge. Much of this diverted flow is not returned directly to the streams. During most years, a part of the streamflow consists of water discharged from detention storage in natural marshes and ponds, as well as from manmade impoundments. The rest of the flow is derived from direct runoff of precipitation and from base runoff consisting largely of ground-water discharge.

Stream flow is derived from the combination of surface water runoff moving into streams from the adjacent landmass and groundwater discharge up through streambeds. Some streams in the eastern half of the watershed, particularly headwater streams in the steeper hills of the watershed, are totally dependent upon meltwater and rainwater to maintain flow. These streams often go dry during late summer or dry spells when precipitation and runoff are minimal.

The U.S. Geological Survey (USGS) maintains a gauging station (sta.01117000) near the Old Forge Dam in North Kingstown. The period of record is from 1940 to the present. The average discharge is approximately 46.6 cfs with a maximum discharge of 1,020 cfs measured on June 6, 1982. Stage-discharge relationships have been calculated for approximately 12 stations in the Hunt River basin. These relationships are based on data collected by URI researchers during 1996 and 1997.

Diversions occur in the Hunt River basin, where an average of about $7ft^3/sec$ is diverted upstream from the gaging station for supplies of North Kingstown, West Greenwich, and East Greenwich. A substantial part of the water withdrawn from the water-supply wells is exported from the drainage area of the Hunt Aquifer, treated, used for various purposes, and then discharged into Narragansett Bay.

Within the watershed, groundwater and surface waters are connected and land development affects both. Deep sand and gravel deposits under the Hunt River form part of an aquifer that provides the only source of drinking water in North Kingstown. Precipitation, stream leakage, and ground-water inflow from adjacent till-bedrock uplands recharge the Hunt aquifer. The aquifer also is recharged locally by septic-system return flow. Under natural conditions, ground water discharges to streams, ponds, and wetlands, and by evapotranspiration and underflow to adjacent flow systems.

Areas in the Hunt basin overlain by till and fine-grained stratified drift deposits generally yield greater surface runoff during storm events than areas overlain by coarse-grained deposits because rainfall infiltrates the coarse-grained deposits more rapidly than the fine-grained deposits. Although a large percentage of rainfall on the till and fine-grained sediments in the Hunt basin run off rapidly and becomes stream flow, much of the rainfall on the coarse-grained sediments recharges ground-water storage in aquifers.

The groundwater resources of the Hunt-Potowomut watershed include the Hunt River Aquifer Recharge area and several public wellhead protection areas (WHPA) (Figure 2.3). These well head areas include the Frenchtown WHPA, which is the largest and extends across three communities; the proposed Davisville WHPA, and the North Kingstown WHPA, located on the north side of Stony Lane, North Kingstown. The Pheasant Ridge WHPA is a non-community well head area in western East Greenwich.

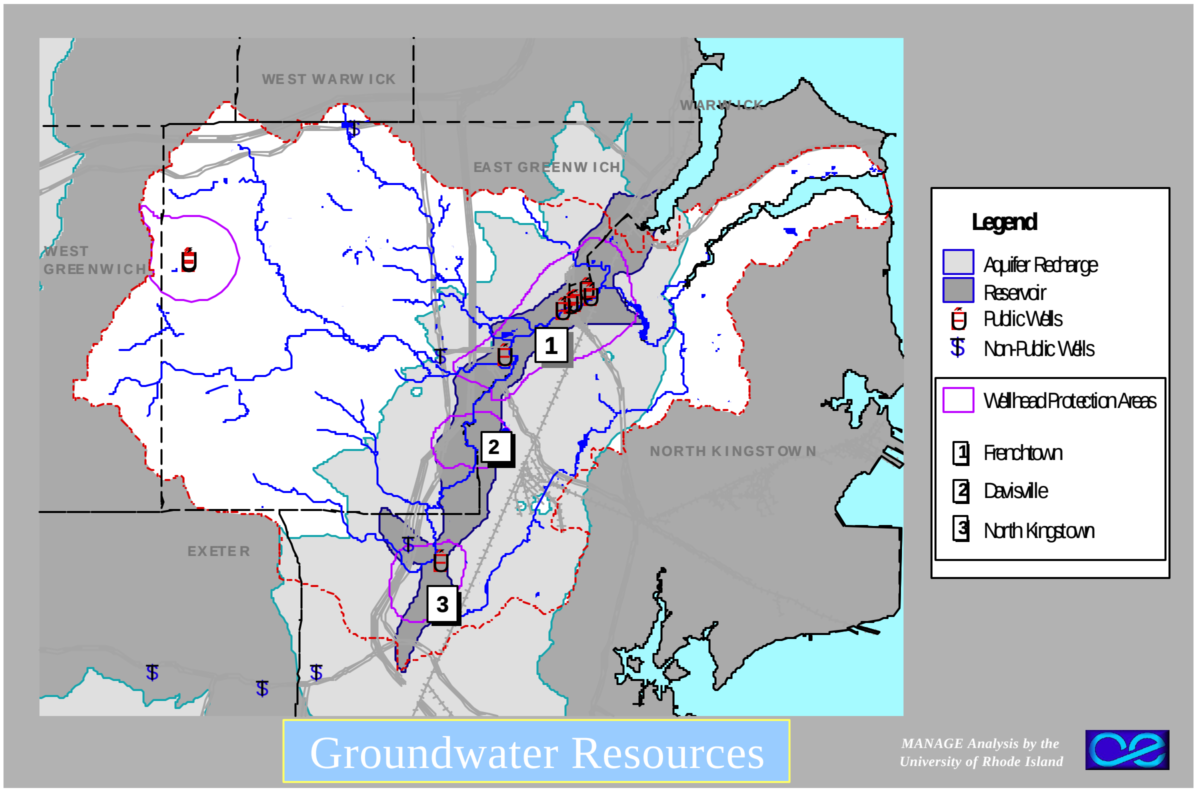


Figure 2.3. Location of groundwater recharge area and public wellhead protection areas in the Hunt River watershed.

2.5 Wetlands Resources

There are 4 dominant classes of wetland habitats in the Hunt-Potowomut River watershed. These are: (1) Riverine, (2) Lacustrine, (3) Palustrine, and (4) Estuarine. Wetland habitats in the Hunt River watershed support a variety of animal species. Muskrats are perhaps the most typical and widespread wetland mammal in the Hunt River watershed. Other fur-bearers likely inhabiting wetlands include river otter, mink, beaver, raccoon, skunk, red fox, and weasel. Common reptiles and amphibians in Rhode Island freshwater wetlands, as well as likely residents of wetlands in the Hunt River watershed, include the eastern painted, spotted, box, stinkpot, wood, and snapping turtles. Common snakes found in and near wetlands include northern water, northern redbelly, eastern garter, eastern ribbon, eastern smooth green, and northern black racer. Among the more common toads and frogs in the Hunt River wetlands are Fowlers toad, American toad, northern spring peeper, green frog, bullfrog, wood frog, pickerel frog, and gray tree frog. These habitats also support several salamander and newt species.

Wetlands in the Hunt River watershed help maintain good water quality as well as improve degraded waters in several ways: (1) nutrient removal and retention, (2) processing chemical and organic wastes, and (3) reducing sediment load of water. Wetlands are particularly good water filters because of their locations between land and open water. Thus, they can both intercept runoff from land before it reaches the water and help filter nutrients, wastes, and sediment from floodwaters and urban runoff.

It has been found that wetlands can act as both sources and sinks of fecal coliform bacteria. In the case of the large wetland located between monitoring stations HR01 and HR02, both wet and dry weather fecal coliform concentrations drop dramatically between these stations. In other areas in the watershed, wildlife in the wetlands may actually act as a source of fecal coliform loads.

2.6 Land Use

The Narragansett Bay basin, including of the Hunt River watershed, is part of one of the oldest industrialized areas in the country. Adjacent water bodies provided convenient transportation, drinking water, power production, industrial cooling and process water, and waste disposal for early municipalities and manufacturing interests.

Water use in the western portion of the Hunt River watershed was dominated by agriculture and livestock uses. Most of the medium to large streams in the basin were regulated, diverted, or both, to accommodate these uses. Livestock were watered in many of the smaller tributaries, a practice that still continues in some areas of the watershed.

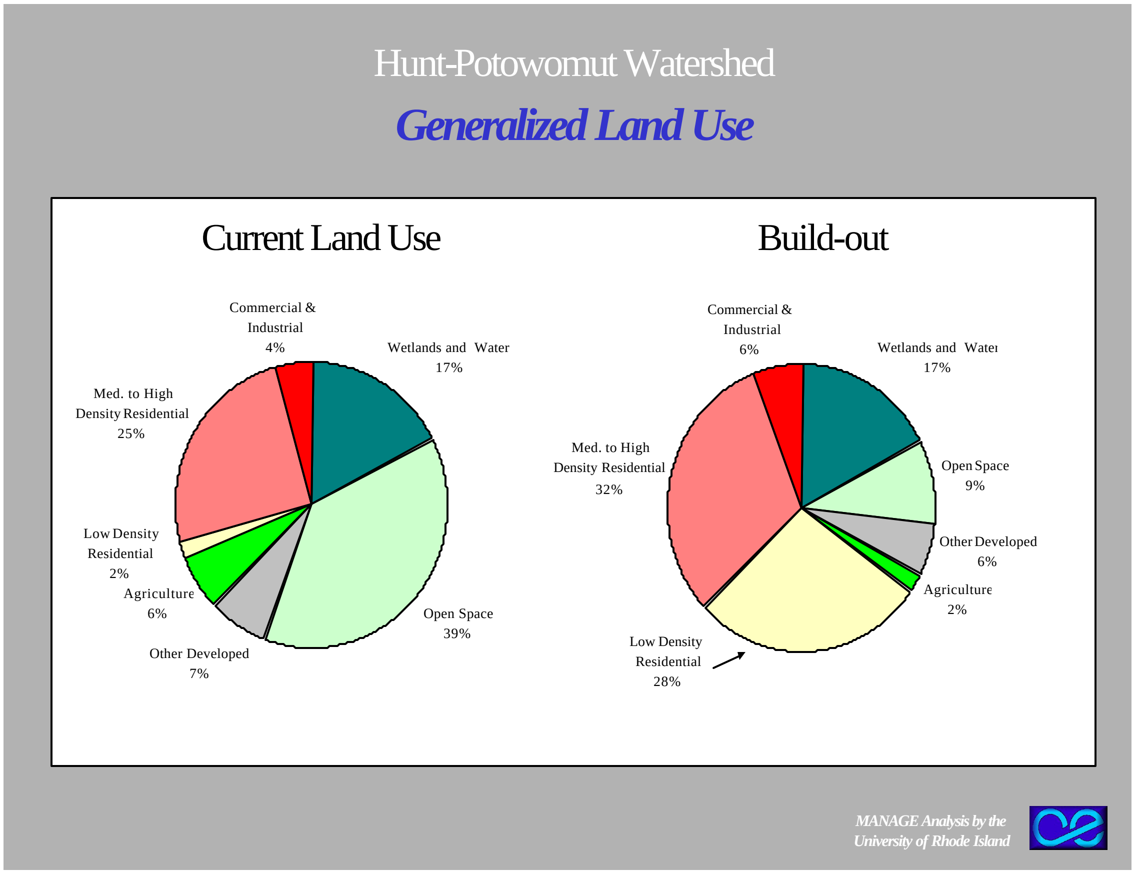
The watershed is characterized by undeveloped or lightly developed rolling countryside in the western half and more highly developed with commercial, high-density residential, industrial and major travel routes in the eastern half. There are several dairy and horse farms located in the upper tributaries of the Hunt River.

Changes in land use in the Hunt River watershed are those typically associated with the conversion of rural land to urban land. The associated impacts of most concern in the watershed are (1) the increase in the number of septic systems installed in limiting soils, and (2) increases in the amount of impervious areas adjacent to drainageways. Figure 2.4 shows the current land use as well as the projected changes in land uses in the Hunt River watershed that would result from build-out, assuming current zoning regulations.

The conversion of rural and forest land to urban land is usually accompanied by increases in the discharge and volume of storm runoff, as well as any associated pollutants, in a watershed. In urbanizing watersheds, the amount of impervious surfaces, including roads, sidewalks, parking lots, and buildings, increases. This leads to decreased infiltration of precipitation and decreases in groundwater levels near affected stream channels.

Because less runoff infiltrates into underlying groundwater, reduced baseflow in streams may be observed during times of little or no precipitation. Lower baseflow levels may worsen water quality conditions, as the dilution capacity of the stream is limited when less water is in the channel.

Figure 2.4. Changes in Land Use with build-out in the Hunt River watershed.



Mallin (1998) found that the most important anthropogenic factor associated with fecal coliform abundance was percent watershed impervious surface coverage. A study conducted by Burnhart (1991) attempted to identify land uses in industrial, commercial, and residential areas, which were the largest contributors of fecal coliform. Burnhart found that the primary contributor of fecal coliform bacteria in industrial and commercial areas was parking lots. In the residential areas, the primary contributors of fecal coliform loads were streets. The study also concluded that residential streets are able to support the growth of fecal coliforms.

Schueler (1987) maintains that bacterial levels in urban runoff exceed public health standards for water contact recreation almost without exception. Schueler further states that although nearly every urban and suburban land use exports enough bacteria to violate health standards, older and more intensively developed urban areas typically produce the greatest export.

Pitt (1998) reports a mean fecal coliform concentration in stormwater runoff of about 20,000 fc/100ml based on 1,600 storm runoff samples largely collected during the Nationwide Urban Runoff Program (NURP) in the early 1980's. Pitt also reported a nearly identical mean fecal coliform concentration of about 22,000 fc/100ml, derived from a second database containing 25 additional stormwater monitoring studies conducted since NURP.

The Center for Watershed Protection has recently developed a third database containing 34 more recent urban stormwater monitoring studies. An analysis of the Center's database indicates a slightly lower mean concentration of fecal coliform in urban stormwater of about 15,000 fc/100ml (CWP 1999).

3.0 DESCRIPTION OF WATER QUALITY MONITORING ACTIVITIES IN THE HUNT RIVER WATERSHED

Recent efforts to monitor water quality in the Hunt River watershed began with a 1993 study by U.S. Food and Drug Administration (FDA) which focused on pathogen loads to Greenwich Bay. The results of that study led to more comprehensive research carried out by URI, under contract to RIDEM, in 1996-1997. More recently, RIDEM conducted supplemental monitoring in 1999 to support the development of this TMDL. The results of these three studies are summarized below.

3.1 Greenwich Bay Study (1993)

In 1992, Rhode Island's Shellfish Program found sustained violations of the Class SA fecal coliform standards in Greenwich Bay. These water quality findings led RIDEM to temporarily close Greenwich Bay to shellfishing in December of 1992. The closing of this popular shellfishing area prompted FDA and RIDEM to jointly investigate water quality issues in Greenwich Bay and surrounding waterbodies. The study took place during April and June 1993.

The primary objectives of the FDA study were to assess the relative importance of pollution sources impacting the Greenwich Bay's water quality and to develop recommendations for the classification and management of the Bay. The study plan included standard hydrographic and hydrologic measures, and utilized the standard National Shellfish Sanitation Program (NSSP) microbiological indicators of pollution. Flow rates of identified pollution sources were determined from flow measurements taken at the same times as samples were obtained. Estimates of average daily inputs of pollution to the Bay from identified sources were then calculated. The localization and identification of nonpoint sources of contamination in the surrounding watershed (i.e. agriculture, dairy operations, individual septic systems, etc.) were not within the scope of this study.

The Hunt River has the largest flow of all freshwater inputs to Greenwich Bay. Only one station in the Hunt River watershed, located at the Hunt-Potowomut transition immediately south of Forge Road, was sampled for pathogens. The fecal coliform geometric mean for the twelve samples collected at that station was 37.5 fc/100ml, with minimum and maximum values of 1 fc/100ml and 840 fc/100ml, respectively. Fecal coliform densities and instantaneous flow rates at the Hunt River station were used to estimate daily loading factors. These daily loadings were then averaged to determine the average fecal coliform inputs per day to Greenwich Bay from the Hunt-Potowomut River.

Fecal coliform daily loads for the April study were estimated to be 3.25×10^{10} fc/day, while daily loads for the June study were estimated to be 1.72×10^{11} fc/day. Based on these results, the FDA study concluded that up to 31% of the fecal coliform load entering Greenwich Bay has its origins in the Hunt-Potowomut River. According to FDA, this was true under either dry or wet weather conditions.

It should be emphasized that the Potowomut River does not directly discharge into Greenwich Bay, and presumably its indirect impacts on the area, if any are delivered only by flood tidal cycles. The Hunt River station is located approximately 2 miles from the mouth of the Potowomut River. It is very unlikely that the calculated fecal coliform loadings would reach or significantly impact Greenwich Bay. Also, the lower Hunt River is designated as a Class B waterbody, and the calculated fecal coliform geometric mean of 37.5 fc/100ml is well below the State of Rhode Islands Class B standard. Data from the FDA study was not used in developing this TMDL, because it does not adequately represent conditions in the Hunt River watershed, nor did it establish the relationship between high fecal coliform counts and source areas.

3.2 URI Study (1996-1997)

The most extensive water quality assessment of the Hunt River watershed was conducted, under contract to RIDEM, by researchers from the University of Rhode Island's Civil and Environmental Engineering Department (Wright et al. 1999). This study of the Hunt-Potowomut River basin was conducted during 1996 and 1997. Water quality data were collected from 22 sites within the watershed and included determinations of: temperature, salinity, dissolved oxygen, sodium, chloride, ammonia, pH, nitrate, phosphate, SOD, fecal coliform, TSS, VSS, TKN, and total phosphorus.

The URI study was divided into two phases: a preliminary site assessment (dry weather water quality monitoring program) and a wet weather characterization. Figure 3.1 shows water quality sampling locations for the study. Dry weather monitoring consisted of 6 surveys, each sampling 21 stations, with 4-8 samples completed over a 24-hour period. For this study, a dry day was defined as a day with rainfall totals no greater than 0.03 inches and less than 0.5 inches of rainfall during the previous seven days.

Wet weather monitoring consisted of four storm event surveys that sampled 10 stations. Wet weather field sampling began with a pre-storm sample taken approximately 3 hours before the storm, with subsequent sampling hourly for the first 12 hours and at two-hour intervals for the next 12 hours. The following rainfall criteria were used for the URI wet weather study:

- Minimum rainfall total of 0.5 inches in a 24-hr period.
- Minimum rainfall duration of 5 hours
- Minimum antecedent dry period of 3 days
- Minimum number of 2 post-storm days

A discussion of the dry and weather data that was collected by URI is provided below. A more detailed analysis of the data is available in the project final report (Wright et al., 1999).

Dry Weather Data

For the Hunt River watershed, high levels of fecal coliform bacteria were seen at several locations along the mainstream and tributaries. The results of the URI dry weather data are presented in Table 3.1. The geometric means for each station for all dry weather samples are shown in Figure 3.2 and discussed below, starting in the headwaters of the Hunt River and moving downstream.

Dry weather fecal coliform concentrations at station SC01 were among the highest in the Hunt River watershed, with maximum concentrations of 1000 fc/100ml and a geometric mean of 258 fc/100ml.

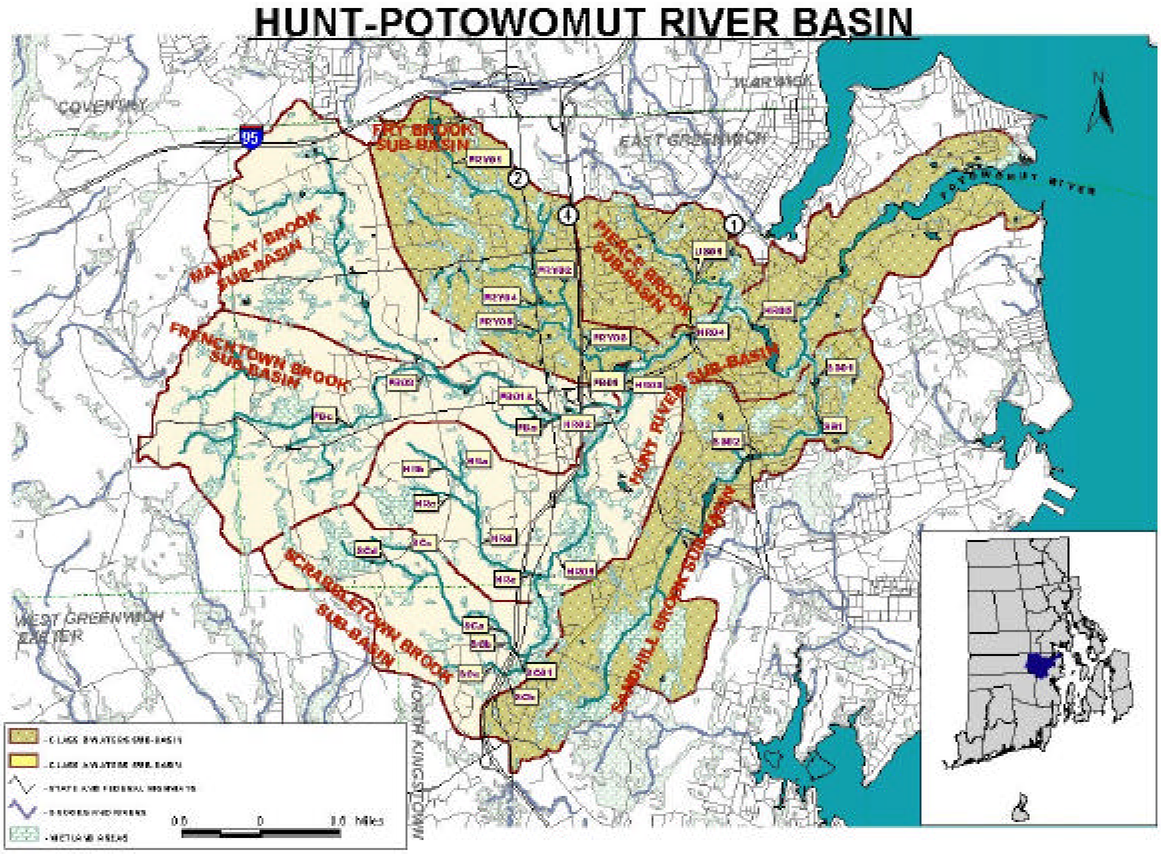


Figure 3.1 - URI Hunt/Potowomut River Sampling Locations (1996-1997)

Table 3.1 - Results from URI Dry Weather Monitoring.

Station	Waterbody	No. of samples	Minimum value	Maximum value	Geometric mean
HR01	Hunt River [a]	28	3	130	38
HR02	Hunt River [a]	28	2	90	14
HR03	Hunt River [b]	8	8	450	76
HR04	Hunt River [b]	28	1	410	16
HR05	Hunt River [b]	28	15	250	81
HR06	Hunt River [b]	25	5	63	19
HR07	Hunt River [b]	28	17	220	48
SB01	Sandhill Brook [b]	28	38	400	84
SB02	Sandhill Brook [b]	28	15	690	75
SB03	Sandhill Brook [b]	26	1	140	21
SB04	Sandhill Brook [b]	28	5	780	58
SC01	Scrabbletown Brook [a]	28	25	1000	258
FB01	Frenchtown Brook [a]	30	1	84	18
FB03	Frenchtown Brook [a]	28	1	100	14
FB04	Frenchtown Brook [a]	23	1	48	6
MY01	Mawney Brook [a]	28	1	40	7
UB01	Pierce Brook [b]	24	1	830	128
PR01	Potowomut River	11	35	190	61
PR02	Potowomut River	12	7	129	30
PR03	Potowomut River	11	1	210	13
PR04	Potowomut River	12	1	9	2

[a] *denotes Class A waterbody.*
[b] *denotes Class B waterbody.*
[sa] *denotes Class SA waterbody.*

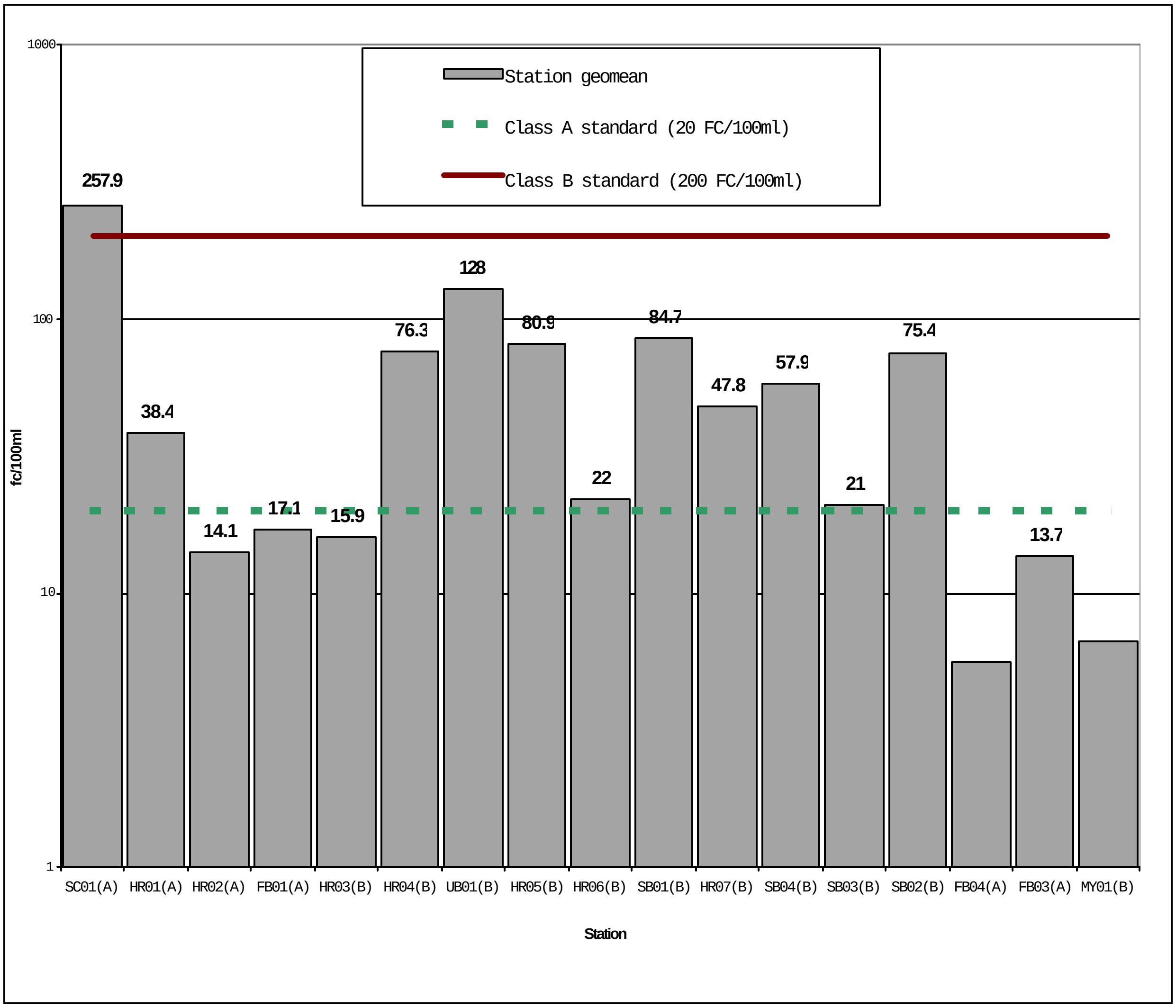


Figure 3.2 Geometric Means of URI Dry Weather Data by Station. Class A and Class B waters are denoted inside parentheses after station name.

Station HR01 had a dry weather fecal coliform geometric mean of 38.4 fc/100ml. The fecal coliform criteria for this Class A waterbody is 20 fc/100ml. Minimum and maximum fecal coliform concentrations at HR01 were 3.0 and 130 fc/100ml, respectively. Fecal coliform concentrations at this station are likely elevated due to inputs from Scrabbletown Brook at SC01. Elevated fecal coliform concentrations at HR01 could also be a result of inputs from the Hunt River headwaters. Field investigations in this sub-basin revealed two horse farms located along minor tributaries.

Station HR02 is approximately 2000 yards downstream of station HR01. This segment of the Hunt River flows through an undisturbed wetland area. Fecal coliform concentrations show marked and consistent declines between stations HR01 and HR02 (from a geometric mean at HR01 of 38.4 fc/100ml to a geometric mean of 17.0 fc/100ml), indicating, in this case, the assimilative capacity of the wetland.

Frenchtown Brook flows into the Hunt River between stations HR02 and HR03. Station FB01 is approximately 500 yards upstream of this confluence. Dry weather fecal coliform concentrations at FB01 ranged from a maximum of 84.0 fc/100ml to a minimum of 1.0 fc/100ml, with a geometric mean of 17.1 fc/100ml. The absence of any increases in fecal coliform concentrations between stations HR02 and HR03 indicate that Frenchtown Brook is not a dry weather contributor of pathogens to the Hunt River. Fecal coliform geometric means at stations HR02 and HR03 were 14.1 fc/100ml and 15.9 fc/100ml, respectively.

Dry weather fecal coliform concentrations decrease upstream of station FB01. Station FB03 is approximately 3000 yards upstream of FB01. Fecal coliform concentrations at FB03 range from 1.0 fc/100ml to 100 fc/100ml, with a geometric mean of 13.7 fc/100ml. Station FB04, approximately 4000 yards upstream, had a dry weather fecal coliform geometric mean of 5.6 fc/100ml. Minimum and maximum fecal coliform concentrations were 1.0 fc/100ml and 48.0 fc/100ml respectively. Fecal coliform concentrations at FB01, FB03, and FB04 fall well within the States class specific criteria for this Class A waterbody.

Station MY01, in Mawney Brook had a dry weather fecal coliform geometric mean of 6.7 fc/100ml. Minimum and maximum fecal coliform concentrations were 1.0 fc/100ml and 40.0 fc/100ml respectively. Fecal coliform concentrations at MY01 fall well within the state's class specific criteria for this Class A waterbody.

The Hunt River becomes a Class B waterbody at station HR03. Rhode Island class specific criteria state that fecal coliform concentrations are not to exceed a geometric mean value of 200 fc/100ml and not more than 20% of the samples shall exceed a value of 500 fc/100ml. Fecal coliform concentrations at HR01, HR02, and HR03 fall well within the State's class specific criteria.

Instream dry weather fecal coliform concentrations show a consistent increase between stations HR03 and HR04. Fry Brook flows into the Hunt River between these two stations, however no URI dry weather data exist for Fry Brook. Fecal coliform geometric means at stations HR03 and HR04 were 15.9 fc/100ml and 76.3 fc/100ml, respectively.

Instream dry weather fecal coliform concentrations show inconsistent, slight, and perhaps negligible increases between stations HR04 and HR05. Fecal coliform geometric means increase from 76.3 fc/100ml at station HR04 to 81.0 fc/100ml at HR05. Essentially, there are no differences in fecal coliform concentrations between HR04 and HR05. Approximately 1000 yards of wooded wetlands separate these two stations.

Pierce Brook confluences with the Hunt River halfway between stations HR04 and HR05. Dry weather discharge data show Pierce Brook to have, on average, between 0.5% to 5% of the flow of the Hunt River at stations HR04 and HR05. Dry weather fecal coliform concentrations for station UB01 (Pierce Brook) range from a minimum of 1.0 fc/100ml to a maximum of 830 fc/100ml. The fecal coliform geometric mean for station UB01 is 128 fc/100ml. The absence of any substantial increase in fecal coliform concentrations between stations HR04 and HR05 indicate that Pierce Brook is not a dry weather contributor of pathogens to this segment of the Hunt River.

Stations HR05 and HR06 are located respectively at the inflow and outflow of Potowomut Pond. Fecal coliform geometric means decrease from 81.0 fc/100ml at station HR05 to 19.4 fc/100ml at station HR06. All dry weather fecal coliform data show a consistent decrease between HR05 and HR06, indicating that Potowomut Pond acts as a sink for fecal coliform bacteria. Instream dry-weather fecal coliform concentrations show a consistent increase between stations HR06 and HR07. The station geometric mean at HR06 is 19.4 fc/100ml and increases to 48 fc/100ml at HR07. Sandhill Brook enters the Hunt River approximately 500 yards downstream of station HR06 and appears to be the cause of these elevated bacteria levels to this segment of the Hunt River.

Station SB04, in the headwaters of Sandhill Brook, had dry weather fecal coliform concentrations ranging from 5.0 fc/100ml to 780.0 fc/100ml with a geometric mean of 57.9 fc/100ml. Further downstream, SB03 had a slightly lower geometric mean of 21.0 fc/100ml. Fecal coliform concentrations show consistent increases between stations SB03 and SB02, as indicated by a fecal coliform geometric mean at SB02 of 75.4 fc/100ml. Fecal coliform concentrations at SB02 ranged from 15.0 fc/100ml to 690.0 fc/100ml. The highest geometric means in Sandhill Brook were found at station SB01, located approximately 500 yards upstream of the confluence with the Hunt River. Here, the geometric mean increased from 75.4 fc/100ml at SB02 to 84.7 fc/100ml at SB01. This increase is small and perhaps negligible.

Wet Weather Data
Four wet weather events were monitored: April 12-13, 1997 (WWS#1), August 13-15, 1997 (WWS#2), November 7-10, 1997 (WWS#3), and November 7-10, 1997 (WWS#4). The total rainfall and duration for each storm were 1.02 inches/12 hrs, 0.60 inches/4 hrs, 1.56 inches/28 hrs, and 2.02 inches/24 hrs, respectively. Fecal coliform data collected during each wet weather sampling event are shown below in Tables 3.2, 3.3, 3.4 and 3.5. The URI wet weather data, by sub-basin, are discussed below.

The URI data clearly show higher fecal coliform concentrations during wet weather events. The highest fecal coliform concentrations in the Hunt River basin were observed during WWS#2. According to Wright et al. (1999), these higher fecal coliform counts during WWS#2 may be more reflective of the low flow (low dilution) in the river in late summer (August 1997, total rainfall was 0.6 inches). In contrast, the lower concentrations in

WWS#1 are likely due to the high flows (high dilution) of the early spring (April 1996, total rainfall was 1.2 inches).

Table 3.2 Results from URI wet weather event (WWS#1). P= pre-storm sample. All data are in fc/100ml.

Station RUN (hrs)	SC01	HR01	HR02	FB01	HR03	HR04	HR05	HR06bp	SB01	HR07
	SC01	HR01	HR02	FB01	HR03	HR04	HR05	HR06bp	SB01	HR07
P	37	3	4	7	11	70	12	3	15	8
1										
2	61		1	16	14	24	27	6	22	11
3										
4	380	2	43	60		38	42	9	51	14
5										
6	380	26	<1	50	40	110		14	140	22
7										
8	240	55	14	260	100	7500	720	28	890	44
9						6200	970	50	670	140
10	280	80	32	210	220	1000	4700	68	1300	210
11						320	1800	520	1800	270
12	140	90	33	120	100					
14	70	110	70	41	50	90	200	810	180	1900

Table 3.3 Results from URI wet weather event (WWS#2). P= pre-storm sample. All data are in fc/100ml.

Station RUN (hrs)	SC01	HR01	HR02	FB01	HR03	HR04	HR05	HR06bp	SB01	HR07
P	890	100	20	19	91	82	12	3	15	8
1	9500	200	130	720	220	7300				
2	20000	860	130	1700	1400	1100	27	6	22	11
3	3200	3400	38	810	1400	2100				
4	11000	3100	43	470	540	8600	42	9	51	14
5	6200	5700	47	370	240	15000				
6	3500	5700	52	230	240	4600		14	140	22
7	1600	2600	100	400	140	3500				
8	1500	1100	280	180	97	940	720	28	890	44
9	4700	320	130	90	160	1100	970	50	670	140
10	1700	170	80	50	170	200	4700	68	1300	210

Table 3.4 Results from URI wet weather event (WWS#3). P= pre-storm sample. All data are in fc/100ml.

Station RUN	SC01	HR01	HR02	FB01	HR03	HR04	HR05	HR06bp	SB01	HR07
P	2300	35	32	9	16	20	23	7	36	64
1	960	30	26	10	20	95	32	3	25	51
2	2800	65	18	97	830	14000	1100	24	24	39
3	8700	200	19	610	430	1900	430	13	360	82
4	4000	1300	47	800	590	7500	4800	22	3100	460
5	3100	2000	41	710	490	2600	15000	40	2700	770
6	1100	2200	380	530	410	980	6600	130	1400	880
7	1500	1100	630	680	500	820	140	1150	2800	1600
8	510	140	0	220	300	440	510	960	220	310

Table 3.5 Results from URI wet weather event (WWS#4). P= pre-storm sample. All data are in fc/100ml.

Station RUN	SC01	HR01	HR02	FB01	HR03	HR04	HR05	HR06bp	SB01	HR07
P	1600	33	4	60	12	59	74	3	30	13
1	2400	54	1	170	43	6000	83	8	770	44
2	4000	100	5	130	95	230	340	13	1100	77
3	1200	330	5	51	36	2000	750	8	790	105
4	1800	310	4	37	21	3000	400	9	870	120
5	2800	330	5	260	150	2800	3700	9	1000	390
6	2200	470	22	220	110	9500	1500	45	3300	690
7	800	560	270	270	210	3100	3300	740	4700	810
8	850	3400	370	99	140	1200	3100	1800	3100	1600
9	870	120	320	77	120	230	580	1100	500	700
10	590	74	100	33	63	430	290	270	230	340
11	1200	61	65	23	29	100	320	170	110	180

Since wet weather pollutant concentrations are time varying, the concentration of fecal coliform for each run at every station was summarized as an Event Mean Concentration (EMC). The EMC is a weighted mean taking into consideration the concurrent river flow at the time each fecal coliform sample was taken. For this study, fecal coliform concentrations for each run were coupled with the flow value at that time. These values were summed and divided by the total flow for that station. The fecal coliform EMC's for the four wet weather surveys are shown in Figure 3.3. Figure 3.3 also shows the fecal coliform geometric means for all dry weather surveys for each station, allowing for comparison between wet weather events and dry (baseline) conditions.

As shown in Figure 3.3, the highest fecal coliform event mean concentrations were observed at the headwaters (SC01), mid river at HR04 and HR05, and in Sandhill Brook (SB01).

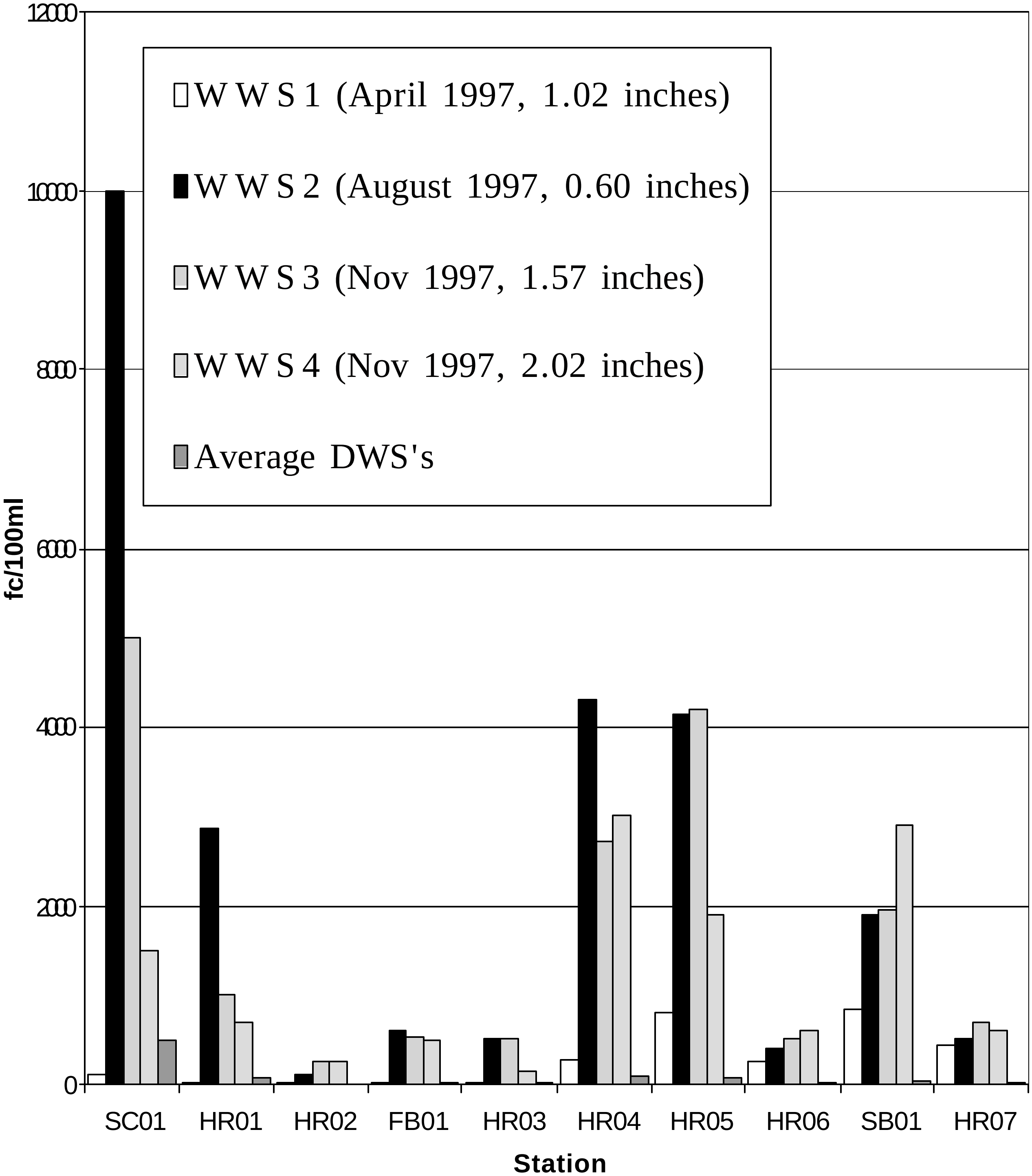


Figure 3.3 Fecal coliform EMC's for the 4 URI wet weather surveys.

Station HR02 is approximately 2000 yards downstream of station HR01. This segment of the Hunt River flows through an undisturbed wetland area. Wet weather fecal coliform concentrations show marked and consistent declines between stations HR01 and HR02 (from a geometric mean (for all storms) at HR01 of 233.0 fc/100ml to a geometric mean (for all storms) of 32.0 fc/100ml), indicating, in this case, the assimilative capacity of the wetland.

Wet weather data indicate a consistent and significant increase in fecal coliform concentrations between stations HR02 and HR03. This increase is likely due to inputs from Frenchtown Brook at FB01. The wet weather fecal coliform geomean increases from 32.0 fc/100ml at station HR02 to 122.0 fc/100ml at station HR03. The wet weather fecal coliform geomean at station FB01 was 126.0 fc/100ml. Wet weather data were not collected upstream of FB01.

The wet weather fecal coliform concentration geomean for station HR03 was 122.0 fc/100ml, increasing to a geomean of 844.0 fc/100ml at station HR04. These data implicate Fry Brook as a wet weather source of pathogens to this section of the Hunt River.

Wet weather fecal coliform concentrations decrease slightly between stations HR04 and HR05. Fecal coliform concentration geomeans decrease from 844.0 fc/100ml at HR04 to 710.0 fc/100ml at station HR05. Pierce Brook flows into the Hunt River approximately 600 yards downstream of HR04. No wet weather data were collected at station UB01 (Pierce Brook) and the available data, which show the decrease in fecal coliform concentrations, do not suggest that Pierce Brook has negative impacts on this section of the Hunt River.

Wet weather pathogen concentrations between HR05 and HR06 continue to decrease and data from HR06 show a fecal coliform concentration geomean of 62.0 fc/100ml. This represents an approximate 12-fold decrease in the fecal coliform geomeans between HR05 (710.0 fc/100ml) and HR06.

Wet weather pathogen concentrations increase again between HR06 and HR07. Sandhill Brook confluences with the Hunt River approximately 500 yards downstream of HR06. Wet weather fecal coliform geometric mean concentrations increase from 62 fc/100ml at HR06 to 178 fc/100ml at HR07. The wet weather fecal coliform geometric mean concentration at SB01 was 459 fc/100ml.

3.3 RIDEM Supplementary Monitoring (1999)

In 1999, RIDEM staff conducted supplemental monitoring in the Hunt River watershed to support the development of fecal coliform TMDLs for the Hunt River and Fry and Scrabbletown Brooks. This effort included ambient monitoring for fecal coliform at 34 sampling stations (Figure 3.4) located along the mainstem of the Hunt River and many of its tributaries. Dry weather samples were collected from three to eight times at each station during the spring, summer, and fall of 1999 (June 17, July 19, August 17, and Sept 14).

Wet weather samples were collected from 2 separate storms: Sept 30- Oct 1 and Oct 17-18, 1999. The following rainfall guidelines were used for the RIDEM wet weather study:

- Minimum rainfall total of 0.5 inches in a 24-hr period.
- Minimum rainfall duration of 5 hours

- Minimum antecedent dry period (ADP) of 3 days
- Minimum number of 2 post-storm days

These rainfall criteria are similar to those employed by the Narragansett Bay Commission and the Narragansett Bay Project in their recent efforts to quantify nonpoint source pollution to the Providence River. These rainfall criteria were also applied to EPA monitoring efforts on the Blackstone River. The rainfall figure of 0.5 inches is an assurance that there will be sufficient rainfall to cause a runoff event. The minimum duration of 5 hours rules out short, high-intensity rainfall events commonly associated with summer thunderstorms, and directs the storm collection to a more extensive storm system, making it somewhat easier to forecast and increasing the probability of capturing a successful storm. The 2-day post-storm criterion was used to prevent back to back storms and avoid the problem associated with the separation of multiple storm signals in the data.

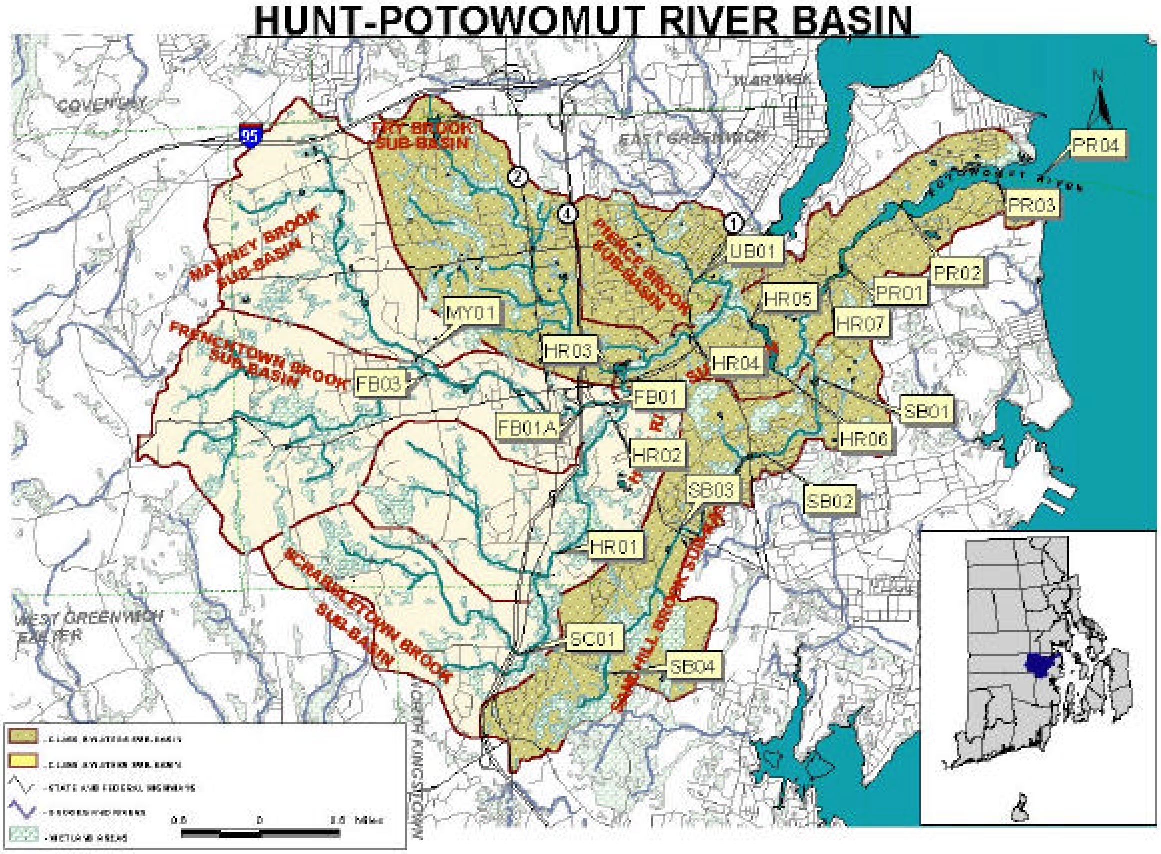


Figure 3.4. RIDEM Hunt River Watershed Sampling Locations (1999)

Dry Weather Data

The 1999 RIDEM dry weather fecal coliform concentrations were significantly higher than those taken during the 1996-1997 URI study at similar stations. The DEM monitoring in 1999 took place during severe drought conditions in southern New England. Reduced baseflow in streams was observed during these times of little or no precipitation. Lower baseflow levels may worsen water quality conditions, as the dilution capacity of the stream is limited when less water is in the channel. This situation may help to explain the differences in both the dry and wet weather bacteria data between 1996-1997 and 1999.

For the Hunt River watershed, high levels of fecal coliform bacteria were measured at several locations along the mainstem and tributaries. Results from the URI study indicated that there were no dry weather violations in Sandhill, Frenchtown, Pierce, or Mawney Brook, therefore these tributaries were not monitored during the 1999 monitoring. The RIDEM dry weather monitoring focused on Scrabbletown and Fry Brook, as well as the Hunt River headwaters and mainstem. The results of the RIDEM 1999 dry weather data are presented in Table 3.6. Included in this table are results from three preliminary site visits (PSV).

Seven stations in Scrabbletown Brook and tributaries were sampled for fecal coliform bacteria. With a few exceptions, measured fecal coliform concentrations were above the Class A criteria of 20 fc/100ml. As the summer progressed, and drought conditions worsened, measured fecal coliform concentrations either increased, or the stream section went dry. The highest fecal coliform concentrations in Scrabbletown Brook were measured at SC01. Measured concentrations ranged from 130 fc/100ml during PSV #1 to 5300 fc/100ml during dry weather survey #3. A large population of pigeons roost under the Route 4-Stony Lane overpass and deposit large amounts of fecal matter directly into the stream. This bacteria source is likely responsible for the elevated levels of bacteria measured downstream in the Hunt River (approx. 600 yards) at HR01.

Fecal coliform concentrations were measured at five locations in the Hunt River headwaters. Stations HRb and HRc had the lowest concentrations (15 fc/100ml and 4 and 3 fc/100ml, respectively). Station HRa, located downstream from a horse farm, had minimum and maximum fecal coliform concentrations of 45 and 380 fc/100ml, respectively, with a geometric mean of 128 fc/100ml. Station HRd had measured fecal coliform concentrations ranging from 37 to 130 fc/100ml, with a geometric mean value of 103 fc/100ml. Station HRe, the most downstream station in the Hunt River headwaters, had measured fecal coliform concentrations ranging from 14 to 110 fc/100ml, with a geometric mean value of 39 fc/100ml, only slightly above the Class A standard of 20 fc/100ml.

Dry weather fecal coliform concentrations at HR01 ranged from 130 to 810 fc/100ml with a geometric mean value of 217 fc/100ml. Fecal coliform concentrations were slightly lower at HR02, with a minimum and maximum value of 17 and 500 fc/100ml, respectively. The geometric mean value at HR02 was 51 fc/100ml. Further downstream at station HR03, fecal coliform concentrations ranged from 94 to 270 fc/100ml, with a geometric mean value of 127 fc/100ml. Frenchtown Brook confluences with the Hunt River between HR02 and HR03, however it was not sampled during dry weather by RIDEM. The fecal coliform geometric mean value at HR04 was 208 fc/100ml, with values ranging from 140 to 350 fc/100ml.

Fry Brook confluences with the Hunt River between stations HR03 and HR04 approximately 150 yards downstream of HR03. Station FRY03, located at the mouth of Fry Brook, had a fecal coliform geometric mean concentration of 1424 fc/100ml, with values ranging from 240 to 5800 fc/100ml. Dry weather data show that the measured increases between HR03 and HR04 are likely due to inputs from Fry Brook, as reflected by concentrations at FRY03. Field investigations in the Fry Brook watershed reveal both a golf course and a dairy farm in this sub-basin, as well as a large resident population of geese.

Fecal coliform concentrations at HR05 ranged from 230 to 400 fc/100ml, with a geometric mean value of 300 fc/100ml. Pierce Brook confluences with the Hunt River between stations HR04 and HR05, however it was not sampled during dry weather.

Wet Weather Data

Wet weather samples were collected from 2 separate storms: Sept 30- Oct 1 and Oct 17-18, 1999. Thirty stations in the Hunt River watershed were sampled during the first wet weather event and 29 were sampled during the second. Bacteria samples were collected from Frenchtown Brook, Scrabbletown Brook, Sandhill Brook, Pierce Brook, Fry Brook, and both the mainstem and headwaters of the Hunt River. RIDEM data clearly show higher fecal coliform concentrations in the Hunt River basin during wet weather events. The highest fecal coliform concentrations in the Hunt River basin were observed during the first wet weather event. This was likely due to lower baseflow conditions and less water in the channel to dilute the incoming stormwater runoff.

The RIDEM data show elevated wet weather concentrations of fecal coliform bacteria at all stations in the Hunt River watershed (Tables 3.6 and 3.7). Stormwater runoff represents a significant source of wet weather fecal coliform contamination in many areas of the watershed. Non-attainment of the state's fecal coliform standards, regardless of waterbody classification, was observed at all water quality stations during both wet weather events. Almost all of the stations were observed by RIDEM staff to be impacted by stormwater runoff. Figure 3.5 shows the relative source strengths, in geometric mean values, for mainstem stations and tributary mouth stations, for both wet weather events.

Table 3.6. Summary of RIDEM 1999 Dry Weather Data (All numbers are in fc/100ml).

WQ Station	Waterbody	Preliminary Site Visit #1 (5/21/99)	Preliminary Site Visit #2 (5/21/99)	Preliminary Site Visit #3 (5/21/99)	DW 1	DW 2	DW 3	DW 4
SCa	Scrabbletown Brook	14	22	34	90	270	91	130
SCb	Scrabbletown Brook	17	22	28	120	99	98	71
SCc	Scrabbletown Brook		2	Dry	100	Dry		Dry
SCd	Scrabbletown Brook	29	10	Dry	260	Dry		220
SCh	Scrabbletown Brook			660	550	330		Dry
SC01	Scrabbletown Brook	170	130	520	2500	1600	5300	1200
HRa	Hunt R. headwaters		45	60	380	Dry		260
HRb	Hunt R. headwaters		15	Dry		Dry		Dry
HRc	Hunt R. headwaters		4	3	450	Dry		Dry
HRd	Hunt R. headwaters		37	230	130	Dry		Dry
HRe	Hunt R. headwaters	14	20	41	22	37	110	53
HR01	Hunt R. mainstem				240	160	810	130
HR02	Hunt R. mainstem				32	17	500	26
HR03	Hunt R. mainstem				94	100	270	120
FRY01	Fry Brook				19	dry		160
FRY02	Fry Brook			52	15	74	620	130
FRY03	Fry Brook		4000	3300	5500	240	620	360
FRY04	Fry Brook			210	500	13000	12000	2700
FRY05	Fry Brook			210	200	47	Dry	280
HR04	Hunt R. mainstem				150	240	350	
HR05	Hunt R. mainstem				230	310	350	270

Table 3.7a RIDEM 1999 Data for Wet Weather Event # 1.

SAMPLE	COLLECTION DATE	COLLECTION TIME	ACTUAL SAMPLE TIME- HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
HR01-0	9/30/99	0751	0.0	70
HR01-2	9/30/99	1038	3.0	2,200
HR01-03	9/30/99	1141	4.0	1,300
HR01-04	9/30/99	1247	5.0	4,900
HR01-6	9/30/99	1510	7.0	14,000
HR01-12	9/30/99	1725	9.5	12,000
HR01-24	10/1/99	1129	27.5	1,800
HR02-0	9/30/99	0810	0.0	40
HR02-2	9/30/99	1020	3.0	100
HR02-4	9/30/99	1205	5.0	210
HR02-6	9/30/99	1515	7.0	110
HR02-12	9/30/99	1932	9.5	120
HR02-24	10/1/99	1124	27.5	710
HR03-0	9/30/99	0820	0.0	180
HR03-2	9/30/99	1023	3.0	2,800
HR03-4	9/30/99	1213	5.0	13,000
HR03-6	9/30/99	1427	7.0	3,000
HR03-12	9/30/99	1846	9.5	190
HR03-24	10/1/99	1050	27.5	1,100
HR04-0	9/30/99	0830	0.0	90
HR04-2	9/30/99	1040	3.0	21,000
HR04-4	9/30/99	1228	5.0	7,200
HR04-6	9/30/99	1500	7.0	8,000
HR04-12	9/30/99	1934	9.5	12,000
HR04-24	10/1/99	1129	27.5	670
HR05-0	9/30/99	0819	0.0	100
HR05-2	9/30/99	1035	3.0	11,000
HR05-4	9/30/99	1222	5.0	3,400
HR05-6	9/30/99	1455	7.0	18,000
HR05-12	9/30/99	1928	9.5	24,000
HR05-24	10/1/99	1122	27.5	2,900
SCa-0	9/30/99	0759	0.0	120
SCa-2	9/30/99	1015	3.0	200,000
SCa-03	9/30/99	1120	4.0	33,000
SCa-04	9/30/99	1228	5.0	40,000
SCa-6	9/30/99	1449	7.0	23,000
SCa-12	9/30/99	1709	9.5	6,100
SCa-24	10/1/99	1111	27.5	410
SCb-02	9/30/99	1020	3.0	52,000
SCb-03	9/30/99	1126	4.0	38,000
SCb-04	9/30/99	1229	5.0	69,000
SCb-6	9/30/99	1453	7.0	24,000
SCb-12	9/30/99	1712	9.5	4,400
SCb-24	10/1/99	1114	27.5	440

Table 3.7b RIDEM 1999 Data for Wet Weather Event # 1.

SAMPLE	COLLECTION DATE	COLLECTION TIME	ACTUAL SAMPLE TIME-HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
SCe-0	9/30/99	0803	0.0	37
SCe-02	9/30/99	1023	3.0	5,500
SCe-03	9/30/99	1120	4.0	30,000
SCe-04	9/30/99	1231	5.0	50,000
SCe-6	9/30/99	1455	7.0	14,000
SCe-12	9/30/99	1714	9.5	6,600
SCe-24	10/1/99	1117	27.5	350
SCc-03	9/30/99	1107	4.0	27,000
SCc-04	9/30/99	1212	5.0	11,000
SCc-6	9/30/99	1435	7.0	630
SCc-12	9/30/99	1734	9.5	200
SCd-0	9/30/99	0744	0.0	110
SCd-03	9/30/99	1110	4.0	7,600
SCd-04	9/30/99	1215	5.0	24,000
SCd-6	9/30/99	1440	7.0	7,200
SCd-12	9/30/99	1737	9.5	1,300
SCd-24	10/1/99	1101	27.5	1,500
SCh-03	9/30/99	1130	4.0	65,000
SCh-04	9/30/99	1234	5.0	27,000
SCh-6	9/30/99	1456	7.0	5,400
SCh-12	9/30/99	1700	9.5	8,700
SCh-24	10/1/99	1119	27.5	780
SC01-0	9/30/99	0810	0.0	690
SC01-2	9/30/99	1020	3.0	11,000
SC01-3	9/30/99	1133	4.0	45,000
SC01-04	9/30/99	1238	5.0	51,000
SC01-6	9/30/99	1500	7.0	27,000
SC01-12	9/30/99	1705	9.5	8,800
SC01-24	10/1/99	1123	27.5	1,400
HRe-0	9/30/99	0814	0.0	160
HRe-2	9/30/99	1035	3.0	12,000
HRe-3	9/30/99	1138	4.0	40,000
HRe-04	9/30/99	1242	5.0	260,000
HRe-6	9/30/99	1502	7.0	27,000
HRe-12	9/30/99	1748	9.5	9,500
HRe-24	10/1/99	1126	27.5	27
HRc-0	9/30/99	0736	0.0	70
HRc-03	9/30/99	1104	4.0	1,600
HRc-04	9/30/99	1208	5.0	8,900
HRc-6	9/30/99	1433	7.0	18,000
HRc-12	9/30/99	1741	9.5	1,400
HRa-0	9/30/99	0730	0.0	130
HRa-03	9/30/99	1100	4.0	320,000
HRa-04	9/30/99	1200	5.0	82,000
HRa-6	9/30/99	1429	7.0	12,000
HRa-12	9/30/99	1747	9.5	1,500
HRa-24	10/1/99	1051	27.5	400

Table 3.7c RIDEM 1999 Data for Wet Weather Event # 1.

SAMPLE	COLLECTION DATE	COLLECTION TIME	ACTUAL SAMPLE TIME-HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
HRd-03	9/30/99	1113	4.0	2,900
HRd-04	9/30/99	1220	5.0	1,500
HRd-6	9/30/99	1443	7.0	590
HRd-12	9/30/99	1731	9.5	270
HRd-24	10/1/99	1105	27.5	1,500
HRb-24	10/1/99	1055	27.5	170
SB01-0	9/30/99	0810	0.0	420
SB01-2	9/30/99	1028	3.0	6,200
SB01-4	9/30/99	1217	5.0	6,100
SB01-6	9/30/99	1449	7.0	31,000
SB01-12	9/30/99	1922	9.5	14,000
SB01-24	10/1/99	1115	27.5	2,100
SB1-0	9/30/99	0803	0.0	480
SB1-2	9/30/99	1022	3.0	7,800
SB1-4	9/30/99	1212	5.0	17,000
SB1-6	9/30/99	1444	7.0	> 20,000*
SB1-12	9/30/99	1917	9.5	13,000
SB1-24	10/1/99	1109	27.5	2,200
SB02-0	9/30/99	0749	0.0	130
SB02-2	9/30/99	1114	3.0	4,200
SB03-3	9/30/99	1003	4.0	20,000
SB02-6	9/30/99	1433	7.0	13,000
SB02-12	9/30/99	1907	9.5	5,500
SB02-24	10/1/99	1100	27.5	700
SB03-0	9/30/99	0734	0.0	180
SB03-3	9/30/99	1104	4.0	200
SB03-4	9/30/99	1204	5.0	560
SB03-6	9/30/99		7.0	300
SB03-12	9/30/99	1903	9.5	2,900
SB03-24	10/1/99	1049	27.5	2,100
FBc-0	9/30/99	0730	0.0	200
FBc-3	9/30/99	1118	4.0	29,000
FBc-3A	9/30/99	1116	4.0	3,600
FBc-3B	9/30/99	1115	4.0	24,000
FBc-6	9/30/99	1435	7.0	20,000
FBc-12	9/30/99	1858	9.5	5,500
FBc-24	10/1/99	1055	27.5	770
FBa-0	9/30/99	0752	0.0	70
FBa-3	9/30/99	1133	4.0	600
FBa-6	9/30/99	1500	7.0	17,000
FBa-12	9/30/99	1920	9.5	1,500
FBa-24	10/1/99	1110	27.5	940
FB01-0	9/30/99	0815	0.0	60
FB01-2	9/30/99	1025	3.0	8,900
FB01-4	9/30/99	1215	5.0	8,900
FB01-6	9/30/99	1525	7.0	2,500
FB01-12	9/30/99	1941	9.5	3,300
FB01-24	10/1/99	1130	27.5	1,500

Table 3.7d RIDEM 1999 Data for Wet Weather Event # 1.

SAMPLE	COLLECTION DATE	COLLECTION TIME	ACTUAL SAMPLE TIME- HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
FB01A-0	9/30/99	0758	0.0	40
FB01A-3	9/30/99	1135	4.0	4,400
FB01A-6	9/30/99	1508	7.0	5,900
FB01A-12	9/30/99	1925	9.5	4,500
FB01A-24	10/1/99	1116	27.5	1,100
FB03-0	9/30/99	0740	0.0	150
FB03-3	9/30/99	1125	4.0	160,000
FB03-6	9/30/99	1447	7.0	24,000
FB03-12	9/30/99	1910	9.5	7,700
FB03-24	10/1/99	1105	27.5	610
FRY01-0	9/30/99	0750	0.0	40
FRY01-3	9/30/99	1047	4.0	1,800
FRY01-6	9/30/99	1452	7.0	2,700
FRY01-12	9/30/99	1907	9.5	420
FRY01-24	10/1/99	1113	27.5	70
FRY02-0	9/30/99	0804	0.0	80
FRY02-3	9/30/99	1058	4.0	21,000
FRY02-6	9/30/99	1502	7.0	18,000
FRY02-12	9/30/99	1920	9.5	5,900
FRY02-24	10/1/99	1127	27.5	430
FRY03-0	9/30/99	0729	0.0	1,100
FRY03-2	9/30/99	1003	3.0	4,900
FRY03-4	9/30/99	1200	5.0	240,000
FRY03-6	9/30/99	1436	7.0	66,000
FRY03-12	9/30/99	1853	9.5	39,000
FRY03-24	10/1/99	1100	27.5	3,400
FRY04-0	9/30/99	0810	0.0	2,200
FRY04-3	9/30/99	1104	4.0	450,000
FRY04-6	9/30/99	1504	7.0	20,000
FRY04-12	9/30/99	1924	9.5	14,000
FRY04-24	10/1/99	1130	27.5	3,500
FRY05-0	9/30/99	0814	0.0	1,400
FRY05-3	9/30/99	1115	4.0	13,000
FRY05-6	9/30/99	1508	7.0	2,100
FRY05-12dup	9/30/99	1927	9.5	920
FRY05-24	10/1/99	1132	27.5	670

Table 3.8a RIDEM 1999 Data for Wet Weather Event #2.

SAMPLE NO	COLLECTION DATE	DESIGNATED SAMPLE TIME	ACTUAL SAMPLE TIME- HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
HR01-0	10/17/99	2041	0	41
HR01-2	10/18/99	111	4	100
HR01-4	10/18/99	726	10	1,300
HR01-6	10/18/99	1057	14	1,200
HR01-12	10/18/99	1451	18	1,100
HR01-24	10/19/99	1336	41	230
HR02-0	10/17/99	2034	0	14
HR02-2	10/18/99	0042	4	7
HR02-4	10/18/99	0723	10	19
HR02-6	10/18/99	1114	14	30
HR02-12	10/18/99	1438	18	80
HR02-24	10/19/99	1413	41	150
HR03-0	10/17/99	2033	0	36
HR03-2	10/18/99	0053	4	400
HR03-4	10/18/99	0706	10	1,100
HR03-6	10/18/99	1041	14	510
HR03-12	10/18/99	1427	18	500
HR03-24	10/19/99	1327	41	100
HR04-0	10/17/99	2025	0	50
HR04-2	10/18/99	0045	4	4,000
HR04-4	10/18/99	0659	10	32,000
HR04-6	10/18/99	1033	14	13,000
HR04-12	10/18/99	1422	18	4,600
HR04-24	10/19/99	1323	41	240
HR05-0	10/17/99	2006	0	71
HR05-2	10/18/99	0030	4	110
HR05-4	10/18/99	0647	10	2,600
HR05-6	10/18/99	1022	14	38,000
HR05-12	10/18/99	1412	18	7,700
HR05-24	10/19/99	1312	41	430
SCa-0	10/17/99	2024	0	25
SCa-2	10/18/99	0055	4	450
SCa-4	10/18/99	0712	10	1,500
SCa-6	10/18/99	1035	14	630
SCa-12	10/18/99	1436	18	280
SCa-24	10/19/99	1315	41	110
SCb-0	10/17/99	2026	0	23
SCb-2	10/18/99	0058	4	340
SCb-4	10/18/99	0715	10	1,600
SCb-6	10/18/99	1035	14	580
SCb-12	10/18/99	1439	18	170
SCb-24	10/19/99	1317	41	120
SCc-0	10/17/99	2012	0	25
SCc-2	10/18/99	0040	4	7,000
SCc-2upstream	10/18/99	0039	4	14,000
SCc-6	10/18/99	1046	14	1,200
SCc-12	10/18/99	1420	18	470
SCc-24	10/19/99	1323	41	31

Table 3.8b RIDEM 1999 Data for Wet Weather Event #2.

SAMPLE NO	COLLECTION DATE	DESIGNATED SAMPLE TIME	ACTUAL SAMPLE TIME-HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
SCd-0	10/17/99	2016	0	24
SCd-2	10/18/99	0043	4	110
SCd-2upstream	10/18/99	0044	4	140
SCd-4	10/18/99	0700	10	570
SCd-6	10/18/99	1044	14	2,300
SCd-12	10/18/99	1424	18	1,800
SCd-24	10/19/99	1321	41	230
SCh-0	10/17/99	2020	0	1,200
SCh-2	10/18/99	0100	4	5,300
SCh-4	10/18/99	0717	10	3,200
SCh-6	10/18/99	1031	14	2,000
SCh-12	10/18/99	1440	18	710
SCh-24	10/19/99	1309	41	62
SC01-0	10/17/99	2033	0	140
SC01-2	10/18/99	0103	4	2,200
SC01-4	10/18/99	0719	10	2,100
SC01-6	10/18/99	1033	14	760
SC01-12	10/18/99	1442	18	400
SC01-24	10/19/99	1312	41	160
SB01-0	10/17/99	2048	0	340
SB01-2	10/18/99	0109	4	1,400
SB01-4	10/18/99	0744	10	8,600
SB01-6	10/18/99	1122	14	5,200
SB01-12	10/18/99	1455	18	7,100
SB01-24	10/19/99	1357	41	300
SB1-0	10/17/99	2052	0	150
SB1-2	10/18/99	0101	4	1,500
SB1-2RR	10/18/99	0104	4	5,800
SB1-4	10/18/99	0748	10	3,900
SB1-6	10/18/99	1119	14	7500
SB1-6	10/18/99	1119	14	6,900
SB1-12	10/18/99	1452	18	2,800
SB1-24	10/19/99	1354	41	360
SB02-0	10/17/99	2100	0	340
SB02-2	10/18/99	0054	4	330
SB02-4	10/18/99	0738	10	3400
SB02-6	10/18/99	1115	14	3,700
SB02-12	10/18/99	1447	18	1,900
SB02-24	10/19/99	1349	41	250
SB03-0	10/17/99	2106	0	20
SB03-2	10/18/99	0048	4	110
SB03-4	10/18/99	0733	10	1,600
SB03-6	10/18/99	1109	14	3,200
SB03-12	10/18/99	1442	18	2,000
SB03-24	10/19/99	1343	41	250

Table 3.8c RIDEM 1999 Data for Wet Weather Event #2.

SAMPLE NO	COLLECTION DATE	DESIGNATED SAMPLE TIME	ACTUAL SAMPLE TIME- HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
FBc-0	10/17/99	2002	0	60
FBc-2	10/18/99	0105	4	24
FBc-2stormpipe	10/18/99	0045	4	15
FBc-4	10/18/99	0652	10	2,800
FBc-6upstream	10/18/99	1035	14	2,100
FBc-12	10/18/99	1416	18	1,300
FBc-24	10/19/99	1355	41	320
FBa-0	10/17/99	2018	0	60
FBa-2	10/18/99	0120	4	24
FBa-4	10/18/99	0709	10	1,800
FBa-6	10/18/99	1100	14	670
FBa-12	10/18/99	1426	18	400
FBa-24	10/19/99	1300	41	360
FB01-0	10/17/99	2028	0	24
FB01-2	10/18/99	0034	4	130
FB01-4	10/18/99	0721	10	1,500
FB01-6	10/18/99	1125	14	610
FB01-12	10/18/99	1433	18	380
FB01-24	10/19/99	1410	41	130
FB01A-0	10/17/99	2021	0	26
FB01A-2	10/18/99	0125	4	150
FB01A-4	10/18/99	0710	10	1,400
FB01A-6	10/18/99	1106	14	570
FB01A-12	10/18/99	1428	18	480
FB01A-24	10/19/99	1304	41	200
FB03-0	10/17/99	2008	0	25
FB03-2upstream	10/18/99	0105	4	85
FB03-2	10/18/99	0105	4	130
FB03-4	10/18/99	0703	10	1,600
FB03-6upstream	10/18/99	1045	14	2,100
FB03-6	10/18/99	1050	14	1500
FB03-12	10/18/99	1421	18	1000
FB03-24	10/19/99	1400	41	250
FRY02-0	10/17/99	2055	0	80
FRY02-2	10/18/99	0118	4	1000
FRY02-4	10/18/99	0724	10	2700
FRY02-6	10/18/99	1058	14	2000
FRY02-12	10/18/99	1443	18	940
FRY02-24	10/19/99	1345	41	78
FRY03-0	10/17/99	2041	0	2400
FRY03-2	10/18/99	0103	4	8600
FRY03-4	10/18/99	0716	10	33000
FRY03-6	10/18/99	1048	14	13000
FRY03-12	10/18/99	1433	18	12000
FRY03-24	10/19/99	1335	41	1600

Table 3.8d RIDEM 1999 Data for Wet Weather Event #2.

SAMPLE NO	COLLECTION DATE	DESIGNATED SAMPLE TIME	ACTUAL SAMPLE TIME- HOURS AFTER PS SAMPLE	FECAL COLIFORM PER 100 ml
FRY04-0	10/17/99	2100	0	300
FRY04-2	10/18/99	0121	4	4300
FRY04-4	10/18/99	0728	10	7200
FRY04-6	10/18/99	1100	14	1400
FRY04-12	10/18/99	1445	18	560
FRY04-24	10/19/99	1346	41	150
FRY05-0	10/17/99	2104	0	1600
FRY05-2	10/18/99	0125	4	7300
FRY05-4	10/18/99	0731	10	5100
FRY05-6	10/18/99	1103	14	920
FRY05-12	10/18/99	1448	18	630
FRY05-24	10/19/99	1349	41	250
UB01-0	10/17/99	2127	0	260
UB01-2	10/18/99	0040	4	3300
UB01-4	10/18/99	0654	10	15000
UB01-6	10/18/99	1027	14	8300
UB01-12	10/18/99	1418	18	5500
UB01-24	10/19/99	1338	41	910
HRa-0	10/17/99	2002	0	80
HRa-2	10/18/99	0030	4	1500
HRa-4	10/18/99	0649	10	80000
HRa-6	10/18/99	1049	14	3800
HRa-12	10/18/99	1415	18	820
HRa-24	10/19/99	1327	41	180
HRc-0	10/17/99	2006	0	30
HRc-2	10/18/99	1235	4	130
HRc-4	10/18/99	0652	10	1300
HRc-6	10/18/99	1052	14	1600
HRc-12	10/18/99	1417	18	640
HRc-24	10/19/99	1330	41	140
HRd-0	10/17/99		0	
HRd-2	10/18/99	0050	4	38
HRd-4	10/18/99	0701	10	480
HRd-6	10/18/99	1056	14	1700
HRd-12	10/18/99	1422	18	1600
HRd-24	10/19/99	1325	41	260
HRe-0upstream	10/17/99	2020	0	33
HRe-0	10/17/99	2037	0	32
HRe-2upstream	10/18/99	0107	04	150
HRe-2	10/18/99	0106	04	225
HRe-4upstream	10/18/99	0709	10	3700
HRe-4	10/18/99	0724	10	2400
HRe-6	10/18/99	1025	14	630
HRe-12	10/18/99	1449	18	240
HRe-24	10/19/99	1306	41	180

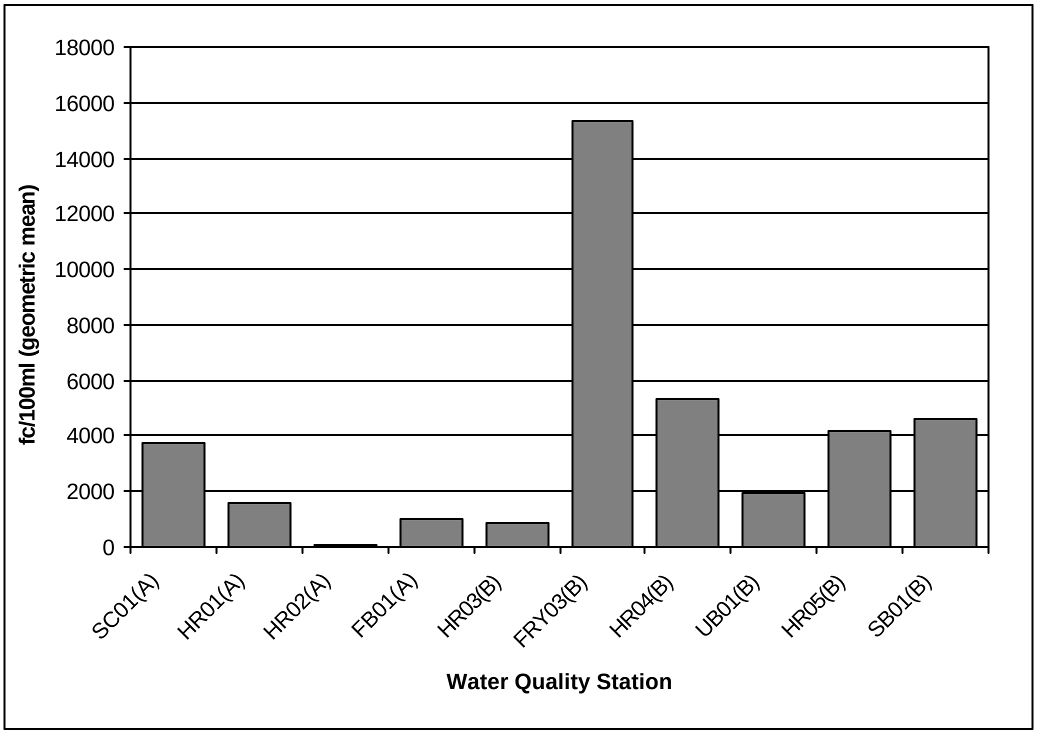


Figure 3.5 Relative Source Strengths for selected stations for RIDEM 1999 Wet Weather Survey.

4.0 WATER QUALITY CHARACTERIZATION

The database used for this TMDL utilizes over 1,400 fecal coliform samples collected by both RIDEM (1999) and URI (1996-1997). Both dry and wet weather data were used to characterize water quality conditions in the Hunt River watershed. Dry weather data was used to assess steady state conditions when the waters are most likely to be utilized for the designated uses of primary and secondary recreational activities. Wet weather data were used primarily to assess worst case conditions and to help locate nonpoint source pollution hot spots in the watershed.

Given that the conditions were so different during the monitoring periods (i.e., there was a severe drought in 1999), the dry and wet weather data collected from the URI and RIDEM studies are evaluated independently below. The data sets were then combined to assess compliance with the water quality standards, as described below.

In order to determine compliance with the geometric mean portion of the criteria, a "weighted average" geometric mean was established for each station. To assess compliance with the percent exceedence part of the criteria, a 80^{th} or 90^{th} percentile value was calculated, depending on whether the waterbody was delineated as Class A or Class B, respectively, at that given station. Both of these approaches are described below.

4.1 Dry Weather Characterization

It should be noted that the RIDEM monitoring in 1999 took place during severe drought conditions in southern New England. Reduced baseflow in streams may be observed during these times of little or no precipitation. Lower baseflow levels may worsen water quality conditions, as the dilution capacity of the stream is limited when less water is in the channel. This situation may help to explain the differences in both the dry and wet weather bacteria data between 1996-1997 and 1999.

URI Water Quality Study (1996-1997)

University of Rhode Island (URI) researchers completed six dry-weather surveys and two wet-weather water quality surveys in the Hunt River watershed during 1996-1997. A total of 17 water quality monitoring stations (Figure 2.1) were sampled in the Hunt River watershed during dry weather conditions. Only 2 of the 21 stations had dry weather fecal coliform geometric mean values that exceeded the class specific criteria for that waterbody (Table 4.1). Elevated dry weather fecal coliform levels were found in Scrabbletown Brook and downstream in the Hunt River.

RIDEM Supplementary Monitoring (1999)

The most recent assessment of the Hunt River basin (RIDEM 1999) included ambient monitoring for fecal coliform bacteria at a total of 34 sampling stations located along the mainstem of the Hunt River and many of its tributaries (Figure 3.4). Each station was sampled from three to eight times during dry weather in spring, summer, and fall of 1999.

The 1999 assessment found that most of the Hunt River and its tributaries do not fully support the designated uses for either Class A or Class B waterbodies during dry weather conditions (Table 4.2). Data are summarized below for the mainstem Hunt River stations and tributary stations.

Table 4.1 Summary of URI (1996-1997) Dry Weather Data.

Station	Waterbody	No. of samples	Minimum value	Maximum value	Geometric Mean
HR01	Hunt River [a]	28	3	130	38*
HR02	Hunt River [a]	28	2	90	14
HR03	Hunt River [b]	8	8	450	76
HR04	Hunt River [b]	28	1	410	16
HR05	Hunt River [b]	28	15	250	81
HR06	Hunt River [b]	25	5	63	19
HR07	Hunt River [b]	28	17	220	48
SB01	Sandhill Brook [b]	28	38	400	84
SB02	Sandhill Brook [b]	28	15	690	75
SB03	Sandhill Brook [b]	26	1	140	21
SB04	Sandhill Brook [b]	28	5	780	58
SC01	Scrabbletown Brook [a]	28	25	1000	258*
FB01	Frenchtown Brook [a]	30	1	84	18
FB03	Frenchtown Brook [a]	28	1	100	14
FB04	Frenchtown Brook [a]	23	1	48	6
MY01	Mawney Brook [a]	28	1	40	7
UB01	Pierce Brook [b]	24	1	830	128

[a] *denotes Class A waterbody where geometric mean value must not exceed 20 fc/100ml.*
[b] *denotes Class B waterbody where geometric mean value must not exceed 200 fc/100ml.*
** Indicates violation of criteria for fecal coliform bacteria at that station.*

Table 4.2 Summary of RIDEM 1999 Dry Weather Data.

Station	Waterbody	No. of samples	Minimum value	Maximum value	Geometric mean
SC01	Scrabbletown Brook [a]	9	170	5300	778*
HRe	H. R. headwaters [a]	10	14	110	39*
HR01	H.R. mainstem [a]	7	41	810	146*
HR02	H.R. mainstem [a]	6	14	500	40*
FB01	Frenchtown Brook [a]	-	-	-	
HR03	H.R. mainstem [b]	7	36	270	112*
FRY03	Fry Brook [b]	8	240	5800	1424*
HR04	H.R. mainstem [b]	6	50	350	143*
UB01	Pierce Brook [b]	-	-	-	
HR05	H.R. mainstem [b]	9	71	400	227*
SB01	Sandhill Brook [b]	-	-	-	

[a] *denotes Class A waterbody where geometric mean value must not exceed 20 fc/100ml.*
[b] *denotes Class B waterbody where geometric mean value must not exceed 200 fc/100ml.*

- *Indicates violation of criteria for fecal coliform bacteria at that station.*

4.2 Wet Weather Characterization

URI Water Quality Study (1996-1997)

Four wet weather events were monitored: April 12-13, 1997 (WWS#1), August 13-15, 1997 (WWS#2), November 7-10, 1997 (WWS#3), and November 7-10, 1997 (WWS#4). The total rainfall and duration for each storm was 1.02 inches/12 hrs, 0.60 inches/4 hrs, 1.56 inches/28 hrs, and 2.02 inches/24 hrs, respectively. A total of 10-water quality monitoring stations were sampled for fecal coliform during wet weather conditions. Seven of the 10 stations had wet weather fecal coliform geometric mean values that exceeded the class specific criteria for that waterbody (Table 4.3). The URI wet weather data show elevated levels of fecal coliform bacteria in Scrabbletown Brook, Frenchtown Brook, and Sandhill Brook. The elevated wet weather concentrations of fecal coliform bacteria measured in the Hunt River likely reflect inputs from the tributaries.

Table 4.3 Summary of URI (1996-1997) Wet Weather Data.

Station	Waterbody	No. of samples	Minimum value	Maximum value	Geometric mean
HR01	Hunt River [a]	39	2	5700	233*
HR02	Hunt River [a]	39	1	630	32*
HR03	Hunt River [b]	39	11	1400	122*
HR04	Hunt River [b]	41	20	15000	843*
HR05	Hunt River [b]	40	12	15000	710*
HR06	Hunt River [b]	41	3	1800	62
HR07	Hunt River [b]	41	8	1900	178*
SC01	Scrabbletown Brook [b]	36	61	20000	1406*
FB01	Frenchtown Brook [b]	40	7	1700	126*
SB01	Sandhill Brook [b]	41	15	4700	459*

[a] *denotes Class A waterbody where geometric mean value must not exceed 20 fc/100ml.*
[b] *denotes Class B waterbody where geometric mean value must not exceed 200 fc/100ml.*
* *Indicates violation of criteria for fecal coliform bacteria.*

RIDEM Supplementary Monitoring (1999)

Wet weather samples were collected from 2 separate storms: Sept 30- Oct 1, 1999 and Oct 17th-18th, 1999. The 1999 assessment found that most of the Hunt River and its tributaries do not fully support the designated uses for either Class A or Class B waterbodies during wet weather conditions (Table 4.4). Data are summarized below for the mainstem Hunt River stations and tributary stations.

Stormwater runoff represents a significant source of wet weather fecal coliform contamination in many areas of the watershed. The negative impact of stormwater runoff on water quality in the Hunt River watershed is unquestionable. Non-attainment of the state's fecal coliform standards, regardless of waterbody classification, was observed at all 34 water quality stations during both wet weather events. Of these 34 stations, 32 were observed to be impacted by stormwater runoff.

Table 4.4 Summary of RIDEM 1999 Wet Weather Data.

Station	Waterbody	No. of samples	Minimum value	Maximum value	Geometric Mean
SC01	Scrabbletown Brook [a]	11	160	51000	3720*
HRe	H. R. headwaters [a]	12	32	260000	2361*
HR01	H.R. mainstem [a]	11	100	14000	1593*
HR02	H.R. mainstem [a]	10	7	710	79*
FB01	Frenchtown Brook [a]	10	130	8900	1300*
HR03	H.R. mainstem [b]	10	100	13000	873*
FRY03	Fry Brook [b]	10	1600	240000	15356*
HR04	H.R. mainstem [b]	10	240	32000	5311*
UB01	Pierce Brook [b]	5	910	15000	1944*
HR05	H.R. mainstem [b]	10	110	38000	4195*
SB01	Sandhill Brook [b]	10	300	31000	4637*

[a] denotes Class A waterbody.

[b] denotes Class B waterbody.

** Indicates violation of criteria for fecal coliform bacteria.*

4.3 Weighted Average Approach

In order to develop an overall assessment of water quality conditions in the watershed, the dry and wet weather data sets from both the URI and RIDEM studies were combined. RIDEM developed an approach to completing this assessment by combining all the data in the form of a "weighted average" based on the percentage of wet and dry days that occur, annually, in the watershed. The approach also incorporates the time needed for the stream to return to steady state conditions after a rain event. Current bacterial conditions in the Hunt River were determined based on this "weighted average" approach.

The weighted average calculation incorporates the probability of occurrence of both dry and wet weather conditions to calculate a weighted average geometric mean value representative of the frequency of occurrence of wet and dry weather conditions in the watershed. The weighted average is compared to the water quality standard to determine if water quality standards are violated. Percent reductions needed at each water quality station were based on the weighted average value, calculated from the following equation:

Weighted Avg. Geomean (for each WQ station) = (% of dry weather days) x (Dry weather geomean) + (% of wet weather days) x (Wet weather geomean)

Initially, the amount of precipitation needed to produce runoff in the watershed was determined. Any precipitation event in the watershed that produces runoff was considered to be a "wet" weather condition. Based on data collected in the Hunt River basin, runoff from a 0.20-inch precipitation event can be expected. This number was calculated by comparing in-stream fecal coliform concentrations, hourly precipitation data, and discharges from 4 wet weather events (2 RIDEM events and 2 URI events) monitored in the watershed. For all 4 wet weather events, cumulative precipitation was plotted against fecal coliform concentrations and in-stream flows. In all cases, for precipitation amounts of approximately 0.20 inches of rainfall, flows have risen (based on stage readings) and fecal coliform concentrations have increased at least an order of magnitude (sometimes 2 orders of magnitude). The data for both wet weather events sampled by RIDEM in 1999 are given in Table 4.5. The URI wet weather data are shown at the end of this document in Appendix A. Although runoff was observed to occur from precipitation events of less than 0.20 inches, the amount of runoff was considered insignificant and impacts to water quality in the system are unlikely.

The frequency of occurrence of precipitation events on an annual basis was determined using 15 years of rainfall data from T.F. Green Airport (Warwick, RI). The frequency of occurrence was determined for rainfall events greater than or equal to 0.10, 0.15, 0.20, 0.25, and 0.3 inches of rainfall in a 24-hr period (Figure 4.1). Upon examination of meteorological data recorded at T.F. Green Airport over the past 15 years, it was determined that wet weather days, as determined above, occur 17.8% percent of the time, and dry weather days occur 82.2% percent of the time. This means that annually, wet weather conditions dominate the watershed approximately 17.8% of the time.

The overall percentage of wet weather days was adjusted to include recovery time (time required for the in-stream fecal coliform concentrations to return to either pre-storm levels or the Class A criteria of 20 fc/100ml or the Class B criteria of 200 fc/100ml). For all stations, fecal coliform concentrations were plotted against time and fitted to an exponential decay equation. Extrapolation from the decay equations was used to estimate the amount of time needed for fecal coliform concentrations at each station to drop to either the pre-storm values or the Class A or Class B standards for fecal coliform. The calculated decay equations and approximate times to recovery for both RIDEM and URI wet weather events are shown in Table 4.6. It was not necessary to compute decay equations for the URI wet weather data because sampling continued until fecal coliform concentrations dropped to acceptable levels.

Analysis of wet weather data for the Hunt River watershed show that an additional day is required for in-stream fecal coliform concentrations to drop to either pre-storm levels or the Class A criteria of 20 fc/100ml or the Class B criteria of 200 fc/100ml. For an additional day of recovery needed, the percentage was doubled, making the percent of wet weather days equal to 35.6% (17.8% X 2). This takes into consideration wet weather bacteria violations not only for the day of the storm but also for the additional day it takes for the system to recover. Therefore, the percent of dry weather days is 64.4%.

A weighted average calculation for the Hunt River, as determined from the information above, is shown below:

Weighted Avg. Geomean (for each WQ station) = (0.356) X (Wet weather geomean) + (0.644) X (Dry weather geomean)

The results of this calculation are shown in Table 4.7. Once computed, the weighted average geomean can compared to the geometric mean portion of the fecal coliform standard to determine whether that portion of the water quality standard for fecal coliform bacteria is violated.

Table 4.5 RIDEM 1999 hydrologic, bacteria, and rainfall data.

RIDEM 1999 1st Wet Weather Event

HRe

hour	stage	FC/100ml	hour	rainfall (in)
0	0.76	160	0	0
3	1.07	12000	0.5	0.21
4	1.13	40000	1	0.31
5	1.03	260000	1.5	0.31
7	0.9	27000	2	0.32
9.5	0.86	9500	2.5	0.42
27.5	0.81	27	3	0.56

FRY03

hour	stage	FC/100ml	hour	rainfall (in)
0	0.6	1100	0	0
3	0.68	4900	0.5	0.21
5	1.1	240000	1	0.31
7	1.08	66000	1.5	0.31
9.5	0.96	39000	2	0.32
27.5	0.74	3400	2.5	0.42
			3	0.56

HR02

hour	stage	FC/100ml	hour	rainfall (in)
0	7.5	40	0	0
3	7.55	100	0.5	0.21
5	7.66	210	1	0.31
7	7.68	110	1.5	0.31
9.5	7.68	120	2	0.32
27.5	7.68	710	2.5	0.42
			3	0.56

SC01

hour	stage	FC/100ml	hour	rainfall (in)
0	0.81	690	0	0
3	1.32	11000	0.5	0.21
4	1.09	45000	1	0.31
5	1.01	51000	1.5	0.31
7	0.89	27000	2	0.32
9.5	0.94	8800	2.5	0.42
27.5	0.86	1400	3	0.56

FB01

hour	stage	FC/100ml	hour	rainfall (in)
0	7.7	60	1	0.31
3	7.88	8900	2	0.32
5	8.06	8900	3	0.56
7	7.92	2500		
9.5	7.92	3300		
27.5	7.9	1500		

RIDEM 1999 2nd Wet Weather Event

HRe

hour	stage	FC/100ml	hour	rainfall (in)
0	0.98	32	0	0
4	1	225	0.5	0.12
10	1.22	2400	1	0.15
14	1.23	630	1.5	0.16
18	1.15	240	2	0.31
41	1.08	180	2.5	0.41
			3	0.42
			3.5	0.45
			4	0.52
			4.5	0.59
			5	0.69
			5.5	0.79
			6	0.84
			6.5	0.87
			7	0.94
			7.5	1.03
			8	1.16
			8.5	1.32
			9	1.51
			9.5	1.62
			10	1.68

FRY03

hour	stage	FC/100ml	hour	rainfall (in)
0	0.84	2400	0	0
4	0.88	8600	0.5	0.12
10	1.4	33000	1	0.15
14	1.24	13000	1.5	0.16
18	1.2	12000	2	0.31
41	0.94	1600	2.5	0.41
			3	0.42
			3.5	0.45
			4	0.52
			4.5	0.59
			5	0.69
			5.5	0.79
			6	0.84
			6.5	0.87
			7	0.94
			7.5	1.03
			8	1.16
			8.5	1.32
			9	1.51
			9.5	1.62
			10	1.68

HR02

hour	stage	FC/100ml	hour	rainfall (in)
0		14	0	0.15
4		7	1	0.31
10		19	2	0.42
14		30	3	0.52
18		80	4	0.69
41		150	5	0.84
			6	0.94
			7	1.16
			8	1.51
			9	1.68
			10	

SC01

hour	stage	FC/100ml	hour	rainfall (in)
0	0.81	140	0	0
4	1.06	2200	0.5	0.12
10	1.26	2100	1	0.15
14	1.24	760	1.5	0.16
18	1.24	400	2	0.31
41	0.91	160	2.5	0.41
			3	0.42
			3.5	0.45
			4	0.52
			4.5	0.59
			5	0.69
			5.5	0.79
			6	0.84
			6.5	0.87
			7	0.94

FB01

hour	stage	FC/100ml	hour	rainfall (in)
0	0.779	24	1	0.15
4	0.79	130	2	0.31
10	0.835	1500	3	0.42
14	0.828	610	4	0.52
18	0.828	380	5	0.69
41	0.81	130	6	0.84
			7	0.94
			8	1.16
			9	1.51
			10	1.68

Table 4.6 Summary of calculated decay equations and approximate time to recovery for 4 (2 URI and 2 RIDEM) wet weather events.

Station	Class	WW1(DEM) Calculated decay equation	WW1(DEM) approx. time to recovery (days)	URI(WW1) approx. time to Recovery (days)	WW2(DEM) Calculated decay equation	WW2(DEM) approx. time to recovery (days)	URI(WW2) approx. time to recovery (days)
FRY01	B	y=1081.3e^ -0.0995x	1		recovery w/out extrapolation	2	
FRY02	B	y=23504e^0.1455x	1.5		recovery w/out extrapolation	2	
FRY03	B	y=5430.7e^-0.0493x	3		recovery w/out extrapolation	2	
FRY04	B	y=33089e^-0.082x	1.5		recovery w/out extrapolation	2	
FRY05	B	recovery w/out extrapolation	1		recovery w/out extrapolation	2	
HRa	A	y=3013.4e^-0.0734x	2		recovery w/out extrapolation	2	
HRe	A	recovery w/out extrapolation	1		y=701.06e^-0.0348x	3.5	
HR01	A	y=29981e^-0.102x	2.5		y=3743.7e^ -0.068x	3	2
HR02	A	FC still climbing			FC still climbing		2
HR03	B	not enough data		2	y=1761.9e^ 0.07x	2	2
HR04	B	y=55023e^-0.1603x	2	2	recovery w/out extrapolation	2	2
HR05	B	y=73217e^ -0.1174x	2.5	3	y=73641e^ -0.1254x	2	2
SCc	A	y=927054e^ -0.9296x	0.5		recovery w/out extrapolation	2	
SCh	A	not enough data			not enough data		
SC01	A	y=45727e^-0.1207x	2	2	y=819.39e^-0.0398x	2	3
SB01	B	y=38104e^ 0.1054x	2	2	recovery w/out extrapolation	2	2.5
SB1	B	y=38345e^ -0.1043x	2		y=13943e^ 0.892x	2	
SB03	B	not enough data			not enough data		
SB02	B	y=25584e ^0.1321x	2		recovery w/out extrapolation	2	
FB01	A	y=5003.1e^-0.0438x	4	3	y=879.74e^-0.0466x	3	2
FBc	A	y=15524e^ -0.1092x	2		recovery w/out extrapolation	2	
FB03	A	y=29353e^ -0.1409x	2		y=3445.4e^ -0.0643x	3	
		AVERAGE =	**2**	**2.3**	**AVERAGE =**	**2.2**	**2.2**

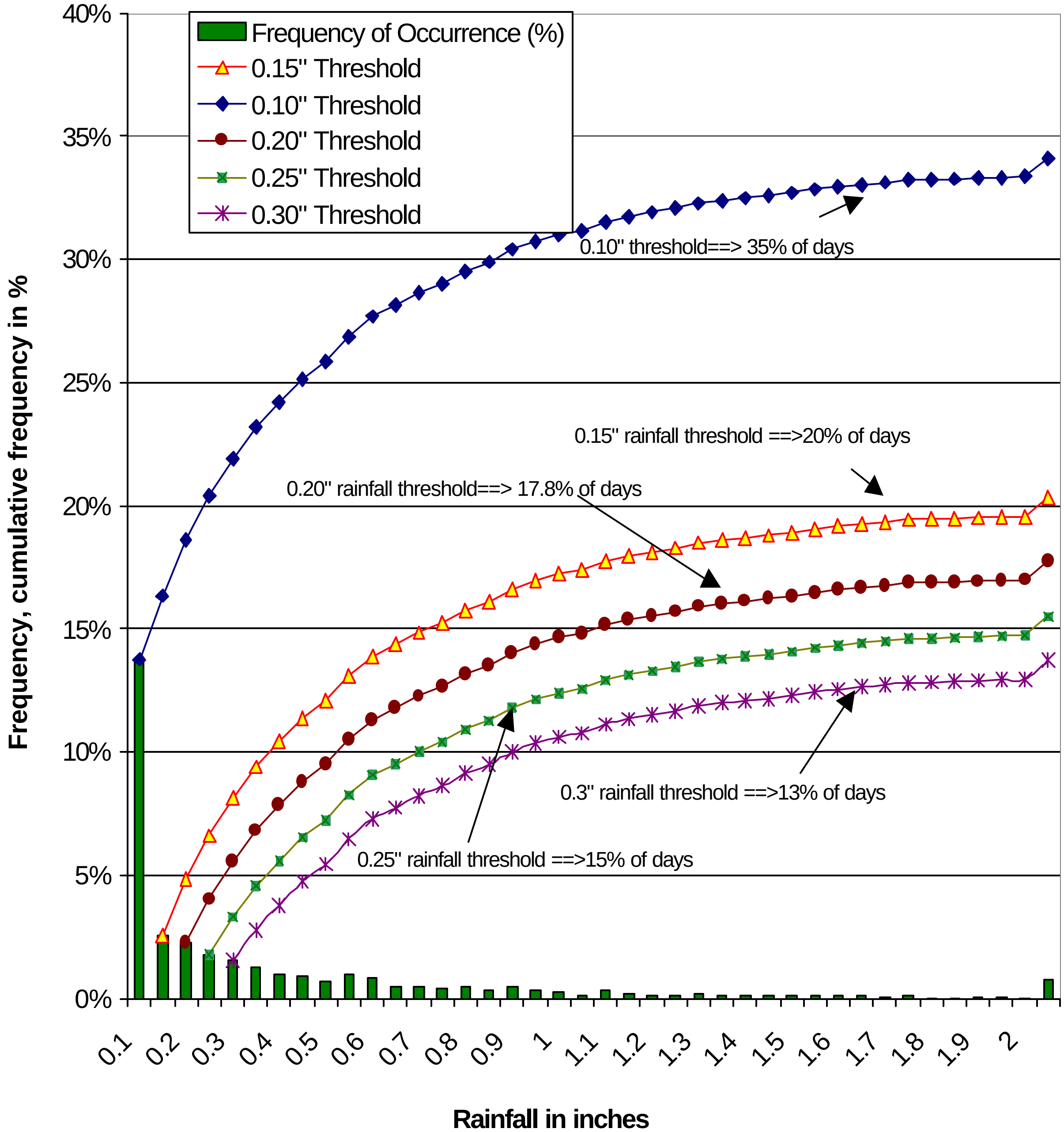


Figure 4.1 Frequency of occurrence of rainfall events for the Hunt River watershed.

Table 4.7 Weighted Average Geometric Mean Calculations.

Station	Waterbody	DW Geometric mean (fc/100ml)	WW Geometric mean (fc/100ml)	Weighted Average Geometric Mean (fc/100ml)
SC01	Scrabbletown Brook[a]	350	3720	854*
HRe	Hunt R. Headwaters[a]	39	2497	914*
HR01	Hunt River[a]	46	449	190*
HR02	Hunt River[a]	16	44	26
FB01	Frenchtown Brook[a]	18	246	99*
HR03	Hunt River[b]	71	210	121
FRY03	Fry Brook[b]	1462	15356	6408*
HR04	Hunt River[b]	40	1650	614*
UB01	Pierce Brook[b]	128	4599	1720*
HR05	Hunt River[b]	91	1321	529*
HR06	Hunt River[b]	17	79	39
SB01	Sandhill Brook[b]	75	946	385*
HR07	Hunt River[b]	45	218	160

[a] *denotes Class A waterbody where geometric mean value must not exceed 20 fc/100ml.*
[b] *denotes Class B waterbody where geometric mean value must not exceed 200 fc/100ml.*
** Indicates violation of criteria for fecal coliform bacteria.*

4.4 Calculation of the Percent Exceedence Value

State water quality standards require that, for Class A waterbodies, not more than 10% of the samples shall exceed a value of 200 MPN/100ml. For Class B waters, not more than 20% of the samples shall exceed a value of 500 MPN/100ml. In order to determine compliance with this portion of the standard, the wet and dry weather data sets from both the URI and RIDEM studies were combined into one data set for each station. The applicable percentile value was then determined for each station from that combined set of concentration values. The results are presented below in Table 4.8.

Table 4.8 Percent Exceedence Values by Station.

Station	Waterbody	Calculated 80th or 90th Percentile Value of Combined Data Sets (fc/100ml)
SC01	Scrabbletown Brook[a]	7200
HRe	Hunt R. headwaters[a]	25550
HR01	Hunt River[a]	2520
HR02	Hunt River[a]	210
FB01	Frenchtown Brook[a]	801
HR03	Hunt River[b]	408
FRY03	Fry Brook[b]	17000
HR04	Hunt River[b]	7000
UB01	Pierce Brook[b]	770
HR05	Hunt River[b]	2940
HR06	Hunt River[b]	170
SB01	Sandhill Brook[b]	2340
HR07	Hunt River[b]	384

[a] *denotes Class A waterbody where 90th percentile value must not exceed 200 fc/100ml.*
[b] *denotes Class B waterbody where 80th percentile value must not exceed 500 fc/100ml.*

5.0 WATER QUALITY IMPAIRMENTS

URI and RIDEM water quality investigations performed in the watershed document that the bacteria impairments in the Hunt River and its tributaries are primarily due to nonpoint sources of pollution and discharges from municipal stormwater sewer systems (MS4's).

Both dry and wet weather data were used to characterize water quality conditions in the Hunt River watershed. Dry weather data was used to assess steady state conditions when the waters are most likely to be utilized for the designated uses of primary and secondary recreational activities. Wet weather data were used primarily to assess worst case conditions and to help locate nonpoint source pollution hot spots in the watershed.

This TMDL addresses the different segments of the Hunt River watershed as defined by the seven-water quality monitoring locations established as part of RIDEM's supplementary monitoring program. The water quality assessment conducted by RIDEM sought to characterize current conditions and identify pollution sources for each stream segment monitored. This information is provided below by station. The stations below are either mainstem Hunt River stations or tributary mouth stations.

In seeking to identify sources of pathogen contamination, RIDEM staff reviewed aerial photos, topographic maps, GIS land use data, and other available sources. In addition, RIDEM staff conducted extensive wet and dry weather field reconnaissance and, where possible, talked to area residents regarding potential sources of bacteria pollution.

5.1 Station SC01 (Scrabbletown Brook at Stony Lane)

Water Quality Impairments

Station SC01 is located approximately 50 yards downstream of the Route 4-Stony Lane overpass. Dry weather fecal coliform geometric mean values increased from 65 fc/100ml, just upstream of the overpass, to 917 fc/100ml approximately 50 yards downstream at SC01. Wet weather fecal coliform geometric mean values increased from 2625 fc/100ml upstream of the overpass at SCb, to 3720 fc/100ml approximately 50 yards downstream at SC01. The resulting weighted average geometric mean at SC01 is 854 fc/100ml.

Pollution Source Identification

RIDEM has identified the major dry weather source of fecal coliform bacteria impacting the mainstem of Scrabbletown Brook, and likely the Hunt River upstream of HR01. Large numbers of pigeons roost under the Route 4-Stony Lane overpass. Excessive amounts of fecal matter were observed both in, and directly adjacent to, the channel. Fecal matter is deposited directly into the stream and dry weather fecal coliform concentrations reflect these loadings. No other dry weather sources of fecal coliform were identified.

The fecal matter deposited in and adjacent to the channel during dry weather accumulate, and become a significant wet weather source of bacteria to Scrabbletown Brook, and it is likely that this bacteria source impacts water quality downstream in the Hunt River at HR01.

The cumulative impacts of stormwater runoff are reflected in the elevated wet weather bacteria concentrations measured at all stations in the Scrabbletown Brook watershed. In the headwaters, stormwater runoff from South Road enters two tributaries of Scrabbletown Brook at stations SCc and SCd. Stormwater runoff from Scrabbletown Road and Routes 2 and 4 impact the southernmost tributary of Scrabbletown Brook at SCe and SCh as well. Runoff during wet weather events was observed to flow into Scrabbletown Brook from Stony Lane, just upstream of SC01.

5.2 Station HRe (Hunt River headwaters at Route 2)

Water Quality Impairments

The dry weather geometric mean value at HRe is 39 fc/100ml, higher than the Class A criteria for fecal coliform. Further upstream in the watershed, at station HRd, the dry weather geometric mean was 103 fc/100ml.

Wet weather fecal coliform concentrations at HRe were high, with a peak concentration of 260,000 fc/100ml and a wet weather geometric mean of 2497 fc/100ml. The wet weather fecal coliform geometric mean upstream at HRd was 891 fc/100ml, significantly less than the wet weather geometric mean at HRe. The resulting weighted average geomean is 914 fc/100ml.

Pollution Source Identification

Elevated dry-weather bacteria concentrations in this sub-watershed are thought to be the result of (1) inputs from the horse farm located upstream of station HRa, and (2) natural background due to wildlife.

A horse farm located in the Hunt River headwaters was identified as a significant dry and wet weather contributor of fecal coliform bacteria in this sub-watershed. Samples collected from a water quality station just downstream of this farm (HRa) showed elevated levels of fecal coliform bacteria during both dry and wet weather. RIDEM field investigators observed rills leading from the dirt roads and horse track around the farm to the stream channel and wetland areas. These rills mark the pathways taken by runoff through the soil. Fecal matter deposited by the horses was observed on the roads, as well as on the horse track. The horse track is sloped toward the road, ensuring that any precipitation not infiltrating into the track, runs off onto the road and directly into the stream channel.

It is not certain how far downstream of station HRa that bacteria concentrations remain elevated. There is no way to discern whether or not the bacteria signal from the farm is picked up at the next station (HRd), located approximately 2000 yards downstream. This tributary (at HRa) is augmented by flow from two other smaller tributaries before flowing into a pond just upstream of HRd. The decreased bacteria concentrations measured at HRd are likely the result of flow augmentation from the other tributaries, as well as any effects that the physical and biological characteristics of the pond have on bacteria concentrations (i.e. settling of bacteria adsorbed to sediment particles, or mortality due to predation or exposure to UV light).

The wet weather fecal coliform geometric mean upstream at HRd was 891 fc/100ml, significantly less than the wet weather geometric mean at HRe. The only observed source of bacteria that impacts HRe during wet weather is untreated stormwater runoff from Route 2. RIDEM staff observed significant amounts of runoff entering the channel from both sides of Route 2.

Untreated stormwater runoff, particularly from Tillinghast Road, South Road, and Route 2 is thought to have a significant impact on water quality in this sub-watershed during wet weather. Review of 1999 aerial photographs show no dry weather anthropogenic sources of fecal coliform bacteria in this section of the Hunt River headwaters. Stations HRe and HRd are separated by approximately ½ mile of undisturbed forested wetlands. There are no houses or roads other than Route 4 impacting this section of the stream (except Route 2 at HRe). Dry weather fecal coliform concentrations decrease by approximately 62% between HRd and HRe, indicating the effectiveness of this forested wetland area in reducing dry weather bacteria loadings.

Elsewhere in the watershed, upstream of HRe, untreated runoff from Route 4, South Road, and Tillinghast Road was observed to enter stream channels untreated by pollution control measures. Elevated bacteria concentrations in untreated stormwater runoff have been documented by Burnhart (1991) and Thiem et al (1999). Fecal matter, deposited on roads and streets by domestic animals, wildlife and waterfowl, accumulate during dry periods, and are subsequently washed into street gutters during rain events. Burnhart (1991) showed that during storm events, roads and streets were the primary contributors of fecal coliform bacteria. Burnhart measured fecal coliform concentrations of 56,000 fc/100ml off mid-traffic roads (> 500 cars/day) in rural areas. Thiem et al. (1999) measured bacteria concentrations during wet weather events from direct discharges of stormwater runoff from selected stormdrains off I-95 in Rhode Island. Thiem measured maximum fecal coliform bacteria concentrations of 240,000 fc/100ml from selected culverts.

Several researchers have sampled small source-areas within the urban landscape to determine where the major nonhuman sources of fecal coliform bacteria are found. Two recent studies conducted in Madison, Wisconsin (Bannerman et al. 1993) and Marquette, Michigan (Steuer et al. 1997) indicated that commercial parking lots, streets, residential lawns, and residential driveways were major source areas for bacteria (Table 5.1). In addition, both studies reported end-of-pipe bacteria concentrations that were at least an order of magnitude higher than any source area in the contributing watershed, suggesting that the stormdrain system was the greatest bacteria source in the watershed.

Table 5.1. Fecal coliform concentrations in runoff from urban-suburban land uses.

Geographic Location	Marquette, Michigan	Madison, Wisconsin
No. of Storms Sampled	**12**	**9**
Commercial Parking Lot	4,200	1,758
High Traffic Street	1,900	9,627
Medium Traffic Street	2,400	56,554
Low Traffic Street	280	92,061
Commercial Rooftop	30	1,117
Residential Rooftop	2,200	294
Residential Driveway	1,900	34,294
Residential Lawns	4,700	42,093

5.3 Station HR01 (Hunt River at South Road)

Water Quality Impairments

The dry weather geometric mean value of 46 fc/100ml is higher than the Class A criteria for fecal coliform. Wet weather fecal coliform concentrations at this station were elevated, with a peak concentration of 14,000 fc/100ml and a wet weather geometric mean of 449 fc/100ml. The resulting weighted average geometric mean at HR01 is 190 fc/100ml, which is in violation of the Class A standard.

Pollution Source Identification

No sources other than those upstream, impacting SC01, have been identified. A review of 1999 aerial photographs show no anthropogenic sources of fecal coliform bacteria in this section of the Hunt River. Since no anthropogenic bacteria-sources were found between stations SC01 and HR01, elevated dry weather fecal coliform levels are likely a result of loadings, however diminished in strength, from Scrabbletown Brook.

Elevated wet weather fecal coliform levels are also likely to be a direct result of upstream loadings from Scrabbletown Brook and the Hunt River headwaters. No stormwater runoff was observed to impact this section of the Hunt River.

5.4 Station HR02 (Hunt River at Davisville Road)

Water Quality Impairments

Fecal coliform data collected at HR02 do not show any dry weather impairments. However, wet weather impacts from upstream sources contribute to the water quality impairments at HR02. The wet weather geometric mean value is 44 fc/100ml. The weighted average geometric mean is 26 fc/100ml, which is slightly higher than the Class A water quality criteria of 20 fc/100ml.

Pollution Source Identification

Fecal coliform standards are not violated at this station during dry weather. Wet weather sources of bacteria in this section of the Hunt River are likely the result of inputs from Scrabbletown Brook and the Hunt River headwaters. Approximately 1.7 river miles of scrub-shrub and forested wetlands separate stations HR01 and HR02. Both dry and wet weather fecal coliform concentrations decrease sharply between HR01 and HR02 (Table 5.2), indicating the effectiveness of wetland areas in reducing both dry and wet weather bacteria loadings. Table 5.2 shows that, on average, dry weather fecal coliform bacteria concentrations at HR01 are reduced by 64-73% by the time they are measured at HR02. The percent reductions between HR01 and HR02 are greater during wet weather (86-90%).

Table 5.2. Percent reductions in bacteria concentrations downstream of wetland area between stations HR01 and HR02*.

Station	URI Dry Weather	URI Wet Weather	RIDEM Dry Weather	RIDEM Wet Weather
HR01	38	233	146	449
HR02	14	32	40	44
% Reduction	64%	86%	73%	90%

* *Geometric mean values in fc/100ml.*

5.5 Station FB01 (Frenchtown Brook at Davisville Road)

Water Quality Impairments

The dry weather geometric mean value of 18 fc/100ml is below the Class A criteria for fecal coliform, however wet weather concentrations at this station were found to be elevated, with a wet weather geometric mean of 246 fc/100ml. The resulting weighted average geometric mean value at FB01 is 99 fc/100ml, which violates the Class A standard of 20 fc/100ml.

Pollution Source Identification

Untreated stormwater runoff is a significant source of bacteria in Frenchtown Brook. The majority of land use in this watershed is low to medium density residential. Based on field observations during wet weather events, combined with documented literature values for bacteria concentrations in stormwater runoff (Burnhart 1991, CWP 1999, and Thiem et al. 1999), stormwater runoff from roads, streets, and parking lots is likely a major contributor of bacteria upstream of this water quality station, as well as all of Frenchtown Brook. In Frenchtown Brook, runoff from Woodbridge Drive, Tillinghast Road, Frenchtown Road, and Route 2 drains, untreated, into the stream. In addition, the commercial area off Route 2, across from water quality stations FB01A and FBa, drains to Frenchtown Brook. Wet weather impacts from roads, highways, and other impervious areas have been discussed in Section 5.2.

Another wet weather source of fecal coliform bacteria in the Frenchtown Brook watershed is likely the indigenous wildlife living in or near the stream or ponds. Fecal coliform bacteria are present in the intestinal tract of a variety of warm-blooded animals (Geldreich et al. 1962) that inhabit the area. Local degradation of water quality in Frenchtown Brook is due, in part, to concentrations of waterfowl found in the series of ponds drained by the brook. There are 4 ponds upstream of FB01, all of which were observed to support resident populations of ducks and geese. No estimates of the number of waterfowl have been made in these ponds.

5.6 Station HR03 (Hunt River at Frenchtown Road)

Class B water quality criteria for fecal coliform bacteria are met at HR03. The dry weather geometric mean is 71 fc/100ml. The wet weather geometric mean of 210 fc/100ml is slightly over the Class B standard of 200 fc/100ml, but the weighted average geomean is under the standard at 121 fc/100ml.

5.7 Station FRY03 (Fry Brook at Route 4)

Water Quality Impairments

Dry weather fecal coliform geometric means at FRY03 ranged from 80 to 5800 fc/100ml, with a geometric mean of 1462 fc/100ml. Wet weather concentrations ranged from 1600 to 240,000 fc/100ml, with a geometric mean of 15,356 fc/100ml. The weighted average geomean is well over the standard at 6408 fc/100ml.

Pollution Source Identification

Elevated fecal coliform concentrations at FRY03 likely reflect inputs from all upstream tributaries. However, the major impacts on water quality are thought to come from agricultural practices at the 77-acre dairy farm located in the watershed. The approximate 70 dairy cows on the farm have unlimited access to the channel and associated wetlands. There is no roof on the manure storage area and the observed rills leading from the manure piles directly to the channel provided evidence that during wet weather, runoff from this area impacts Fry Brook.

Untreated stormwater runoff from the intersection of Middle Road and Route 2 (Fry's Corner), Route 4, and two comercial-industrial facilities all contribute to the elevated wet weather bacteria concentrations measured at FRY03. RIDEM staff have observed runoff from the above-mentioned areas during both wet weather studies, as well as additional wet weather field investigations. Typical bacteria loads from roads and highways are discussed in section 5.2.

In addition to bacteria loadings from stormwater runoff, there is a large, resident population of Canada geese in the FRY03 sub-watershed. The elevated concentrations of bacteria in the untreated stormwater runoff are augmented by wet weather loadings from the geese. RIDEM staff have observed that, during wet weather, accumulated fecal matter, which has been deposited in and adjacent to the natural drainageways, and stormwater detention basins washes off and mixes with untreated stormwater runoff before being transported to the receiving stream.

5.8 Station HR04 (Hunt River at Route 1)

Water Quality Impairments

There is no dry weather impairment at this station. The dry weather geometric mean is 40 fc/100ml. However, the wet weather geometric mean is 1650 fc/100ml, which drives the weighted average geomean up to 614 fc/100ml.

Pollution Source Identification

Wet weather water quality violations at this station are likely the result of bacteria inputs from Fry Brook. In addition, untreated stormwater runoff from the nearby commercial areas, as well as Frenchtown Road and Route 1contribute to the elevated wet weather pollutant load (Table 5.1).

5.9 Station UB01 (Pierce Brook at Route 1)

Water Quality Impairments

The dry weather geometric mean value of 128 fc/100ml is well within the Class B criteria for fecal coliform. However, wet weather fecal coliform concentrations at this station were elevated. The wet weather geometric mean value at UB01 was 4599 fc/100ml with a storm event peak concentration of 15,000 fc/100ml. The weighted average geomean is well over the standard at 1720 fc/100ml.

Pierce Brook was identified on the 2000 303(d) list of impaired waters for pathogens. As a result, a separate TMDL will be developed to address the water quality impairments caused by elevated pathogen concentrations. This TMDL only addresses Pierce Brook's impacts on the Hunt River.

Pollution Source Identification

Suspected sources of runoff, and wet weather impacts to Pierce Brook, include commercial areas, parking lots, and residential streets. Burnhart (1991), Bannerman et al. (1993), and Steuer et al. (1997) have documented high bacteria counts in untreated stormwater runoff. Fecal matter, deposited on roads and streets by domestic animals, wildlife and waterfowl, accumulate during dry periods, and are subsequently washed into street gutters during rain events. Burnhart (1991) showed that during storm events, roads and streets were the primary contributors of fecal coliform bacteria. Burnhart measured fecal coliform concentrations of 56,000 fc/100ml off mid-traffic roads (> 500 cars/day) in rural areas.

Several researchers have sampled small source-areas within the urban landscape to determine where the major nonhuman sources of fecal coliform bacteria are found. Two recent studies conducted in Madison, Wisconsin (Bannerman et al. 1993) and Marquette, Michigan (Steuer et al. 1997) indicated that commercial parking lots, streets, residential lawns, and residential driveways were major source areas for bacteria (Section 5.2 and Table 5.1). In addition, both studies reported end-of-pipe bacteria concentrations that were at least an order of magnitude higher than any source area in the contributing watershed, suggesting that the stormdrain system was the greatest bacteria source in the watershed.

5.10 Station HR05 (Hunt River at Austin Road)

Water Quality Impairments

The dry weather geometric mean value of 91 fc/100ml is well within the Class B criteria for fecal coliform. However, wet weather fecal coliform concentrations at this station were high. The wet weather geometric mean value measured at HR05 was 1321 fc/100ml with a peak storm event concentration of 38,000 fc/100ml. The weighted average geomean is at 529 fc/100ml, well over the standard of 200 fc/100ml.

Pollution Source Identification

Wet weather water quality violations at this station are likely the result of bacteria inputs from both Fry Brook and Pierce Brook, as well as inputs from Route 1 and Frenchtown Road. Stormwater runoff from nearby residential areas may also contribute to the elevated wet weather fecal coliform concentrations (Section 5.2 and Table 5.1).

5.11 Station HR06 (Hunt River at Potowomut Road)

Class B water quality criteria for fecal coliform bacteria are met at HR06. The dry weather geometric mean is 17 fc/100ml. The wet weather geometric mean is 79 fc/100ml. The weighted average geomean of 39 fc/100ml is well under the Class B standard of 200 fc/100ml.

5.12 Station SB01 (Sandhill Brook at North Quidnesset Road)

Water Quality Impairments

The dry weather geometric mean value of 75 fc/100ml is well within the Class B criteria for fecal coliform. However, wet weather fecal coliform concentrations at this station were elevated. The wet weather geometric mean value measured at SB01 was 946 fc/100ml with a storm event peak concentration of 31,000 fc/100ml. The weighted average geomean is 385 fc/100ml, which is in violation of the 200 fc/100ml standard.

Sandhill Brook was identified on the 2000 303(d) list of impaired waters for pathogens. As a result, a separate TMDL will be developed to address the water quality impairments caused by these elevated pathogen concentrations. This TMDL only addresses Sandhill Brook's impacts on the Hunt River.

Pollution Source Identification

While there was no dry weather impairment at SB01, wet weather fecal coliform concentrations were elevated above the Class B standard of 200 fc/100ml. The only dry weather pollutant source identified was the resident population of waterfowl found in several ponds located along Sandhill Brook. No estimates of waterfowl populations were made in the ponds. No other dry weather sources of fecal coliform bacteria were identified.

Stormwater runoff from nearby residential areas also contributes to the elevated wet weather fecal coliform concentrations (Section 5.2 and Table 5.1).

Another likely wet weather source of bacteria in Sandhill Brook is wildlife in and adjacent to the stream. The numerous ponds in the sub-watershed support resident populations of ducks and geese. Wash-off from areas adjacent to the ponds transports fecal matter, deposited by resident waterfowl, directly to the pond. Theoretical values for coliform inputs from waterfowl on a 24-hr basis were calculated by Hussong et al (1979) and Koppelman and Tanenbaum (1982). Geese were reported to produce 10^7 coliforms per day, while ducks were reported to produce 10^9 coliforms per day. Even if a relatively small percentage of coliform bacteria were introduced from the ponds into the stream, it would still be sufficient to violate the state's Class B standards for fecal coliform.

5.13 Station HR07 (Hunt River at Forge Road)

Class B water quality criteria for fecal coliform bacteria are met at HR07. The dry weather geometric mean is 45 fc/100ml. The wet weather geometric mean is 218 fc/100ml. The resulting weighted average geometric mean is 160 fc/100ml, less than the standard of 200 fc/100ml.

5.14 Summary of known and potential sources of fecal coliform bacteria

Sources of bacteria in the Hunt River watershed include inputs from agricultural areas, discharges from MS4's, and loadings from pigeons, waterfowl, domestic pets, and other wildlife. A summary of known and potential sources of fecal coliform bacteria is provided below in Table 5.3.

Table 5.3. Summary of known and potential sources of fecal coliform bacteria in the Hunt River watershed.

Waterbody	Known sources	Potential sources
Scrabbletown Brook	Fecal inputs from pigeons, waterfowl, stormwater runoff	Natural sources of bacteria (i.e. wildlife), domestic pets
Hunt River headwaters	Horse Farm, stormwater runoff	Natural sources of bacteria (i.e. wildlife), domestic pets
Hunt River mainstem	Stormwater runoff	Natural sources of bacteria (i.e. wildlife), domestic pets
Frenchtown Brook	Stormwater runoff, waterfowl	Natural sources of bacteria (i.e. wildlife), domestic pets
Fry Brook	Dairy Farm, waterfowl, stormwater runoff	Natural sources of bacteria (i.e. wildlife), domestic pets
Pierce Brook	Stormwater runoff	Natural sources of bacteria (i.e. wildlife), domestic pets
Sandhill Brook	Stormwater runoff, fecal inputs from pigeons	Natural sources of bacteria (i.e. wildlife), domestic pets

6.0 TOTAL MAXIMUM DAILY LOAD ALLOCATIONS

6.1 TMDL Overview

A TMDL represents the greatest amount of pollutant loading that a waterbody can receive without violating water quality standards. For most pollutants, TMDLs are expressed as mass loading (e.g. pounds per day). For bacteria, however, TMDLs can be expressed in terms of concentrations. The TMDL establishes a level of pollutant loading not to be exceeded by the sum of all sources (point and nonpoint) plus a suitable margin of safety.

The TMDL is often expressed as:

$$\mathbf{TMDL = WLA + LA + MOS}$$

Where:

WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.

LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future nonpoint source of pollution.

MOS = Margin of Safety which accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water.

The Hunt River TMDL is directly based on the state's fecal coliform standard and is expressed in terms of the geometric mean of sample concentrations and percent exceedence over a certain concentration. Therefore, the above equation does not directly apply. In such cases, the TMDL is simply set equal to the standard and may be expressed as follows:

$$\mathbf{[TMDL] = [fecal\ coliform\ standard] = [LA] + [WLA] + [MOS]}$$

6.2 Targeted Water Quality Goal

One of the major components of a TMDL is the establishment of instream water quality targets used to evaluate the attainment of acceptable water quality. These water quality goals are usually based on either the narrative or numeric criteria required by state water quality standards. For the Hunt River, the applicable Class A and Class B fecal coliform standards were used as the applicable endpoint.

6.3 Point Sources

The only point sources in the Hunt River watershed are municipal stormwater pipes. For purposes of this TMDL, these pipes were included in the Load Allocation due to a lack of detailed site-specific information. Therefore, the wasteload allocation for all existing and future point sources is zero.

6.4 Nonpoint Sources

The load allocations for nonpoint sources were determined for each water quality station (i.e., stream segment or tributary) 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 fecal coliform standard, two calculations must be made at each station to determine the reductions necessary to meet each part of the fecal coliform standard. The more conservative (i.e., the greater) of those two values will be the one upon which the TMDL will be based. The values for each are presented below in Tables 6.1 and 6.2.

Weighted average geometric means and the resulting percent reductions are presented in Table 6.1 for water quality stations along the Hunt River.

Table 6.1 Weighted Average Geometric Means and Reductions Needed to Reach a Value of 20 fc/100ml for Class A Waters and 200 fc/100ml for Class B Waters.

Station	Waterbody	Weighted Average Geometric Mean (fc/100ml)	Percent Reduction Needed to Meet Geometric Mean Standard
SC01	Scrabbletown Brook [a]	854	98
HRe	Hunt R. Headwaters [a]	914	98
HR01	Hunt River [a]	190	89
HR02	Hunt River [a]	26	22
FB01	Frenchtown Brook [a]	99	80
HR03	Hunt River [b]	121	No Violation
FRY03	Fry Brook [b]	6408	97
HR04	Hunt River [b]	614	67
UB01	Pierce Brook [b]	1720	88
HR05	Hunt River [b]	529	62
HR06	Hunt River [b]	39	No Violation
SB01	Sandhill Brook [b]	385	48
HR07	Hunt River [b]	160	No Violation

[a] *denotes Class A waterbody where geometric mean value must not exceed 20 fc/100ml.*
[b] *denotes Class B waterbody where geometric mean value must not exceed 200 fc/100ml.*

The applicable 80th or 90th percentile values of the combined dataset of wet and dry weather samples for each water quality station along the Hunt River are presented below in Table 6.2. The accompanying reductions necessary to meet this part of the standard were derived by comparing the 80th percentile values to 500 fc/100ml and the 90th percentile values to 200fc/100ml. .

Table 6.2 Percentile Values and Percent Reductions/Load Allocations for Hunt River.

Station	Waterbody	Calculated 80th or 90th Percentile Value (fc/100ml)	Percent Reduction Needed to Meet Percent Exceedence Standard
SC01	Scrabbletown Brook [a]	7200	97
HRe	Hunt R. headwaters [a]	25550	99
HR01	Hunt River [a]	2520	92
HR02	Hunt River [a]	210	None (no violation)
FB01	Frenchtown Brook [a]	801	75
HR03	Hunt River [b]	408	None (no violation)
FRY03	Fry Brook [b]	17000	97
HR04	Hunt River [b]	7000	93
UB01	Pierce Brook [b]	770	35
HR05	Hunt River [b]	2940	83
HR06	Hunt River [b]	170	None (no violation)
SB01	Sandhill Brook [b]	2340	79
HR07	Hunt River [b]	384	None (no violation)

[a] *denotes Class A waterbody where 90th percentile value must not exceed 200.*
[b] *denotes Class B waterbody where 80th percentile value must not exceed 500.*

Required Load Reductions

The more conservative (i.e., the greater) of the two reduction values were used to base the TMDL upon. The load reductions determined for each stream segment are presented below in Table 6.3. These values represent the TMDL pollutant load reduction goals for the Hunt River.

Table 6.3 Load Reductions Required for the Hunt River Watershed.

Station	Waterbody	Percent Reduction Needed to Meet WQ Standards
SC01	Scrabbletown Brook [a]	98
HRe	Hunt R. headwaters [a]	99
HR01	Hunt River [a]	92
HR02	Hunt River [a]	22
FB01	Frenchtown Brook [a]	80
HR03	Hunt River [b]	None (no violation)
FRY03	Fry Brook [b]	97
HR04	Hunt River [b]	93
UB01	Pierce Brook [b]	88
HR05	Hunt River [b]	83
HR06	Hunt River [b]	None (no violation)
SB01	Sandhill Brook [b]	79
HR07	Hunt River [b]	None (no violation)

[a] *denotes Class A waterbody.*
[b] *denotes Class B waterbody.*

6.5 Margin of Safety

For this analysis, an implicit MOS is provided. In other words, a separate value is not added to the TMDL "equation" to account for a MOS. Instead, the MOS is incorporated "implicitly" into estimates of current pollutant loadings, the targeted water quality goal (i.e., the instream numeric endpoint), and the load allocation. This is done by making conservative assumptions throughout the TMDL development process. These conservative assumptions are described below.

- Conservative estimates of both the amount of rainfall needed to produce runoff and recovery time were used in the weighted average geomean calculations.

- For some of the wet weather events included in the weighted average geomean calculation, enough time may not have elapsed since the preceding storm event for pollutant levels to return to the elevated levels represented by the wet weather data. Similarly, other wet weather events may not be large enough, or long enough in duration, to generate the kind of loads represented by the wet weather data.

- RIDEM 1999 Dry weather data was collected during drought conditions.

- The data used to calculate the 80^{th} or 90^{th} percentile values was conservatively biased, since the data sets include a disproportionate amount of wet weather data with measured values one to three orders of magnitude higher than measured dry weather values.

6.6 Seasonal Variation

The Hunt River TMDL is protective of all seasons, since most of the fecal coliform data was collected during the summer months when instream fecal coliform concentrations are typically the highest.

6.7 Natural Background

Based on extensive field observations and review of available land use information, it is concluded that uncontrollable background concentrations of bacteria resulting from wildlife and other natural sources make up a significant portion of the total fecal coliform loads in the Hunt River. However, due to the limited amount of data regarding fecal coliform contributions from wildlife, natural background loads were not separated from the overall water quality calculations. Without detailed site-specific information on fecal coliform contributions from wildlife, it is difficult to meaningfully separate natural background from the total nonpoint source load.

7.0 IMPLEMENTATION

This TMDL addresses the different segments of the Hunt River watershed as defined by the water quality monitoring locations established as part of RIDEM's supplementary monitoring program. Water quality was assessed, and load allocations set, for each of the segments. Similarly, RIDEM has developed recommendations for BMP implementation for each of those sub-watersheds.

This TMDL relies upon phased implementation to reach its water quality goals. As BMPs are installed, the corresponding response in fecal coliform bacteria concentrations will be measured. If standards are not met after the BMPs recommended herein are implemented, then additional measures will be set forth. It should be noted that, with regards to the effectiveness of stormwater practices, BMPs must be extremely efficient if they are to produce storm outflows that meet either the 20 or 200 fc/100ml standard for fecal coliform bacteria from a site. Given existing stormwater fecal coliform levels equivalent to the national mean of 15,000 fc/100ml (CWP 1999), watershed practices may need to achieve nearly a 99 percent removal rate to meet standards. To date, performance monitoring studies research has indicated that no stormwater practice can reliably achieve a 99 percent removal rate of any urban pollutant on a consistent basis. Significant reductions can be expected however, if the following proposed BMPs and Phase II Stormwater Regulations are implemented.

In almost every stream segment of Hunt River, untreated stormwater runoff from roads, streets, and residential/commercial land uses impacts water quality. Therefore, it is important to address these issues on a watershed basis. RIDEM believes that the best way to accomplish this is by working with RIDOT and the towns of North Kingstown and East Greenwich to highlight these concerns and support their stormwater management planning, including the construction of BMP's where needed. We believe that this effort would be best coordinated through the Phase II Stormwater Permit Program which will include the Towns and RIDOT.

The BMPs that RIDEM currently recommends are provided below by station. Please note that the stations are listed upstream to downstream, inclusive of the tributary stations.

7.1 Station SC01 (Scrabbletown Brook at Stony Lane)

Required Reduction

A reduction of 98% is required in the fecal coliform concentrations at station SC01. A detailed discussion of BMPs proposed for the Scrabbletown Brook watershed can be found in the separate Scrabbletown Brook TMDL for fecal coliform.

7.2 Station HRe (Hunt River headwaters at Route 2)

Required Reduction

A reduction of 99% is required in the fecal coliform concentrations at station HRe.

Proposed BMPs

Runoff from Route 2, South Road, and Tillinghast Road was observed to enter the stream channel unabated by pollution control measures. RIDEM recommends that RIDOT implement one or more structural BMPs to reduce wet weather fecal coliform loads from Route 2 to the maximum extent practicable.

RIDEM recommends that the Town of North Kingstown delineate the catchment areas draining to the Hunt River at South Road and Tillinghast Road, especially those portions of the roads that drain to the stream. Further, the Town should seek to attenuate stormwater runoff from South Road and Tillinghast Road to the maximum extent practicable, through the use of structural BMPs that promote the detention and infiltration of runoff.

There are several options to investigate prior to determining the appropriate BMP to treat stormwater runoff. RIDEM has reviewed current stormwater BMP technologies, and many appear to be effective at removing total suspended solids (TSS). Although bacteria may attach to solids and the removal of solids may reduce the amount of bacteria in stormwater, significant concentrations of fecal coliform bacteria may still exist in runoff low in TSS. A review of several conventional structural BMPs is provided in Table 7.1.

Table 7.1 Effectiveness of Conventional Stormwater BMPs in Reducing Bacteria Concentrations in Runoff.

BMP	Reduction in fecal Coliform	Reduction in fecal streptococci	Reduction in E-Coli
Ponds	65% (n=10)	73% (n=4)	51% (n=2)
Sand filters	51% (n=9)	58% (n=7)	No data
Vegetated Swales	-58% (n=5)	No data	No data

Source: Watershed Protection Techniques. Vol 3. No. 1, 1999.

Similar information for manufactured BMPs and agricultural BMPs designed by NRCS is provided in Table 7.2.

Table 7.2 Effectiveness of Manufactured and Agricultural Stormwater BMPs in Reducing Bacteria Concentrations in Runoff.

System	Manufacturer/ Designer	Description	Applications	Performance
Stormfilter	Stormwater Management	Passive, flow-through filtration system utilizing rechargeable filter cartridges. Media removes TSS by mechanical filtration, ion exchange, and adsorption.	Parking lots for urban environments. Residential to arterial roadways.	High level of performance for the removal of TSS[a] and approximately 50% removal of fecal coliform
NRCS Nutrient & Sediment Control System	Robert Wengrzynek	Living biological filter or treatment system. Combines marsh/pond components of constructed wetlands with other sediment management elements to use physical, chemical, and biological processes for the removal of sediment and nutrients.	Livestock and pasture runoff as well as urban stormwater runoff	Removes 90-100% of TSS[a].
Vortechs	Vortechnics Inc.	Stormwater introduced into system in a vortex-like flow path. Swirling action directs sediment into the center of the chamber.	Parking lots, roadways	Net TSS removal[a] efficiency rate over the course of storm events of over 80%.
Stormtreat	Stormtreat Systems Inc.	Captures and treats first-flush. System consists of 6 sedimentation chambers and a constructed wetland contained in a 9.5 foot diameter tank. The number of tanks depends on the level of treatment required, in-line detention capacity, and the use of the optional infiltration feature.	Parking lots, residential subdivisions, roadways	315 analysis on 33 samples over 8 independent storm events during both winter and summer. 97% removal of fecal coliform and 99% removal of TSS.

Source: Innovative Stormwater Treatment-Products and Services Guide. Prepared for the Stormwater Technologies Trade Show by USDA Natural Resources Conservation Service Community Assistance Partnership.

a. Fecal coliform abundance has been correlated with high levels of TSS.

Plans are currently underway to install BMPs in an area of the horse farm upstream of station HRa. These BMPs will focus on the heavy-use areas where most of the day-to-day operations occur. The BMPs proposed will address the pathogen contributions to the Hunt River from the pasture area and will reduce both dry and wet weather impacts. A description of the BMPs recommended for the horse farm, as well as a general discussion of their effectiveness, taken from EPA (1993), is provided below:

1. **Roof Runoff Management -** A facility will be installed to control and dispose of runoff water from roofs. This will prevent roof runoff water from flowing across concentrated waste areas, barnyards, and roads. In addition, roof runoff management will reduce pollution and erosion, improve water quality, prevent flooding, and improve drainage. This practice may reduce erosion and the delivery of sediment and related substances to surface waters. It will reduce the amount of water polluted by animal wastes. Loadings of bacteria to surface waters are prevented from flowing across concentrated waste areas and barnyards. Pollution and erosion will be reduced.

2. **Waste Storage Structure -** A roofed structure for temporary storage of animal wastes or other agricultural wastes is proposed for the dairy farm. This practice may reduce the nutrient, pathogen, and organic loading to the surface waters. This is accomplished by intercepting and storing the polluted runoff from manure stacking areas, barnyards, and feedlots. (EPA, 1993).

Estimated Pollution Reduction for Recommended BMPs
A brief review of stormwater BMPs used to reduce bacteria concentrations in runoff was provided in Section 7.2 and summarized in Tables 7.1 and 7.2. As for the agricultural BMPs to be constructed on the horse farm, it is difficult to predict accurately predict pathogen reduction rates in advance. However, RIDEM believes that the proposed practices will significantly reduce pollutant loads to receiving waters.

7.3 Station HR01 (Hunt River at South Road)

Required Reduction
A reduction of 92% is required in the fecal coliform concentrations at station HR01.

Proposed BMPs
There were no readily apparent pollution sources between stations HRe and HR01. Elevated wet weather fecal coliform levels are thought to be primarily a result of upstream loadings from the Hunt River headwaters and Scrabbletown Brook. Once load reductions are made in those stream segments, water quality at HR01 should improve significantly.

RIDEM recommends that the Town of North Kingstown delineate the catchment area draining to the Hunt River at South Road, especially those portions of the road that drain to the stream. Further, the Town should seek to attenuate stormwater runoff from South Road to the maximum extent practicable, through the use of structural BMPs that promote the detention and infiltration of runoff.

Estimated Pollution Reduction for Recommended BMPs
A brief review of stormwater BMPs used to reduce bacteria concentrations in runoff was provided in Section 7.2 and summarized in Tables 7.1 and 7.2.

7.4 Station HR02 (Hunt River at Davisville Road)

Required Reduction
A reduction of 22% is required in the fecal coliform concentrations at station HR02.

Proposed BMPs
Fecal coliform standards are not violated at this station during dry weather. Wet weather impairments in this section of the Hunt River are likely to be due to pollution sources located upstream of station HR01. Therefore, unless subsequent investigations identify additional pollution sources, no BMPs are proposed for this portion of the watershed. BMPs implemented upstream of HR02 in the Scrabbletown Brook watershed and Hunt River headwaters would likely have a positive impact on wet weather concentrations at HR02.

7.5 Station FB01 (Frenchtown Brook at Davisville Road)

Required Reduction
A reduction of 80% is required in the fecal coliform concentrations at station FB01.

Proposed BMPs
Fecal coliform standards are not violated at this station during dry weather. Elevated bacteria concentrations during wet weather are thought to be primarily due to the large numbers of waterfowl found in the ponds drained by the brook, and to stormwater runoff from Woodbridge Drive, Tillinghast Road, Frenchtown Road, and Route 2. RIDEM's recommendations address these two pollution sources.

RIDEM recommends that RIDOT implement one or more structural BMPs to reduce wet weather fecal coliform loads from Route 2 to the maximum extent practicable.

RIDEM recommends that the Town of East Greenwich delineate the catchment area draining to Frenchtown Brook at Woodbridge Drive, Tillinghast Road, and Frenchtown Road, especially those portions of the road that drain to the stream. Further, the Town should seek to attenuate stormwater runoff from these areas to the maximum extent practicable, through the use of structural BMPs that promote the detention and infiltration of runoff.

In densely developed residential or commercial areas with higher percentages of impervious surface, the Town should also evaluate the feasibility of retrofitting these areas with stormwater management BMPs. Where feasible, such BMPs should be implemented.

It is evident from RIDEM investigations that waterfowl concentrations in the ponds and impoundments negatively impact the water quality in sections of Frenchtown Brook. Therefore, a public outreach program should be implemented to discourage the practice of feeding waterfowl and to encourage the use of BMPs designed to make these areas less desirable to waterfowl. This would have the effect of decreasing dry and wet weather bacteria contributions from the ponds to the stream.

Several methods exist to rid ponds of waterfowl. RIDEM proposes the following BMPs, as alternatives to be considered by the town of East Greenwich, or private property owners.

1. **G-Grid-** G-grid discourages geese from landing near a waterbody. G-Grid consists of a polypropylene netting placed to a height of 2 feet immediately on the edge of a pond. The pond needs to be completely surrounded, and the netting needs to be placed to the waters edge.

2. **Turf Shield-** Turf Shield is a formulation of two U.S. FDA Generally Recognized as Safe (GRAS) compounds that have been approved by the U.S. EPA as a biological chemical. The active ingredient is methyl anthranilate. Turf Shield has been shown to significantly reduce geese and ducks from feeding on turf for prolonged periods of time when applied according to label directions. Reported removal efficiency of approximately 95% of birds.

3. **Habitat Alterations-** Habitat alterations include reducing grassy areas by planting large borders of ground cover, planting trees and shrubs around the waterbody, increase the rough wherever possible.

3. **Installation of Mechanical Barriers-** Fences, hedgerows, and other physical barriers are effective tools to restrict movement. A low fence or other barrier around ponds, which prevents access, may be sufficient to restrict movement.

As discussed above in section 7.5, there are several methods to reduce the Canada geese population. RIDEM recommends that affected landowners and the Town of East Greenwich work with the RIDEM Division of Fish and Wildlife to implement comprehensive management programs that include a variety of techniques. Control measures will be most effective if coordinated among nearby sites in a community.

Public outreach efforts in this part of the watershed should target residential homeowners and focus on the importance of ISDS maintenance and proper disposal of pet waste.

Estimated Pollution Reduction for Recommended BMPs
A brief review of stormwater BMPs used to reduce bacteria concentrations in runoff was provided in Section 7.1 and summarized in Tables 7.1 and 7.2.

Less information is available to estimate the efficiency of the nuisance waterfowl BMPs. Turf Shield reports a removal efficiency of approximately 95%. We believe that a significant reduction in the geese and duck population in and around the ponds and along the stream would result in a corresponding decrease in the fecal coliform loadings. Furthermore, we believe that application of one or more of the stormwater BMPs recommended above could result in attainment of this goal.

7.6 Station HR03 (Hunt River at Frenchtown Road)
There were no violations of the water quality standard at HR03; therefore no reductions are required for this segment.

7.7 Station FRY03 (Fry Brook at Route 4)
A reduction of 97% is required in the fecal coliform concentrations at station FRY03. A detailed discussion of BMPs proposed for the Fry Brook watershed can be found in the separate Fry Brook TMDL for fecal coliform.

7.8 Station HR04 (Hunt River at Route 1)

Required Reduction

Fecal coliform standards are not violated at this station during dry weather, but wet weather concentrations are in violation of the standard. An 80^{th} percentile value of 7000 fc/100ml leads to a required reduction of 93% in the fecal coliform concentrations at station HR04.

Proposed BMPs

Fecal coliform standards are not violated at this station during dry weather. Wet weather impairments in this section of the Hunt River are thought to be due to wet weather inputs from Fry Brook, as well as untreated stormwater runoff from Route 1. The pollution reductions required for the Fry Brook watershed and the future BMPs discussed below should result in the achievement of water quality standards at HR04.

Currently, there is little or no treatment of stormwater runoff from Rt. 1. However, work is underway by RIDOT to design a number of BMPs associated with improvements to Rt. 1 and the interchange with Frenchtown Road. As part of the project, RIDOT has contracted with an engineering firm to design at least three stormwater BMPs and two wetland restoration/creation areas. The wetland areas will be located on the north and south sides of the river near the Rt. 1 bridge and should provide flood control and habitat benefits. Since other wetland areas in the watershed have been shown to reduce fecal coliform concentrations, a reduction may be seen here as well.

The first stormwater BMP is a series of detention basins that accepts runoff from the highway from the railroad bridge to the entrance to the shopping center – an area of 5.8 acres. Excess flows from the existing BMP in the adjacent Stop and Shop parking lot will be accepted as well. The second BMP drains about 19.0 acres from the railroad bridge down to Bruester Drive. Runoff is conveyed to a detention basin for treatment and then discharged to a wetland area, which contributes flow to Sandhill Brook. The third BMP treats an area of about 4.3 acres and consists of a level spreader designed to provide sheet flow to an adjacent wetland. All of the BMPs are designed to treat runoff from a 10-year storm event. For detention basins, this design criteria provides additional volume, and thus improved treatment, for less frequent storms. We anticipate that these new BMPs and wetland areas will result in a net reduction in wet weather pollutant loads, including pathogens, to both the Hunt River and Sandhill Brook.

7.9 Station UB01 (Pierce Brook at Route 1)

Required Reduction

A reduction of 88% is required in the fecal coliform concentrations at station UB01. Pierce Brook was identified on the 2000 303(d) list of impaired waters as impaired by pathogens. As a result, a separate TMDL will be developed to reduce pathogen concentrations in the Brook so that they meet water quality standards. This TMDL only addresses Pierce Brook's impacts on the Hunt River.

Proposed BMPs

Fecal coliform standards are not violated at this station during dry weather. Suspected sources of stormwater runoff to Pierce Brook include the commercial areas and parking lots adjacent to Route 1, and, further up in the watershed, residential streets.

In general, the Town should seek to address impacts from stormwater runoff in the Pierce Brook watershed to the maximum extent practicable. However, the TMDL to be developed for Pierce Brook will include specific recommendations for structural BMPs for this watershed.

Public outreach efforts in this part of the watershed should target residential homeowners and focus on the importance of ISDS maintenance and proper disposal of pet waste.

Estimated Pollution Reduction for Recommended BMPs
A brief review of stormwater BMPs used to reduce bacteria concentrations in runoff was provided in Section 7.1 and summarized in Tables 7.1 and 7.2.

7.10 Station HR05 (Hunt River at Austin Road)

Required Reduction
A reduction of 83% is required in the fecal coliform concentrations at station HR05.

Proposed BMPs
Fecal coliform standards are not violated at HR05 during dry weather. Wet weather water quality violations at this station are likely the result of bacteria inputs from Fry Brook and Pierce Brook. The pollution reductions required for these two subwatersheds should result in the achievement of water quality standards at HR05. Therefore, unless subsequent investigations identify additional pollution sources, no BMPs are proposed for this portion of the watershed.

7.11 Station HR06 (Hunt River at Potowomut Road)

There were no violations of the water quality standard at HR06; therefore no reductions are required for this segment.

7.12 Station SB01 (Sandhill Brook at Quidnesset Road)

Required Reduction
A reduction of 79% is required in the fecal coliform concentrations at station SB01. Sandhill Brook was identified on the 2000 303(d) list of impaired waters as impaired by pathogens. As a result, a separate TMDL will be developed to reduce pathogen concentrations in the Sandhill Brook so that they meet water quality standards. This TMDL only addresses Sandhill Brook’s impacts on the Hunt River.

Proposed BMPs
Fecal coliform standards are not violated at SB01 during dry weather. Wet weather sources identified in the Sandhill Brook watershed include the resident populations of waterfowl found in the numerous ponds and impoundments along the brook. A discussion of BMPs that can be used to discourage nuisance waterfowl was provided in section 7.5. Other suspected wet weather pollution sources include stormwater runoff from residential streets in the watershed.

In general, the Town should seek to address impacts from stormwater runoff in the Sandhill Brook watershed to the maximum extent practicable. However, the TMDL to be developed for Sandhill Brook will include specific recommendations for structural BMPs for this watershed.

Public outreach efforts should be targeted at reducing the resident population of waterfowl by discouraging the practice of feeding waterfowl and promoting the use of BMPs designed to make these areas less desirable to waterfowl. Public outreach efforts should also target residential homeowners and focus on the importance of ISDS maintenance and proper disposal of pet waste.

Estimated Pollution Reduction for Recommended BMPs
A brief review of stormwater BMPs used to reduce bacteria concentrations in runoff was provided in Section 7.1 and summarized in Tables 7.1 and 7.2.

Less information is available to estimate the efficiency of the nuisance waterfowl BMPs. Turf Shield reports a removal efficiency of approximately 95%. We believe that a sizeable reduction in the geese population in and around the ponds along the streams would be needed to produce a significant decrease in the fecal coliform loadings.

7.13 Station HR07 (Hunt River at Forge Road)

There were no violations of the Class B water quality standard for fecal coliform bacteria at HR07; therefore no reductions are required for this segment.

7.14 Watershed-Wide Stormwater Management Issues

Urban stormwater runoff from roads and residential/commercial land uses impacts water quality in several portions of the Hunt River watershed. Therefore, it is important to address these issues on a watershed basis. RIDEM believes that the best way to accomplish this is by working with RIDOT and the Towns of East Greenwich and North Kingstown to highlight these concerns and by supporting their stormwater management planning, including the construction of BMPs where needed.

Stormwater Phase II Permit Program
Over the next several years, RIDOT and the Towns of East Greenwich and North Kingstown will be required to meet Phase II Stormwater Program requirements. Federal program regulations recently adopted by EPA require that permitted municipalities develop stormwater management programs, control runoff from small construction sites, investigate and eliminate illicit discharges, utilize pollution prevention/good housekeeping practices, and educate and involve the public in stormwater related issues. These aspects of the Phase II program should have a positive impact on water quality in the Hunt River watershed. However, it is very difficult to assign a load reduction to these programs.

Since the Hunt River is an impaired waterbody, RIDEM anticipates that special emphasis will be placed on addressing stormwater impacts to this stream from municipal separate storm sewer systems (MS4s). This TMDL identifies those highway crossings and storm sewer outfalls associated with elevated in-stream bacteria levels. Where appropriate, we recommend investigation and/or implementation of BMPs to reduce pollutant loads through detention and infiltration. Actions to achieve the required reductions can be taken voluntarily by the Towns and RIDOT prior to the issuance of Phase II Stormwater Permits, or will be required by the Phase II permits.

Road Runoff BMPs

Table 7.3 highlights possible locations in the watershed where stormwater BMPs may be the most effectively applied to address road runoff.

Table 7.3. Sites of stormwater discharge from roads and highways in the Hunt River watershed [a, b].

Location-Stations	Responsible Entity	Station-River Segment Impacted
Hunt River headwaters- HRe	RIDOT	Downstream of HRe
Frenchtown Brook- FB01, FB01A, FB03, FBc	RIDOT, Town of North Kingstown	Downstream of water quality stations
Pierce Brook-UB01 (Separate TMDL planned)	RIDOT, Town of North Kingstown	Downstream of UB01
Sandhill Brook- SB01, SB1, SB02, SB03 (Separate TMDL planned)	RIDOT, Town of North Kingstown	Downstream of water quality stations
Hunt River mainstem- HR04, HR05	RIDOT, Town of North Kingstown	Downstream of water quality stations.

a. ***Sites of stormwater discharge in Scrabbletown Brook and Fry Brook are given in the separate Fry Brook and Scrabbletown Brook TMDLs.***

b. ***Separate TMDLs are planned for Pierce Brook and Sandhill Brook.***

Other BMPs proposed for the Hunt River watershed include the following:

Dairy Farm BMPs- Fry Brook

A dairy farm was identified as the largest dry and wet weather source of fecal coliform bacteria to Fry Brook, a major tributary to the Hunt River. The property owner is currently working with NRCS (Natural Resource Conservation Service) and RIDEM's Division of Agriculture to implement BMPs and improve water quality on the farm. We anticipate that RIDEM will be able to provide Section 319 Nonpoint Source Program grant funds to supplement both NRCS and Dairy Farm funding sources to pay for the design and construction of the BMPs. BMP construction is scheduled to begin within the next year, starting with the fencing of riparian and wetland areas. The other proposed BMPs will focus on the heavy-use areas where most of the day-to-day farming operations occur. Subsequent BMPs should focus on the outlying areas of the farm.

Horse Farm BMPs- Hunt River headwaters

A horse farm located in the headwaters of the Hunt River was found to be a significant wet weather source of fecal coliform bacteria. Plans are underway to implement BMPs and improve water quality at the farm. RIDEM has used Nonpoint Source Program

(Section 319) grant funds to supplement NRCS, as well as individual funding sources to pay for the design and construction of BMPs on the farm. Construction of these BMPs should begin this year. The proposed BMPs will include a waste storage facility and roof runoff management.

Pigeon deterrent BMP- Scrabbletown Brook
Implementation of the pigeon deterrent BMP should result in a complete removal of roosting pigeons from the Route 4 overpass, effectively eliminating this source of fecal coliform bacteria to Scrabbletown Brook.

Public Outreach
RIDEM recommends that the Town of North Kingstown and East Greenwich develop and implement public outreach programs aimed at informing and educating citizens about the sources of pathogens in streams and ways to eliminate or reduce those sources.

The public outreach program should be geared towards specific water quality issues identified as impacting each segment of the stream. Specifically, outreach efforts should include information on the importance of ISDS maintenance, proper disposal of pet waste, and discouraging the presence of resident waterfowl in impoundments and controlling their population.

The Towns will have to make a concerted effort for the public outreach and education program to be effective at reducing nonpoint sources of pollution in the watershed. Even though it is difficult to assign reductions to these types of programs, RIDEM believes that once the public is aware of the potential health threats from elevated pathogen levels in surface waters, they will be willing to take corrective actions that will result in improved water quality.

8.0 MONITORING PLAN

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001) recommends a monitoring plan when a TMDL is developed under the phased approach. The phased approach is appropriate when a TMDL is based on limited information and when there is considerable uncertainty associated with the analysis. EPA's guidance provides that a TMDL developed under the phased approach should include a monitoring plan that describes the additional data necessary to determine if the load reductions required by the TMDL will lead to attainment of water quality standards.

Post-implementation monitoring is necessary to assess the effectiveness of applied controls, and whether or not standards are attained. RIDEM's Division of Agriculture (DOA) has made a commitment to conduct water quality monitoring to assess the effectiveness of BMPs implemented on the dairy farm in the Fry Brook sub-watershed. RIDEM will also seek to have the performance of other BMPs monitored as they are installed throughout the Hunt River watershed.

To monitor the effect that implementation activities throughout the watershed will have on water quality in the river, RIDEM will conduct baseline monitoring at key locations in the watershed. These include HRe, SC01, HR01, FB01, HR03, FRY03, HR04, UB01, HR05, SB01, and HR07. Grab samples will be collected bi-monthly (every two months) during warm weather months (from May to September).

Once significant improvements in water quality are observed and the dry weather concentrations meet standards, the decision can be made whether to conduct more intensive monitoring to determine if the waterbody is no longer impaired. If the trend is negative or if there is no improvement in water quality over time, then follow-up assessments will be made and additional BMPs recommended.

9.0 PUBLIC PARTICIPATION

The public participation associated with this TMDL has two components: open meetings and opportunity for public review and comment. An initial meeting was held prior to TMDL development on December 13, 1999. All interested public, private, and government entities were invited to attend. The meeting was held to disseminate information regarding the TMDL issues in the watershed as well as to solicit input regarding pollution sources and/or other concerns.

A second public meeting was held on September 27, 2000 to initiate a 30-day public comment period. RIDEM staff presented the draft TMDL and solicited input, however, no comments were received by the end of the comment period.

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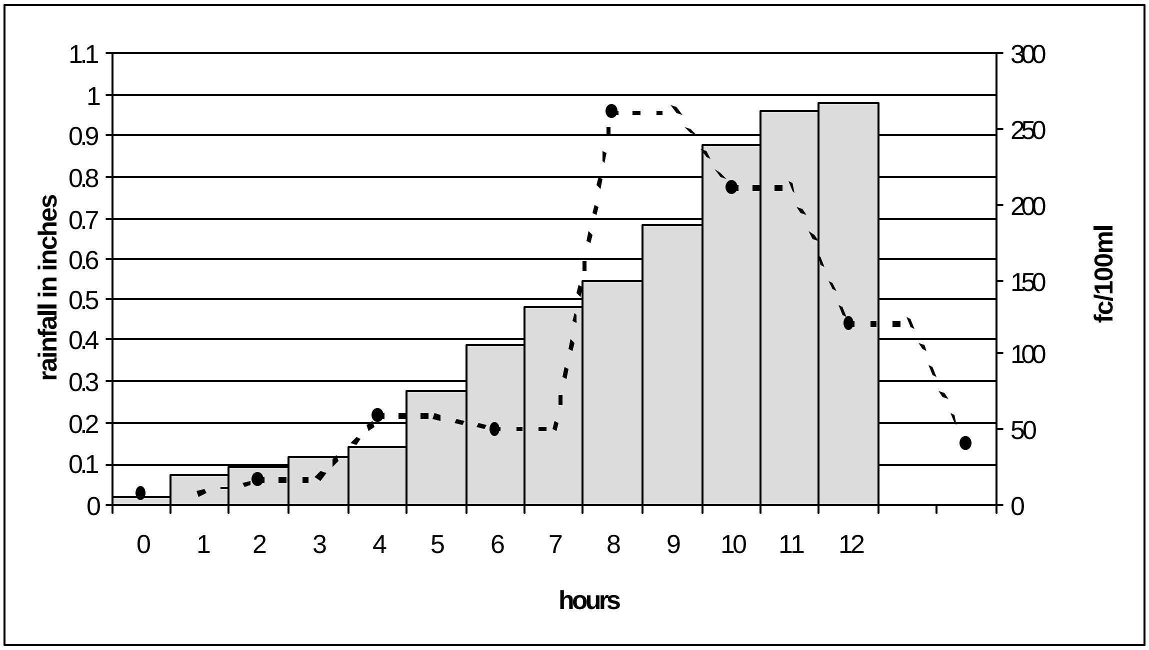
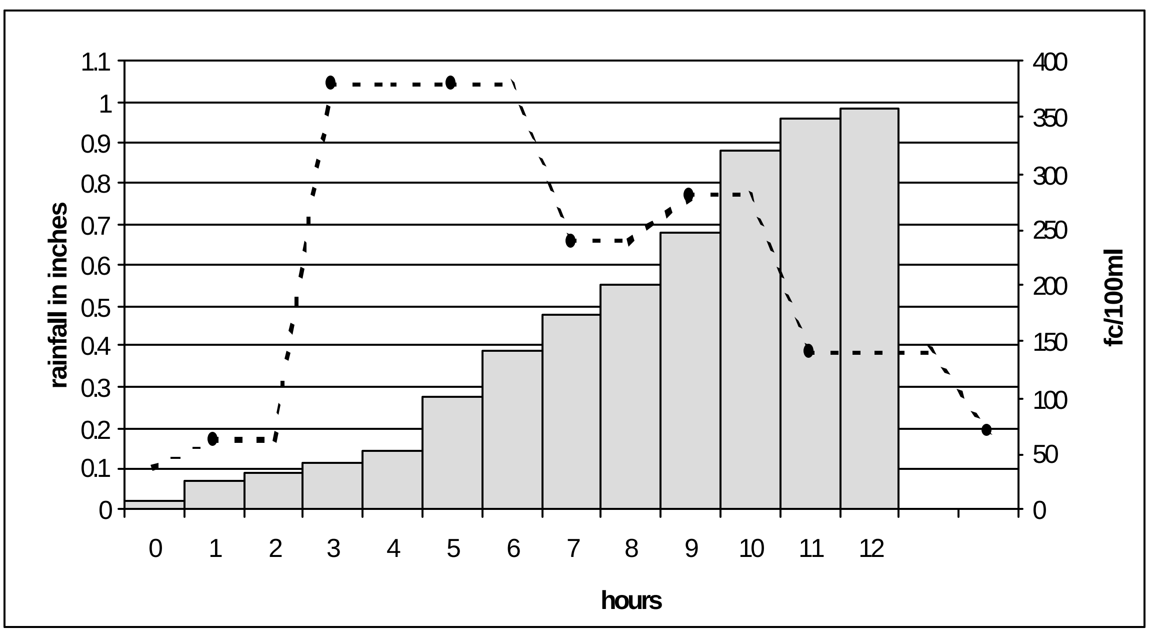
Appendix A. URI wet weather data plots of time, cumulative rainfall amounts, and fecal coliform concentrations for selected water quality stations.

(URI 1996) 1st Wet Weather Event (0.98 inches/ 12hrs)

Station FB01

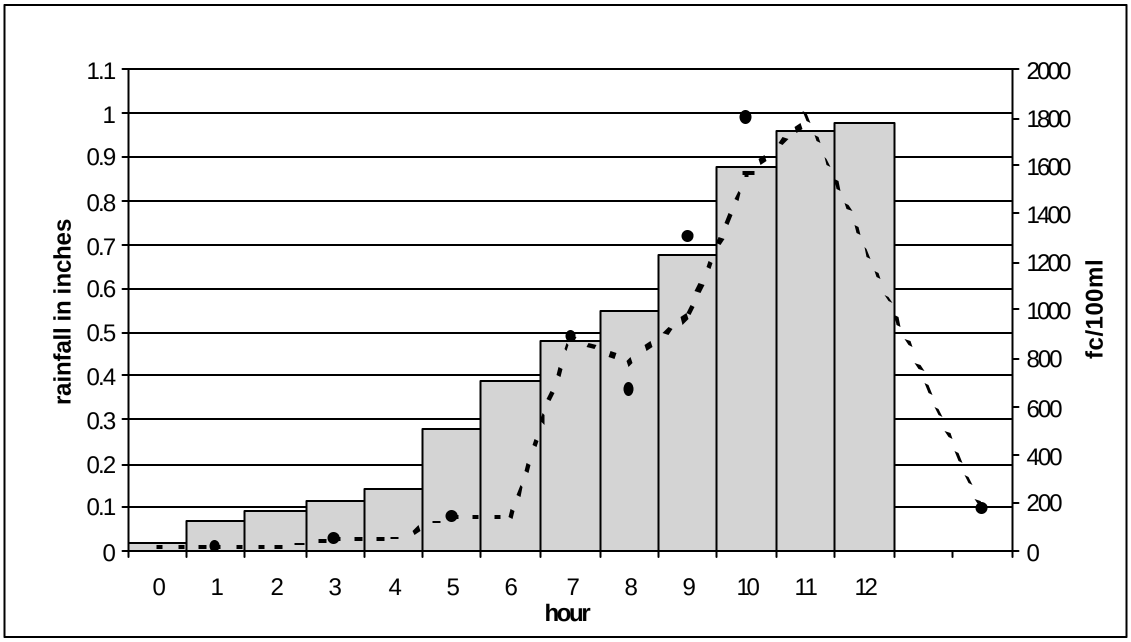


Station SC01

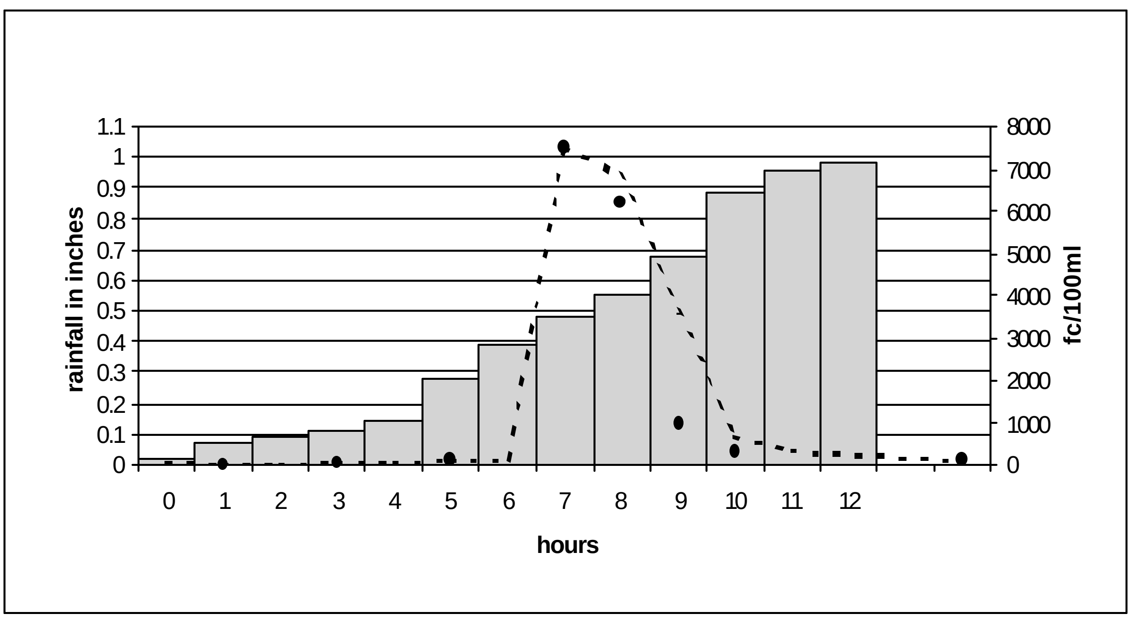


(URI 1996) 1st Wet Weather Event (0.98 inches/ 12hrs)

Station SB01

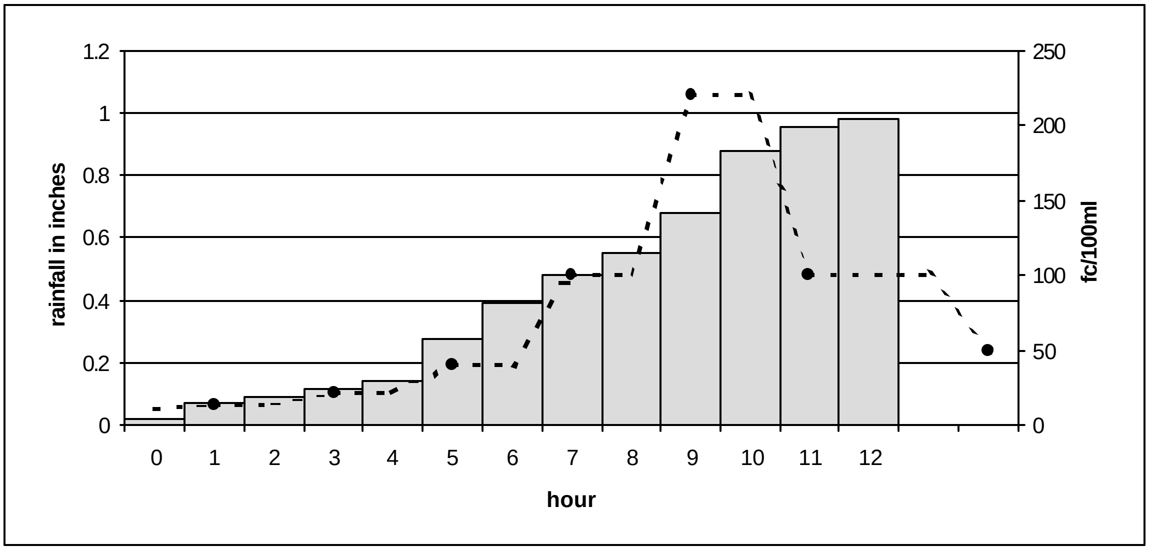


Station HR04



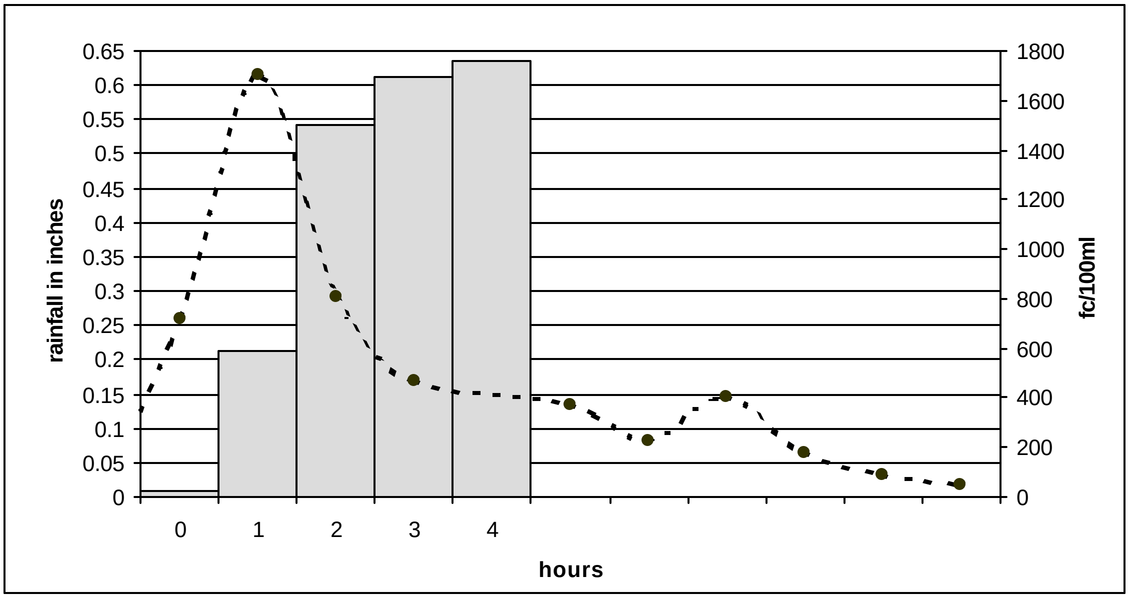
(URI 1996) 1st Wet Weather Event (0.98 inches/ 12hrs)

Station HR03



(URI 1996) 2nd Wet Weather Event (0.63 inches/ 4hrs)

Station FB01



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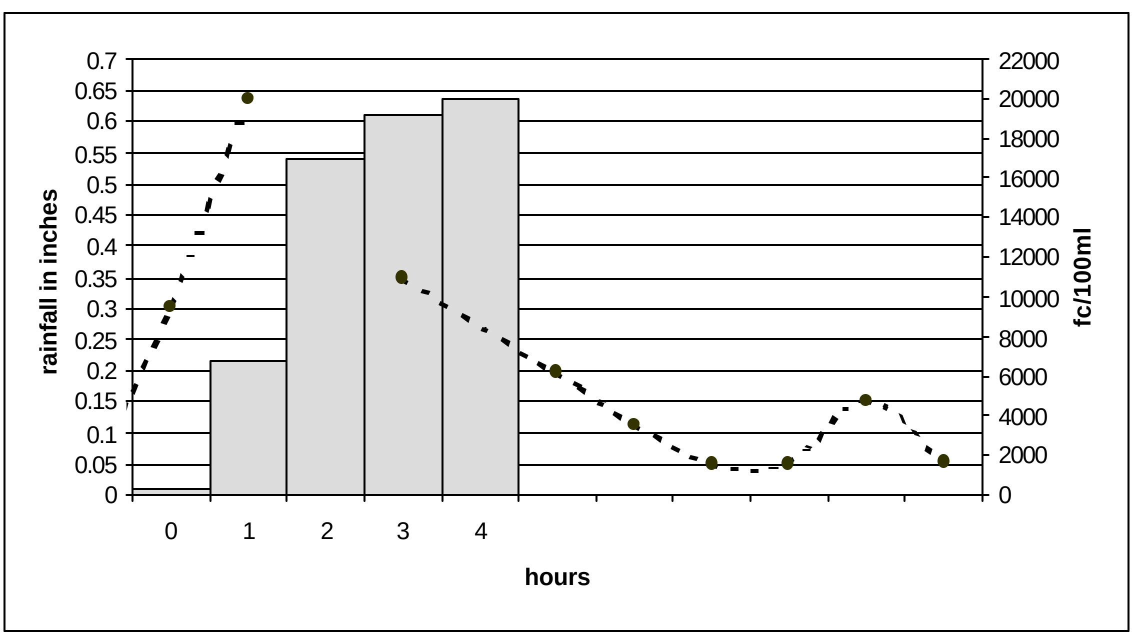
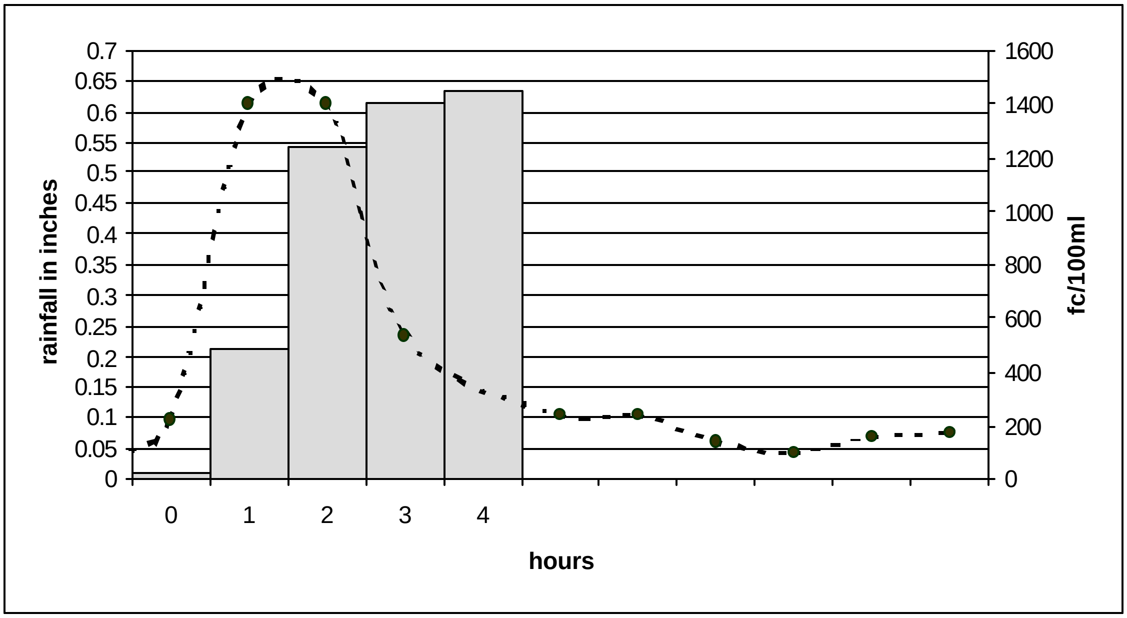
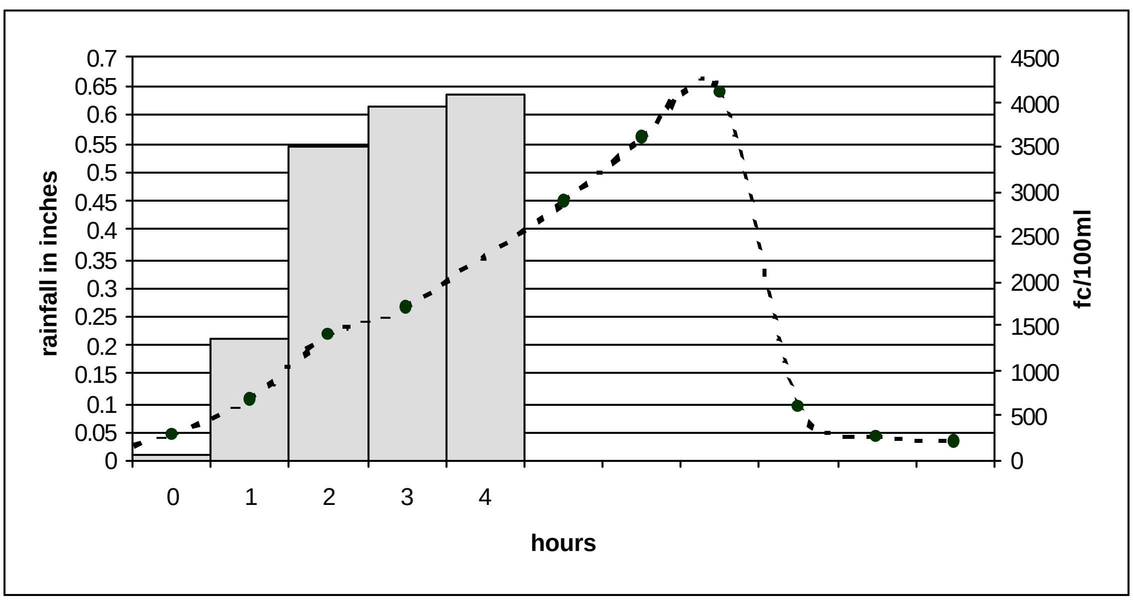


(URI 1996) 2nd Wet Weather Event (0.63 inches/ 4hrs)

Station HR03

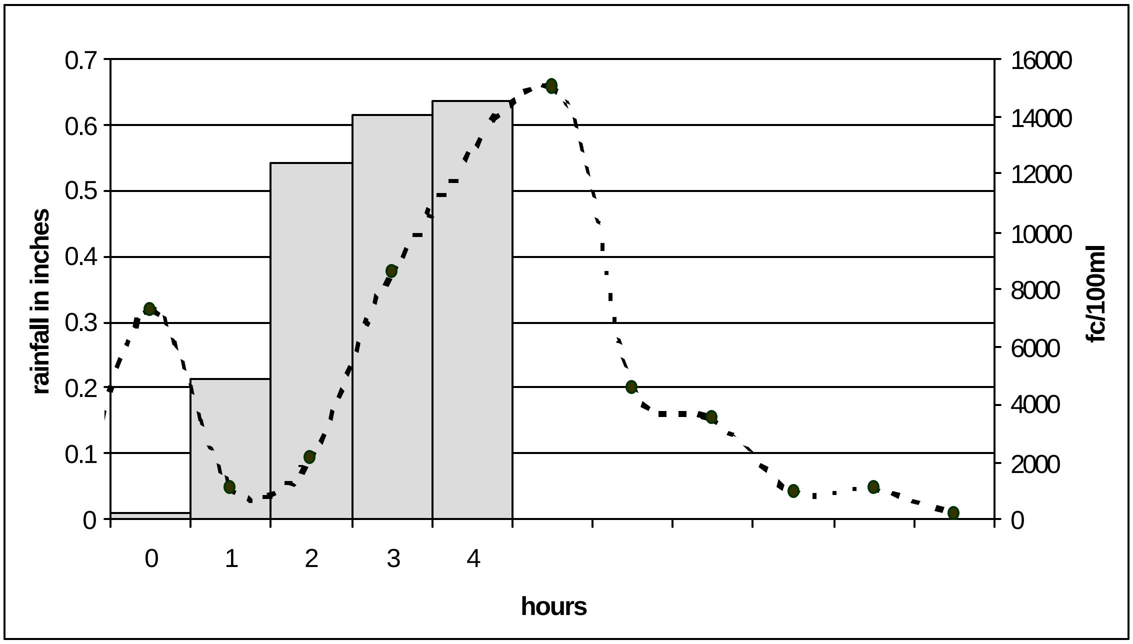


Station SB01



(URI 1996) 2^{nd} Wet Weather Event (0.63 inches/ 4hrs)

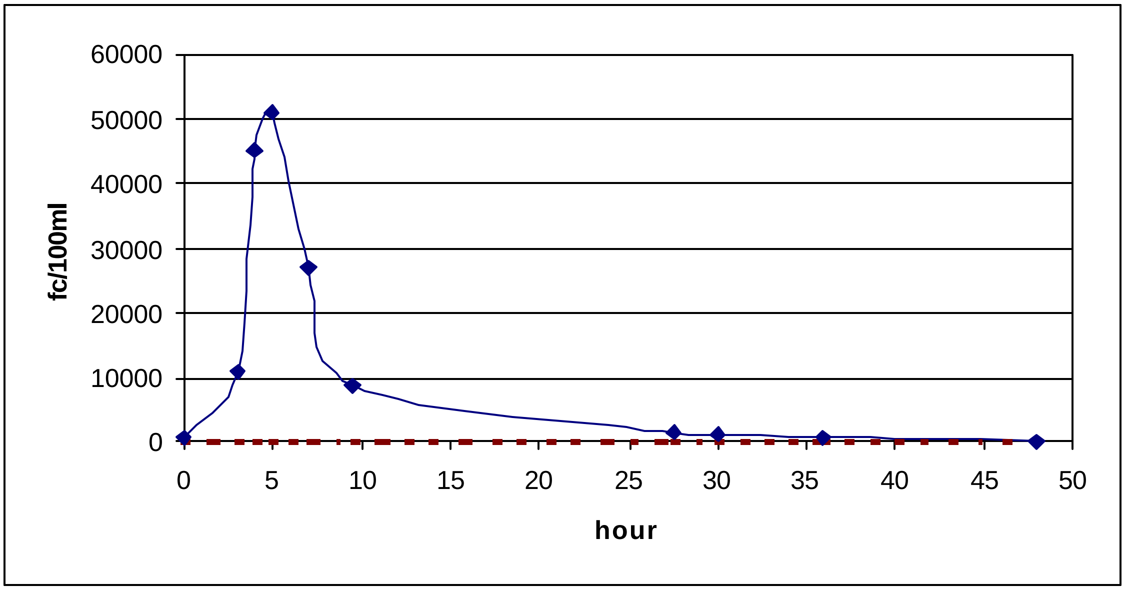
Station HR04



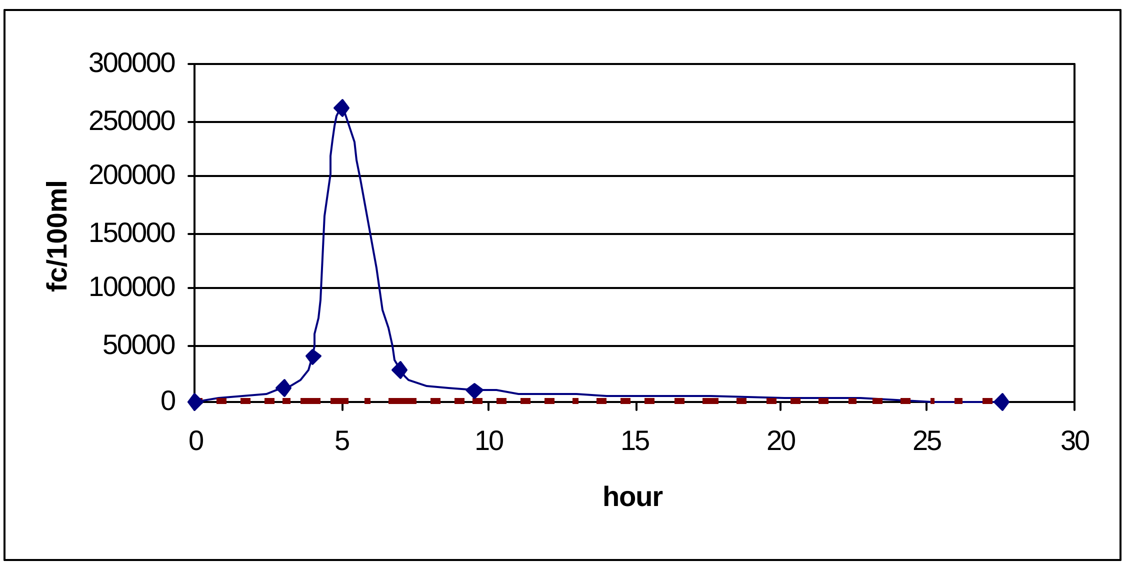
Appendix B. Plots of recovery time for selected stations during wet weather events (RIDEM 1999).

Wet Weather Event #1 (0.56 inches/1.5 hrs) –dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.

Station SC01

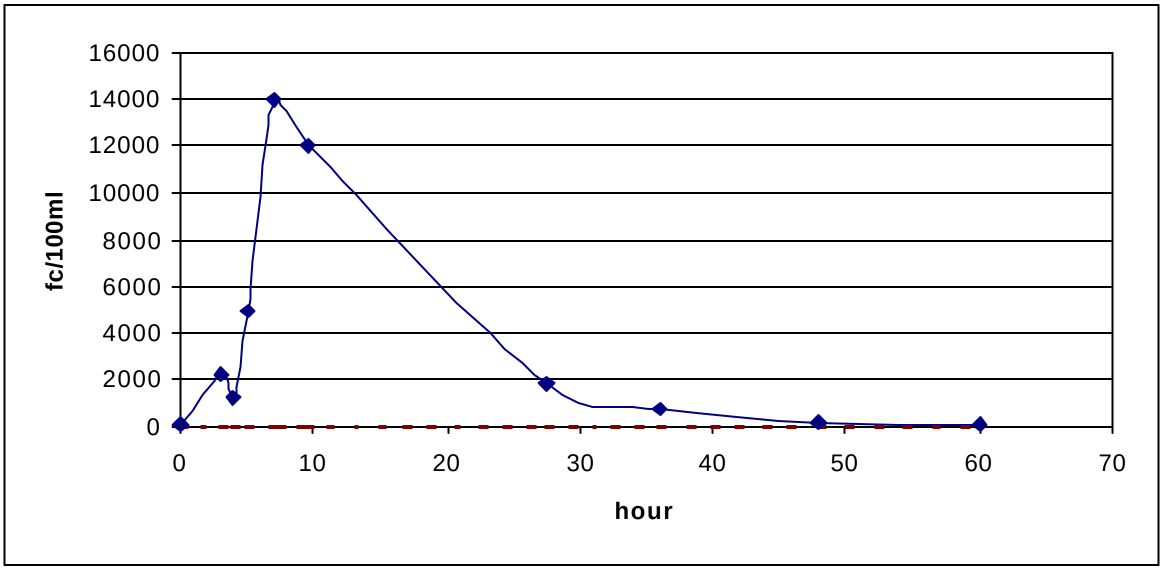


Station HRe

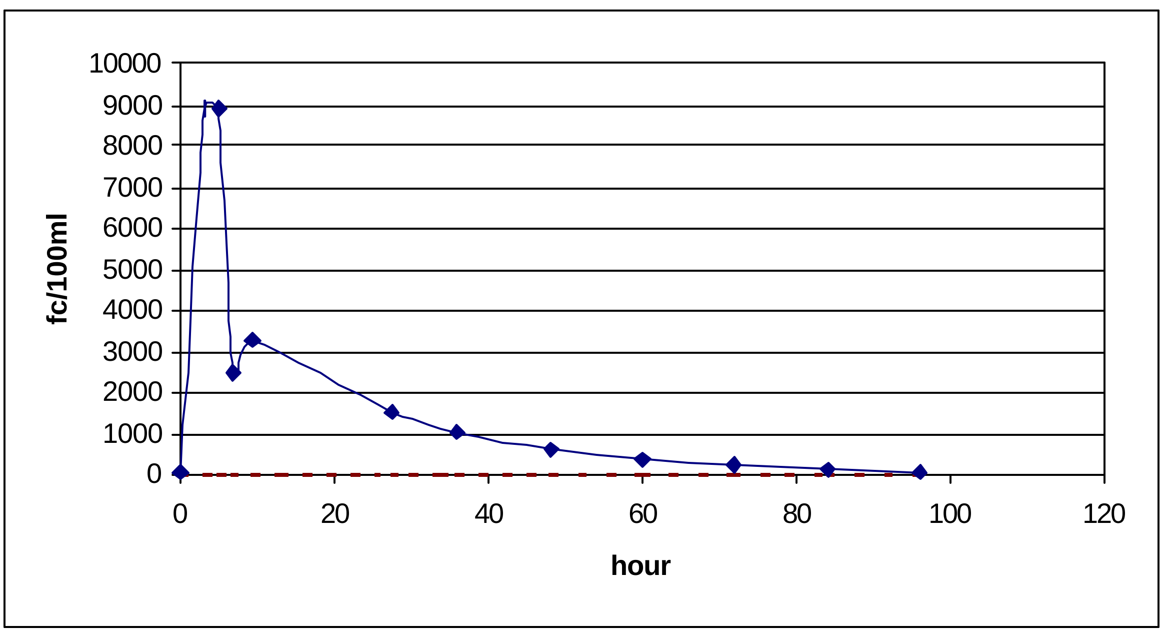


Wet Weather Event #1 (0.56 inches/1.5 hrs) **dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.**

Station HR01

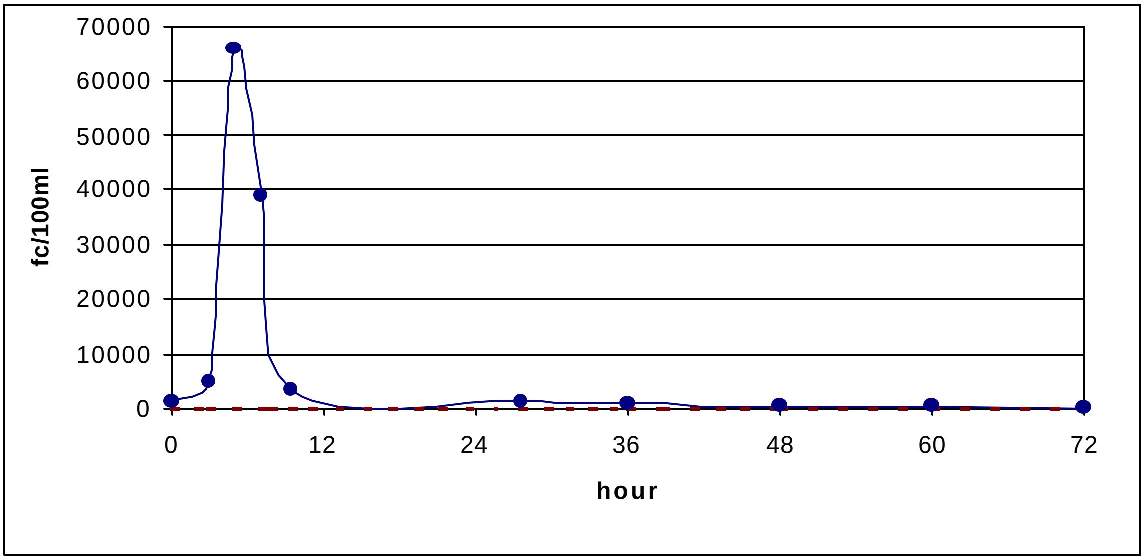


Station FB01

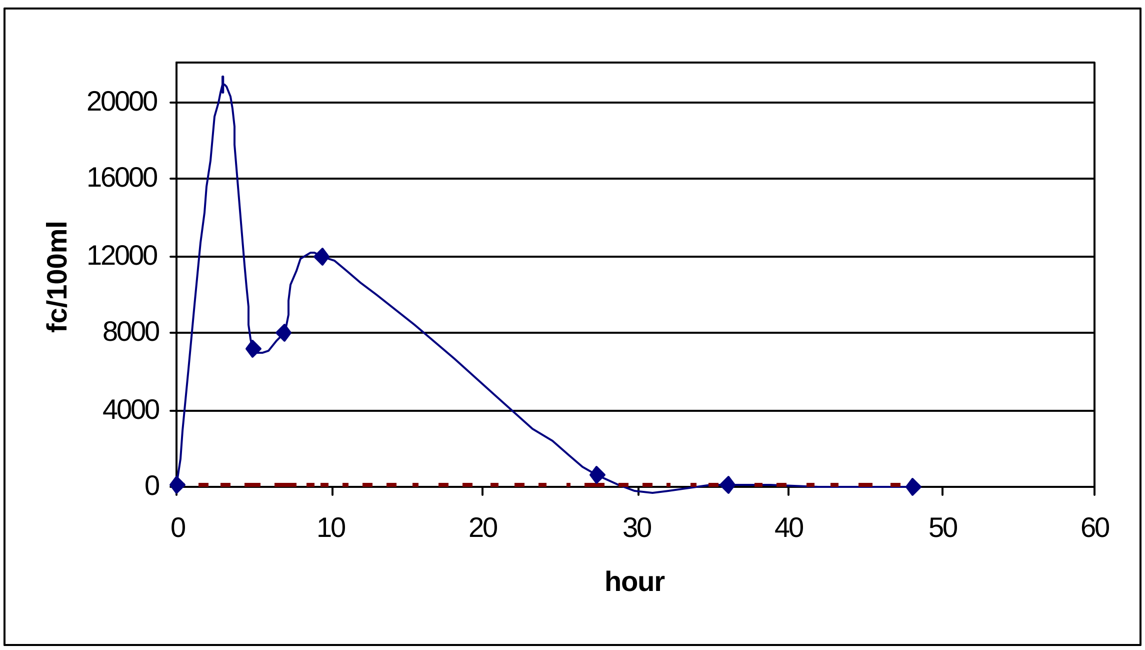


Wet Weather Event #1 (0.56 inches/1.5 hrs) **dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.**

Station FRY03

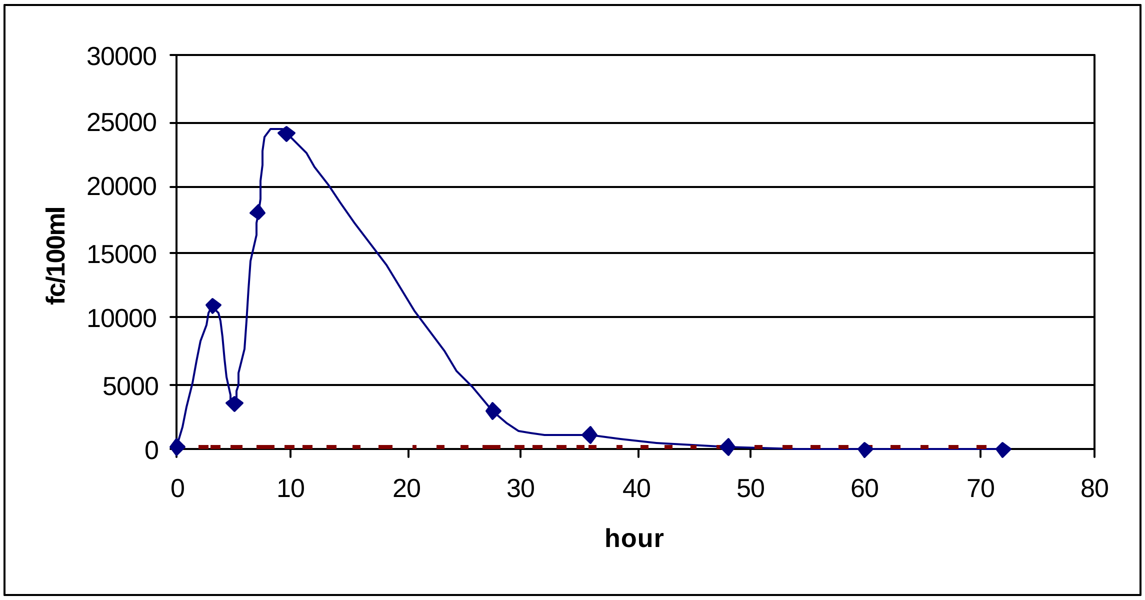


Station HR04

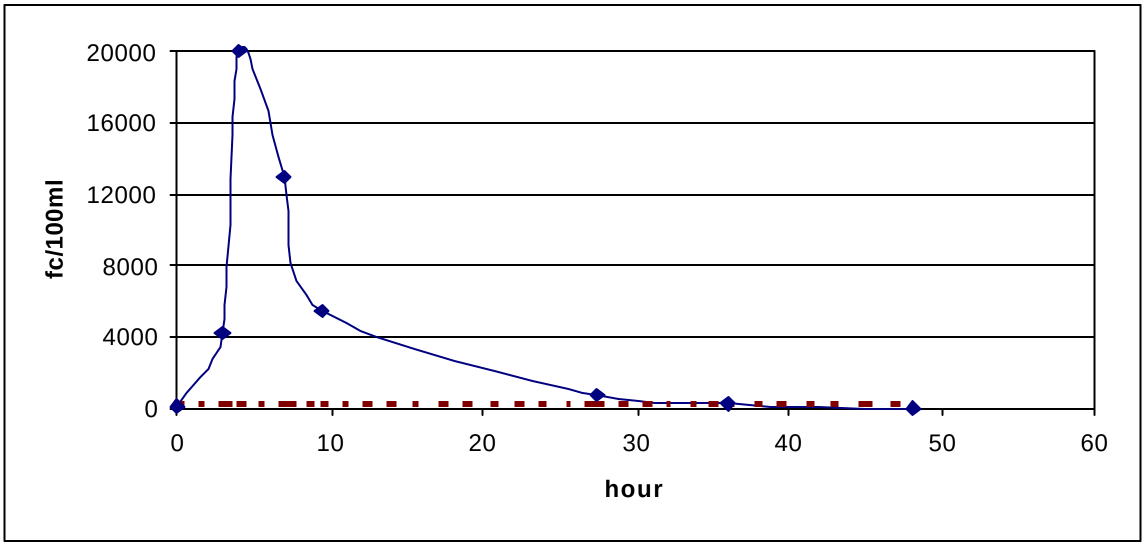


Wet Weather Event #1 (0.56 inches/1.5 hrs) **dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.**

Station HR05

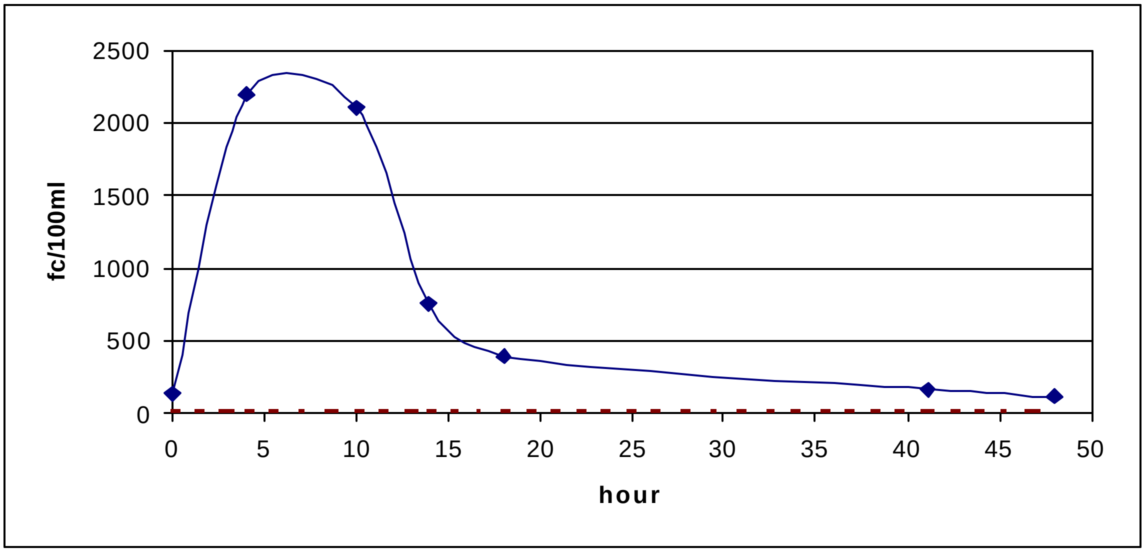


Station SB02

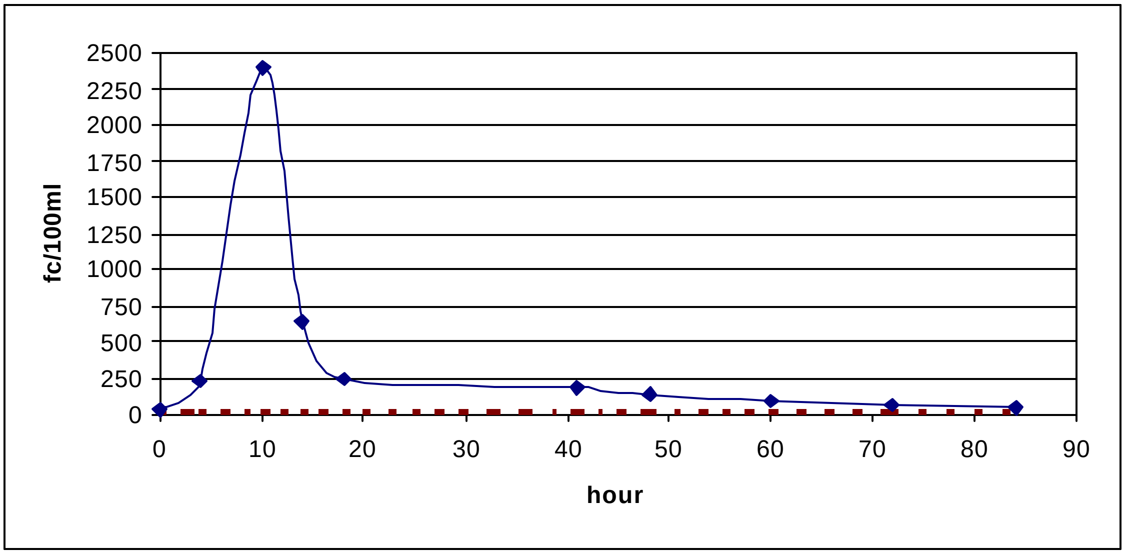


Wet Weather Event #2 (1.74 inches/10 hrs) **dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.**

Station SC01

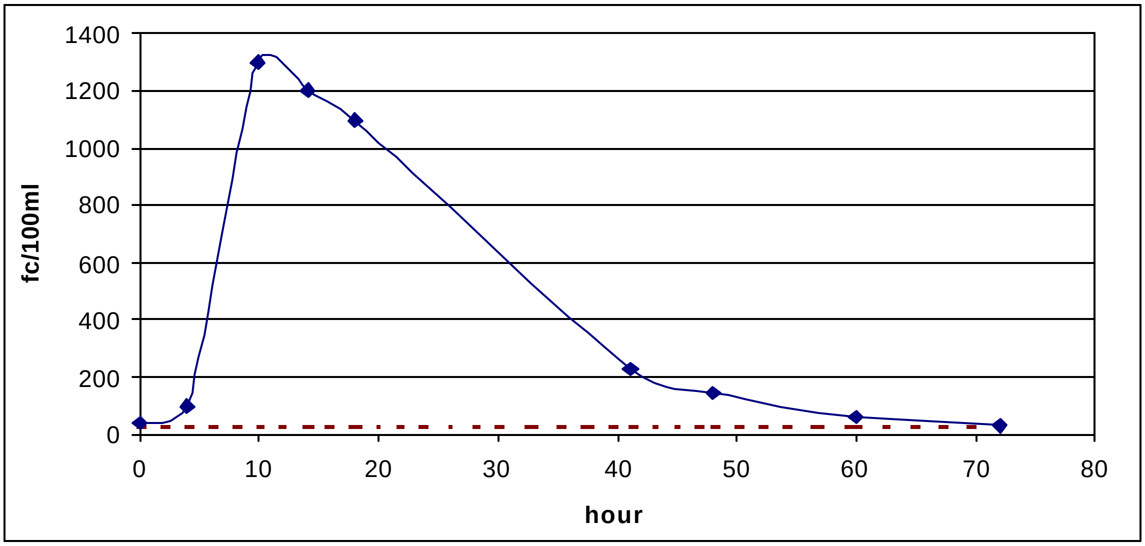


Station HRe

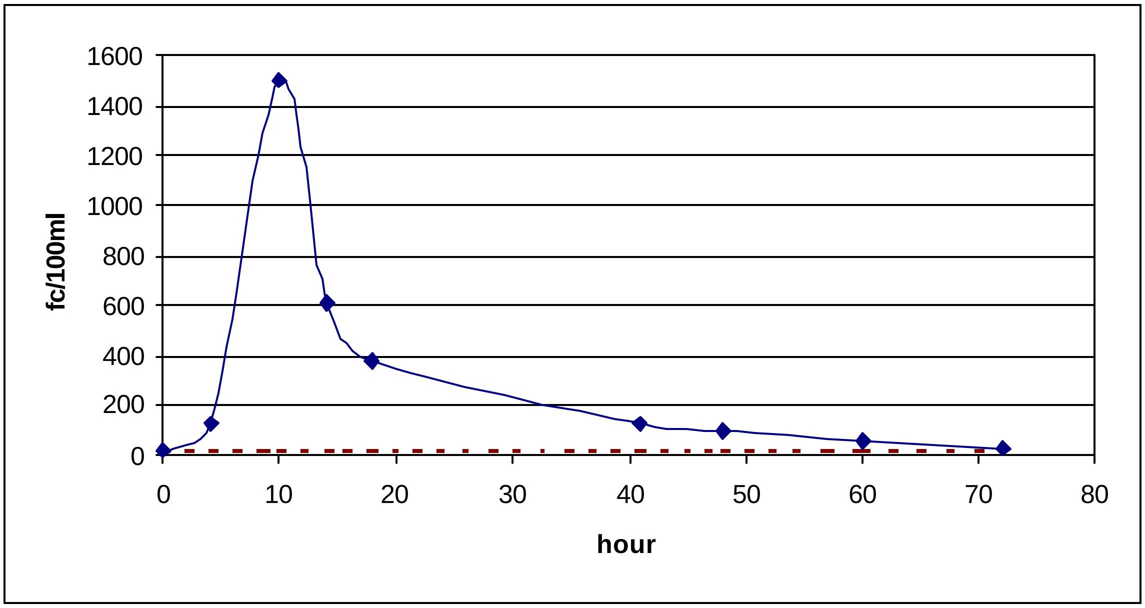


Wet Weather Event #2 (1.74 inches/10 hrs) dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.

Station HR01

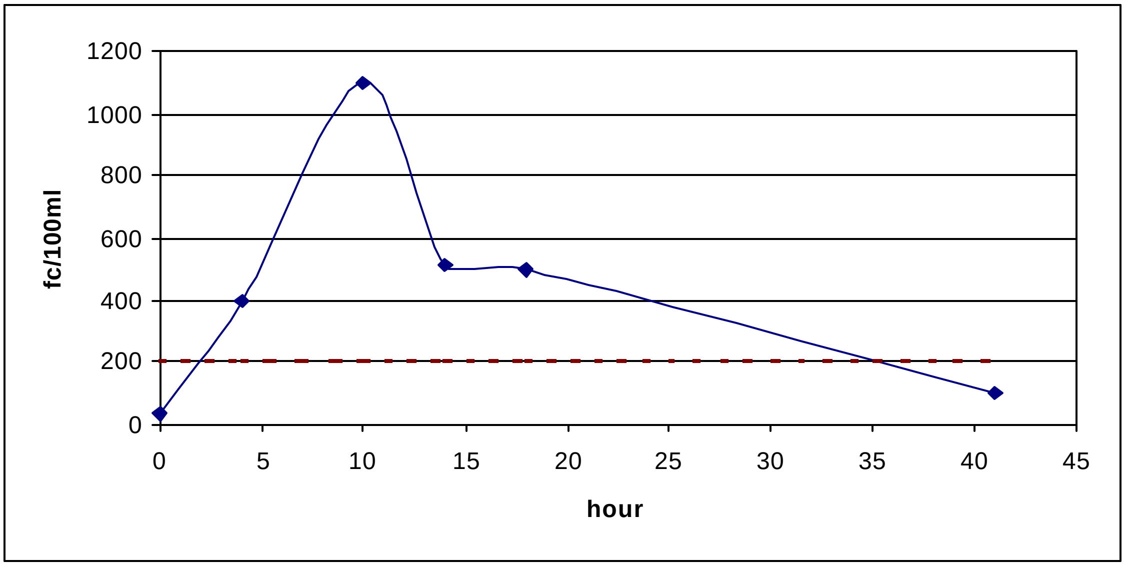


Station FB01

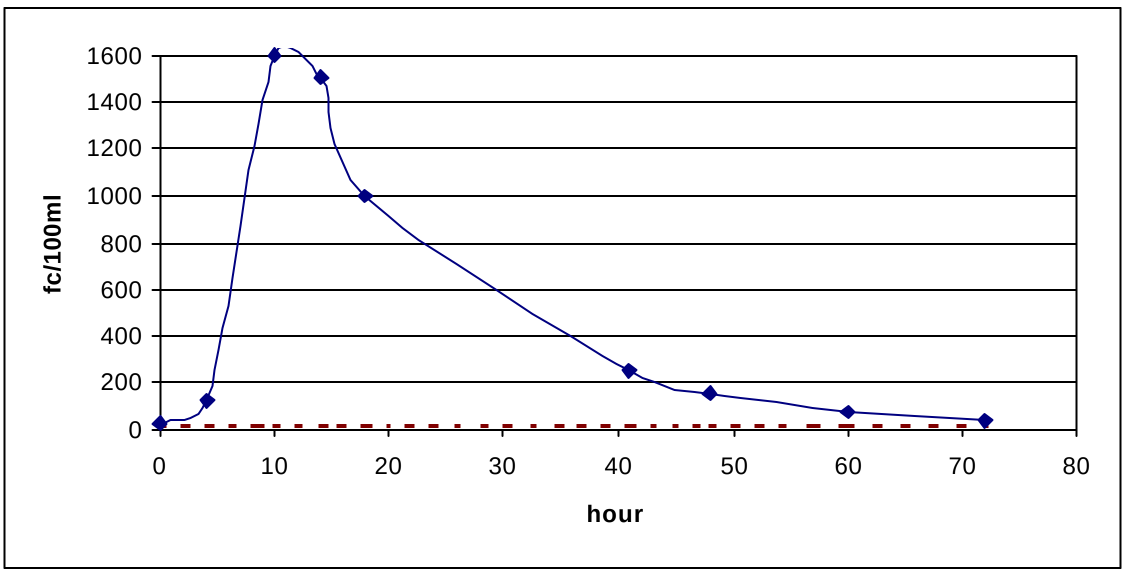


Wet Weather Event #2 (1.74 inches/10 hrs) dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.

Station HR03

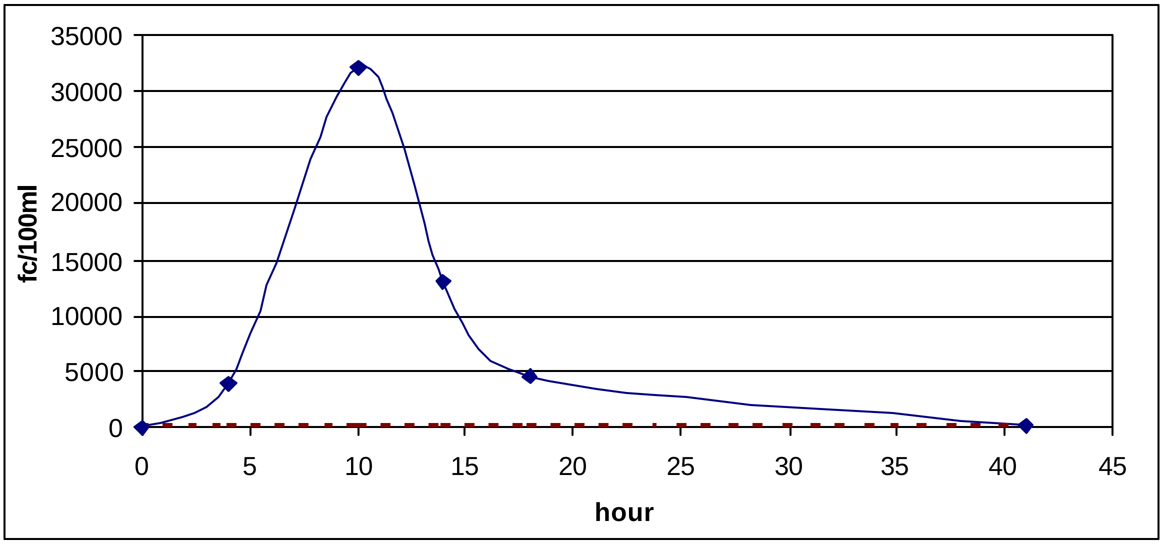


Station FRY03

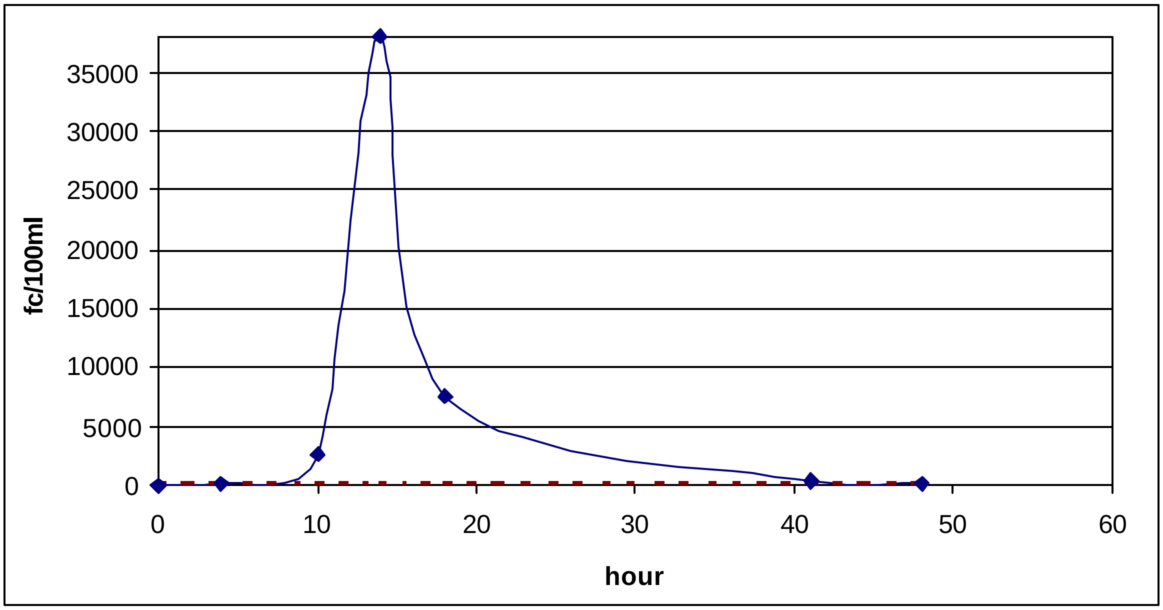


Wet Weather Event #2 (1.74 inches/10 hrs) **dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.**

Station HR04



Station HR05



Wet Weather Event #2 (1.74 inches/10 hrs) **dashed line denotes Class A or Class B standards of 20 fc/100ml or 200 fc/100ml, respectively.**

Station SB01