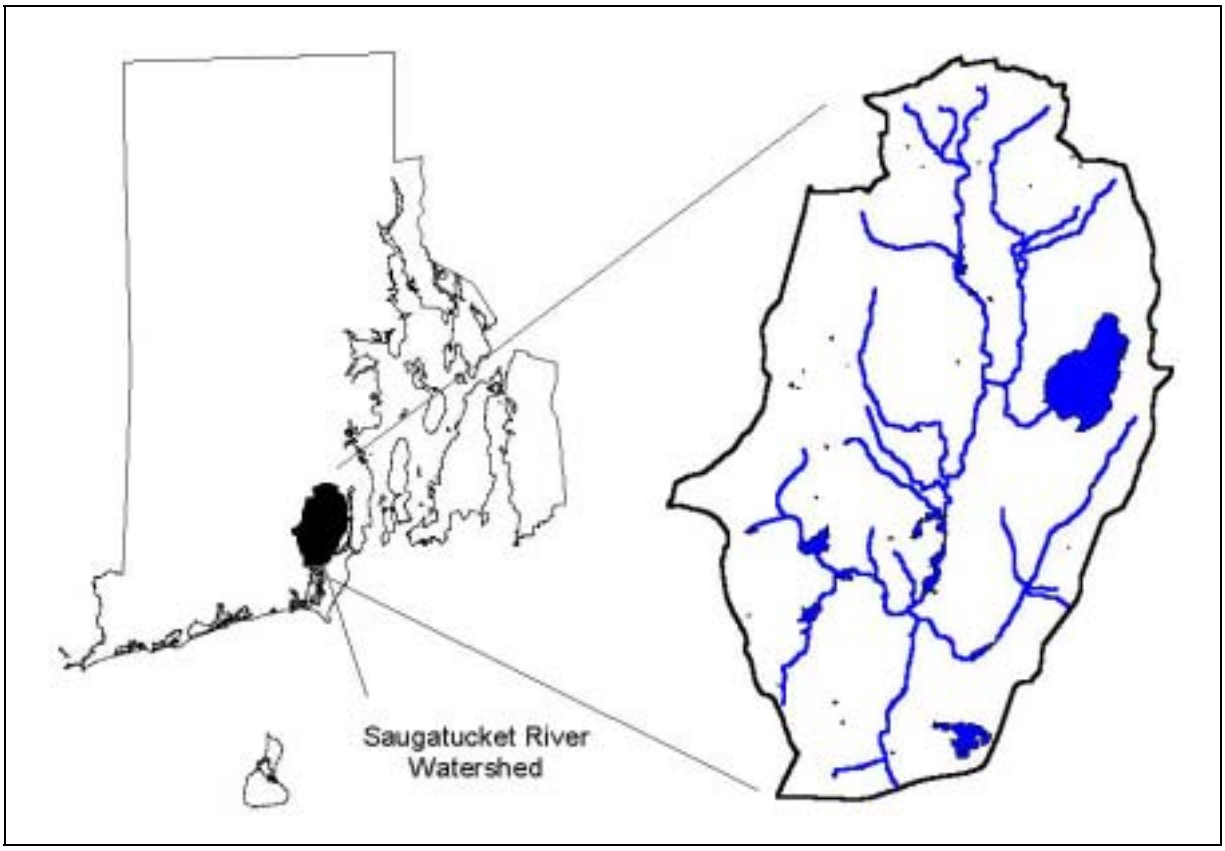
STATE OF RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Office of Water Resources
235 Promenade Street, Providence, RI 02908

FINAL

Pathogen TMDL for Saugatucket River, Mitchell Brook, Rocky Brook and Indian Run Brook

May 16, 2003



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LIST OF ACRONYMS AND TERMS

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

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

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

DPA = Densely populated area

EPA = the United States Environmental Protection Agency

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

LA = Load allocation, the portion of a receiving water's loading capacity that is allocated either to nonpoint sources of pollution or to natural background sources.

Loading capacity = means the maximum pollutant loading that a surface water can receive without violating water quality standards.

MOS = Margin of safety. Because bacteria levels are variable, it is possible that the specified reductions may not be adequate to allow water quality to meet standards. To account for this uncertainty, an additional reduction in bacteria levels beyond the required numeric bacteria concentration is specified. This can be achieved by using conservative assumptions, an explicitly allocated reduction, such as a level 10% below the standard, or a combination of both techniques.

MPN = Most probable number. An estimate of microbial density per unit volume of water sample, based on probability theory.

MS4 - Municipal separate storm sewer system.

Natural Background = all prevailing dynamic environmental conditions in a waterbody or segment, other than those human-made or human-induced. Natural background bacteria concentrations include contributions from wildlife and/or waterfowl.

Nonpoint source = any discharge of pollutants that does not meet the definition of point source in section 502.(14). of the Clean Water Act. Such sources are diffuse, and often associated with

land use practices that carry pollutants to the waters of the state. They include but are not limited to, non-channelized land runoff, drainage, or snowmelt; atmospheric deposition; precipitation; and seepage.

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

RIDEM = Rhode Island Department of Environmental Management

RIPDES = Rhode Island Pollution Discharge Elimination System. The state level program that is responsible for the regulation of point source (Phase I) and MS4 (Phase II) discharges to waterbodies of the state.

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

SWMPP= Stormwater management program plan

TMDL = Total maximum daily load, the amount of a pollutant that may be discharged into a waterbody without violating water quality standards. The TMDL is the sum of wasteload allocations for point sources, load allocations for nonpoint sources, and natural background. Also included is a margin of safety.

Water quality standard = provisions of state or federal law which consist of designated use and water quality criteria for the waters of the state. Water quality standards also consist of an antidegradation policy. Rhode Island's water quality regulations may be found at http://www.state.ri.us/dem/pubs/regs/REGS/WATER/h20qlty.pdf.

WLA = Waste load allocation, the portion of a receiving water's loading capacity that is allocated to point sources of pollution.

EXECUTIVE SUMMARY

1. Description of Waterbody, Priority Ranking, Pollutant of Concern, and Pollutant Sources

Description of Waterbody

The Saugatucket River Basin is south-centrally located in Rhode Island on the westerly side of Narragansett Bay. The watershed drains approximately 16.5 square miles (10,560 acres) and includes parts of four Rhode Island communities: Exeter, Narragansett, North Kingstown, and South Kingstown. The watershed includes the Saugatucket River and its major tributaries, Indian Run Brook, Rocky Brook, and Mitchell Brook.

Based on recent land use information (URI 1995), land use in the watershed is 57.0% forest, 15.21% wetland, 4.23% agriculture, 1.08% commercial-industrial, 2.42% roads, 6.16% high-medium density residential, 6.76% medium-low density residential, 0.81% low density residential, and 6.33% other. The commercial-industrial and majority of the high-medium density residential areas are in the southern half of the watershed.

As reported in the state's 2000 303(d) List of Impaired Waters, the Saugatucket River was listed as impacted by fecal coliform bacteria for a length of approximately 1.6 miles, Indian Run Brook for a length of approximately 4.5 miles, Rocky Brook for a length of 0.75 miles (3,900-ft) , and Mitchell Brook for a length of approximately 1.4 miles. The majority of bacteria violations in the watershed were found to occur during wet weather conditions.

Priority Ranking

The Saugatucket River, Indian Run Brook, Rocky Brook, and Mitchell 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 Saugatucket River TMDL has been developed for fecal coliform, which has been found to exceed the state's water quality standards. Both dry and wet weather water quality data have been collected in the Saugatucket River watershed, revealing elevated fecal coliform concentrations at both instream and tributary stations. Based on this data, Saugatucket River, Indian Run Brook, Rocky Brook, and Mitchell Brook were placed on the state's 303(d) List of Impaired Waterbodies.

Pollutant Sources

RIDEM has identified the major sources of fecal coliform bacteria in the Saugatucket River watershed. These include stormwater runoff from highways and residential/commercial areas, a cow farm, pigeons roosting under the Palisades Industries Complex and the Main Street bridge, resident waterfowl, domestic pets, and wildlife. All sources are summarized below in Table 1. The largest dry weather sources of bacteria are the cow farm, pigeons roosting under the Palisades and Main Street Bridge, resident waterfowl, and other wildlife. Cumulatively, the largest wet weather source of bacteria to the watershed is stormwater runoff. A detailed description of individual sources is presented on a segment-by-segment basis in the Water Quality Impairment section of this report.

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

Location	Dry weather sources	Wet weather sources
Saugatucket River	Inputs from Mitchell Brook and contributions from pigeons	Stormwater runoff, inputs from Indian Run Brook, Rocky Brook, and Mitchell Brook, contributions from pigeons, waterfowl, pet waste and wildlife
Indian Run Brook	Contributions from wildlife	Stormwater runoff, contributions from waterfowl and other wildlife
Rocky Brook	Contributions from wildlife	Stormwater runoff, contributions from pet waste and wildlife
Mitchell Brook	Cow farm, contributions from wildlife	Stormwater runoff, dairy farm, wildlife contributions

Natural Background

Based on field observations and review of land use information, natural background loads from wildlife, especially pigeons, and other sources are thought to make up a significant portion of the total fecal coliform load in the Saugatucket 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

State Water Quality Standard

Section 8.B(1)(b) of the Water Quality Regulations describes Class B waters:

- *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.*

Section 8.B(2)(b) of the Water Quality Regulations describes Class SB waters:

- *These waters are designated for primary and secondary contact recreational activities; shellfish harvesting for controlled relay and depuration; and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation, and industrial cooling. These waters shall have good aesthetic value.*

At the point where the Saugatucket River discharges over the Main Street dam, it must meet the more stringent Class SB water quality standard.

Numeric Water Quality Criteria

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 Saugatucket River TMDL, the applicable Class B fecal coliform standards were used as the applicable endpoint, with the exception of the monitoring stations located above and below the Main Street dam. The applicable Class SB fecal coliform standard was used for the endpoint at those stations. The standards state that fecal coliform concentrations in Class B waters shall not 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. The standards also state that fecal coliform concentrations in Class SB waters shall not exceed a geomean value of 50 fc/100 and not more than 10% of the samples shall exceed a value of 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).

Designated and existing uses for all waterbodies in the Saugatucket 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 Saugatucket River watershed that are impaired by elevated levels of fecal coliform bacteria.

3. Total Maximum Daily Load Analysis

As described in EPA guidelines, a TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards (40 C.F.R. 130.2). The TMDL is often defined as the sum of loads allocated to point sources (i.e. waste load allocation, WLA), loads allotted to nonpoint sources, including natural background sources (i.e. load allocation, LA), and a margin of safety (MOS). The loadings are required to be expressed as mass per time, toxicity, or other appropriate measures (40 C.F.R. 130.2[I]). For the allocation of fecal coliform sources, USEPA Region 1 has stated that the TMDL may alternatively be expressed in concentration units (mass per unit volume). Accordingly, the Saugatucket River watershed TMDL is based directly on the state's two part fecal coliform standard. The rationale for this approach is further described in Section 7.0 of the report.

4. Establishing a numeric water quality target

Margin of Safety (MOS)

The MOS may be incorporated into the TMDL in two ways. One can implicitly incorporate the MOS using conservative assumptions to develop the allocations or explicitly allocate a portion of the TMDL as the MOS. For this analysis, an implicit MOS is provided. The conservative assumptions utilized in developing the Saugatucket watershed TMDL are described in Section 7.1 of the report.

Seasonal Variation/Critical Conditions

Water quality monitoring carried out by RIDEM in past years has shown that fecal coliform concentrations in streams and rivers tend to be at their highest during the summer months. In addition, past monitoring has shown that fecal coliform levels increase significantly during wet weather and high flow events. Monitoring conducted in support of this TMDL focused on the critical summer season and included both wet and dry weather conditions. Therefore, the Saugatucket River TMDL is protective of all seasons.

Numeric Water Quality Target

The water quality target for the Saugatucket River and its tributaries is set at the state's Class B fecal coliform standard, which is a geometric mean of 200 fc/100 ml with an 80^{th} percentile concentration no greater than 500 fc/100 ml. To be protective of downstream water quality, the Saugatucket River must meet the more stringent Class SB fecal coliform standard (geometric mean of 50 fc/100 ml with a 90^{th} percentile concentration of 500 fc/100 ml) at the point of discharge to the estuarine portion of the river.

5. Required reductions (Load Allocation/Waste Load Allocation)

As described above, the loading capacity for this TMDL is expressed as a concentration set equal to the state water quality standard. Extensive field surveys, water quality monitoring, and review of aerial photos/topographic maps were used to establish the link between pollutant sources and in-stream concentrations.

The reduction goal for each segment was determined by comparing current fecal coliform concentrations to the applicable water quality target, then calculating the percent reduction required to reach that target. Since the water quality regulations specify both a geometric mean criterion and the 80^{th} or 90^{th} percent criterion, two calculations are made at each location. These values were then compared to the applicable SB or B portions of the standard. The required reductions for each reach were determined by selecting the station within each reach having the largest violation relative to both parts of the state's fecal coliform standard, as presented in Table 2. The numbers in bold represent the required reduction for each stream segment.

Other than storm sewer outfalls, there are no point sources discharging to the Saugatucket River, Mitchell Brook, Rocky Brook or Indian Run. The required fecal coliform reductions are calculated from observed concentrations at in-stream stations and represent a reduction goal that is applicable to the composite of all point and nonpoint sources contributing to the water quality impairment. Due to the unavailability of data to accurately differentiate point sources (storm

water outfalls) and nonpoint sources, it was not possible to calculate a separate waste load allocation. As such, the required reductions serve as both a load allocation and a waste load allocation.

6. Strengths and Weaknesses in the TMDL Process.

The Saugatucket River TMDL was developed using RIDEM-2000 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. Linkages between pollution sources and the high fecal coliform counts identified by RIDEM field monitoring were confirmed by subsequent site visits to the watershed.

Strengths:

- Approach utilized extensive knowledge of land use in the watershed.
- TMDL based on extensive dry and wet weather monitoring conducted over a multi-year period.
- Runoff and recovery parameters were derived from extensive databases, validated with field observations, and determined to be appropriate, yet conservative, for this application.

Weaknesses:

- Absence of flow data and stage-discharge relationships for waterbodies.

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

Waterbody/ Segment	Station ID	Location	Weighted Geometric Mean Concentration (fc/100ml)	Calculated 80th Percentile	Percent Reduction Needed to Meet Both Parts of the Standard
Rocky Brook	RB9U	Greenwood Dr.	n/a	2200	77
3	RB9D	Greenwood Dr.	3107	6100	**94**
	RB8	Jr. High School	139	220	0
	RB7D	Curtis Corner Rd.	1791	640	89
2	RB6	End of Dam St.	224	170	**11**
	RB5U	Rocky Brook Reservoir outlet	226	78	11
1	RB4	Hopkins Ln.	231	1300	62
	RB3	Anton's Deli	n/a	3900	**87**
	RB2	Patsy's Liquors	383	3800	87
	RB1D	Railroad St.	383	3400	85
Indian Run Brook	IR11	Route 1	417	1000	52
2	IR10	Saugatucket Rd.	1186	8000	**94**
	IR7	St. Dominics	557	1200	64
	IR6	St. Dominics	1201	5200	90
	IR4	Above Indian Run Reservoir outlet	709	3400	85
1	IR3U	Kingstown Rd. at Rt. 108	1022	3100	84
	IR3D	Intersection of Rt. 108, School St. & Indian Run Rd.	n/a	3800	**87**
	IR2	Amos St.	1131	2500	82
	IR1U	Peace Dale Guild	1131	3700	86

Mitchell Brook	MB04	Route 138	288	610	30
	MB03	Rose Hill Rd	884	3300	85
1	MB02	Rose Hill Pet Cemetery	1350	3500	**86**
	MB01	Rose Hill Transfer Station	885	1600	77
Saugatucket River	UT01	Tributary @ Rose Hill Rd.	731	12000	**96**
4	SR03D	Saugatucket Road	329	4500	89
	UT02	Tributary @ Saugatucket Road	1528	12000	**96**
3	SR04D	Above Saugatucket Pond Dam	27	82	0
2	SR05	Church St.	768	2900	**83**
	*SR06U	Above Main St. Dam	183	1000	73
1	*SR06D	Below Main St. Dam (Damon's Hardware)	833	4100	**94**

* Indicates station was evaluated using Class SB standards (90th percentile value shown); % reduction is based upon meeting SB criteria

Numbers in bold represent the required reduction for that segment.

n/a indicates that the weighted geomean was not applicable because station was used for wet weather bracketing only

7. Implementation Plans

This TMDL addresses water quality impairments due to bacteria contamination in the Saugatucket River and its tributaries. Utilizing the water quality monitoring locations established by RIDEM's supplementary monitoring program, the river and tributaries were divided into segments. Water quality data were assessed, load allocations set, and BMPs recommended for each of the segments.

This TMDL relies upon phased implementation to reach its water quality goals. Upon implementation of the TMDL's recommended measures, RIDEM will conduct water quality monitoring to determine the effectiveness of these actions in meeting water quality goals.

In almost every stream segment of the Saugatucket River, untreated stormwater runoff from roads, streets, and residential/commercial land uses impacts water quality. The effective management of stormwater in these existing developed areas will require a watershed-wide approach which combines pollution prevention activities with structural best management practices to reduce the discharge of pollutants and runoff volumes. The stormwater management plans required by the RIPDES Phase II Stormwater permit should set forth the specific actions and schedule for accomplishing the TMDL's goals. It is imperative the RIDEM, RIDOT, and the Town of South Kingstown work cooperatively towards achieving these goals. A summary of recommended remedial actions is provided in Table 3.

Additionally, two other areas of concern were noted within the watershed. At station IR3SW, which is a stormwater outfall at the intersection of Route 108, School Street, and Indian Run Road (Figure 3), an abundance of sand from wintertime street sanding activities was noticed in the Indian Run Brook stream channel. It is recommended that more frequent street sweeping be conducted to minimize the amount of sand and sediment being introduced to the stream. The streambank is eroded from station IR3SW to the Church Street stone bridge and from Spring Street to Columbia Street. High, flashy stormwater flows coupled with mowing practices up to the water's edge have created eroding conditions. It is recommended that streambank stabilization BMPs be implemented to stabilize these two segments of Indian Run Brook. Both areas are located on Town of South Kingstown Property.

Public Outreach/Public Involvement

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

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. This effort should be a component of the public outreach program required by the Phase II Stormwater Management Regulations described later in this section. The Town of South Kingstown is encouraged to work with the Rhode Island Department of Transportation, as an operator of MS4s in the watershed, and the Saugatucket River Watershed Coordinating Council in carrying out this program.

Table 3. BMP recommendations for the Saugatucket River TMDL.

Waterbody/ Segment	Recommended Control Measures	Responsible Entity
Rocky Brook **3**	Catchment area delineation, structural stormwater management measures within catchment area and/or at the outfall at the following location: • **Greenwood Drive** And others as identified by Town/RIDOT	Town of South Kingstown/RIDOT
1	Catchment area delineation, structural stormwater management measures within catchment area and/or at oufall at the following locations: • **Kingstown Road @ Anton's Deli** • **Kingstown Road @ swale below Rocky Bk outlet** • **Railroad Street** And others as identified by Town/RIDOT	RIDOT/ Town of South Kingstown
Indian Run Brook **1**	Pet waste disposal signs/mitts at Peace Dale Green and Old Mountain Fields Catchment area delineation, structural stormwater management measures within catchment area and/or at the outfall at the following location: • **Intersection of Route 108, School Street, and Indian Run Road** And others as identified by Town/RIDOT	Town of South Kingstown RIDOT /Town of South Kingstown
Mitchell Brook **1**	Agricultural BMPs at farm located on Rose Hill Road	Property owner
Saugatucket River **3**	Vegetated buffer strip around pond at URI Agricultural Experiment Station to discourage waterfowl utilization	University of Rhode Island
2	Pigeon Deterrent System at Palisades Industries Complex	Property owners
1	Pigeon Deterrent System at Main Street Bridge	RIDOT
Watershed Wide	Street sweeping, ISDS & stormdrain maintenance, pet waste ordinance, public education & outreach	RIDOT /Town of South Kingstown

The public outreach program in the Saugatucket 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, as well as any other required components of a Phase II Permit.

The Town 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.

Birds, wildlife, and pet wastes

Mitigation of these types of sources can best be addressed by the application of nonstructural BMPs or "good housekeeping" measures. Important actions include policing pet wastes, minimizing fertilizer applications, minimizing impervious cover and restoring the beneficial value of destroyed or degraded wetlands. Pet wastes should be disposed away from the river, tributary streams and all stormwater conveyances. The application of fertilizers and pesticides to gardens and lawns should be limited to recommended doses and avoided prior to rain events. Impervious surfaces in the watershed should be minimized to decrease the volume of runoff generated during storm events.

There are several measures that residents can take to minimize bird-related impacts. They can allow tall, coarse vegetation to grow along the banks of the river segments frequented by waterfowl. Waterfowl, especially grazers like geese, desire easy access from the water to the riverbanks. Leaving an uncut vegetated buffer will make the habitat less desirable to geese and encourage migration. As an alternative, residents along the waterfront can also install commercially available fencing specifically designed for this purpose. Residents should also stop feeding the birds. Eliminating this practice should also help to decrease summer bird populations and make the area less attractive to the year-round residence of migratory birds.

Storm sewer discharges

Storm water runoff is the largest wet weather source of bacteria to the Saugatucket River and its tributaries. Storm sewers magnify the problem by rapidly collecting, concentrating and directly routing polluted runoff to receiving waters. They supply the majority of the fecal coliform load to the river during wet weather. Consistent with the goals of this TMDL, outfalls are targeted for water quality best management practices to mitigate pollutant loadings to the maximum extent technically feasible.

"End-of-pipe" structural BMPs designed to treat current flows and pollutant loadings at the storm sewer outfalls would necessarily be rather expensive and/or require substantial land area. RIDEM suggests that a multi-faceted storm water management strategy be incorporated by the Town of South Kingstown and RIDOT that utilizes a combination of end-of-pipe structural BMPs, smaller-scale structural retention/infiltration BMPs located up-gradient within the catchment areas and the implementation of nonstructural BMPs throughout the watershed.

As mandated by EPA, RIDEM has amended the existing Rhode Island Pollution Discharge Elimination System (RIPDES) regulations to include Phase II Storm Water Regulations (effective March 19, 2002). Automatically designated municipalities must develop a storm water management program plan (SWMPP) that describes the Best Management Practices (BMPs) for each of the following minimum control measures:

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

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

Operators of municipal separate storm sewer systems (MS4s) within urbanized areas (UAs) or densely populated areas (DPAs) will be required to develop a SWMPP and obtain a permit (for those portions within the UA or DPA) by March 10, 2003. DPAs include places that have equal to or greater than 1,000 people per square mile and have, or are part of, a block of contiguous census designated places with a total population of at least 10,000 people, as determined by the latest Decennial Census. Operators of MS4s located outside of UAs and DPAs and that discharge to Special Resource Protection Waters (SRPWs), Outstanding National Resource Waters (ONRWs), or impaired waters will also be required to obtain a permit (or expand permit coverage throughout the jurisdiction) by March 10, 2008, unless the operator has demonstrated effective protection of water quality to the satisfaction of the Director. The Director will also require permits for MS4s that contribute to a violation of a water quality standard, are significant contributors of pollutants to waters of the state or that require storm water controls based on waste load allocations (WLAs) determined through a TMDL.

The MS4s that discharge to the Saugatucket River are owned and operated by the Town of South Kingstown, or by the Rhode Island Department of Transportation (RIDOT). As noted in the RIPDES Regulations, year 2000 census data shows that portions of the Saugatucket River watershed in the villages of Wakefield and Peace Dale meet the criteria of a UA or a DPA. Accordingly, the Town of South Kingstown will be required to apply for a RIPDES permit for portions of their MS4's located within the appropriate UA or DPA by March 10, 2003. The remaining South Kingstown and RIDOT storm sewer outfalls within the watershed are part of MS4s that are not located in a UA or DPA. However, because they discharge significant loadings to an impaired waterbody (which is also a SRPW), because these loadings contribute to a

violation of a water quality standard, and because it has been determined through this TMDL that storm water controls are necessary to restore water quality, the operators will be required to obtain a RIPDES permit (or expand coverage of an existing permit). These areas include MS4s that drain to Mitchell Brook and the portion of Indian Run Brook upstream of Saugatucket Road.

RIDEM will continue to work with the Town of South Kingstown, Rhode Island Department of Transportation (RIDOT), and the Saugatucket River Heritage Corridor Coalition (SRHCC) to identify funding sources and to evaluate locations and designs for storm water control BMPs throughout the watershed. In accordance with the requirements of this phased TMDL, monitoring of the Saugatucket River watershed water quality will continue so that the effectiveness of ongoing remedial activities can be gauged.

Urban stormwater runoff from roads and residential/commercial land uses impacts water quality in several portions of the Saugatucket 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 Town of South Kingstown to highlight these concerns and by supporting their stormwater management planning, including the construction of BMPs where needed.

8. 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 Saugatucket River watershed in order to assess BMP effectiveness. This monitoring plan is detailed in the TMDL report.

9. 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 April 2, 2003, which also initiated the 30-day public comment period.

1.0 INTRODUCTION

The 1998 and 2000 List of Impaired Waters (i.e., the 303(d) list) identifies the Saugatucket River (RI10010045R-05B), Indian Run Brook (RI10010045R-02), Rocky Brook (RI10010045R-04), and Mitchell Brook (RI10010045R-03A) as impaired by pathogens. The purpose of this report is to establish a Total Maximum Daily Load (TMDL) to address fecal coliform contributions to these targeted waterbodies. This TMDL serves as a restoration plan aimed at abating pollution sources so that fecal coliform standards can be attained in the river and its tributaries.

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 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.

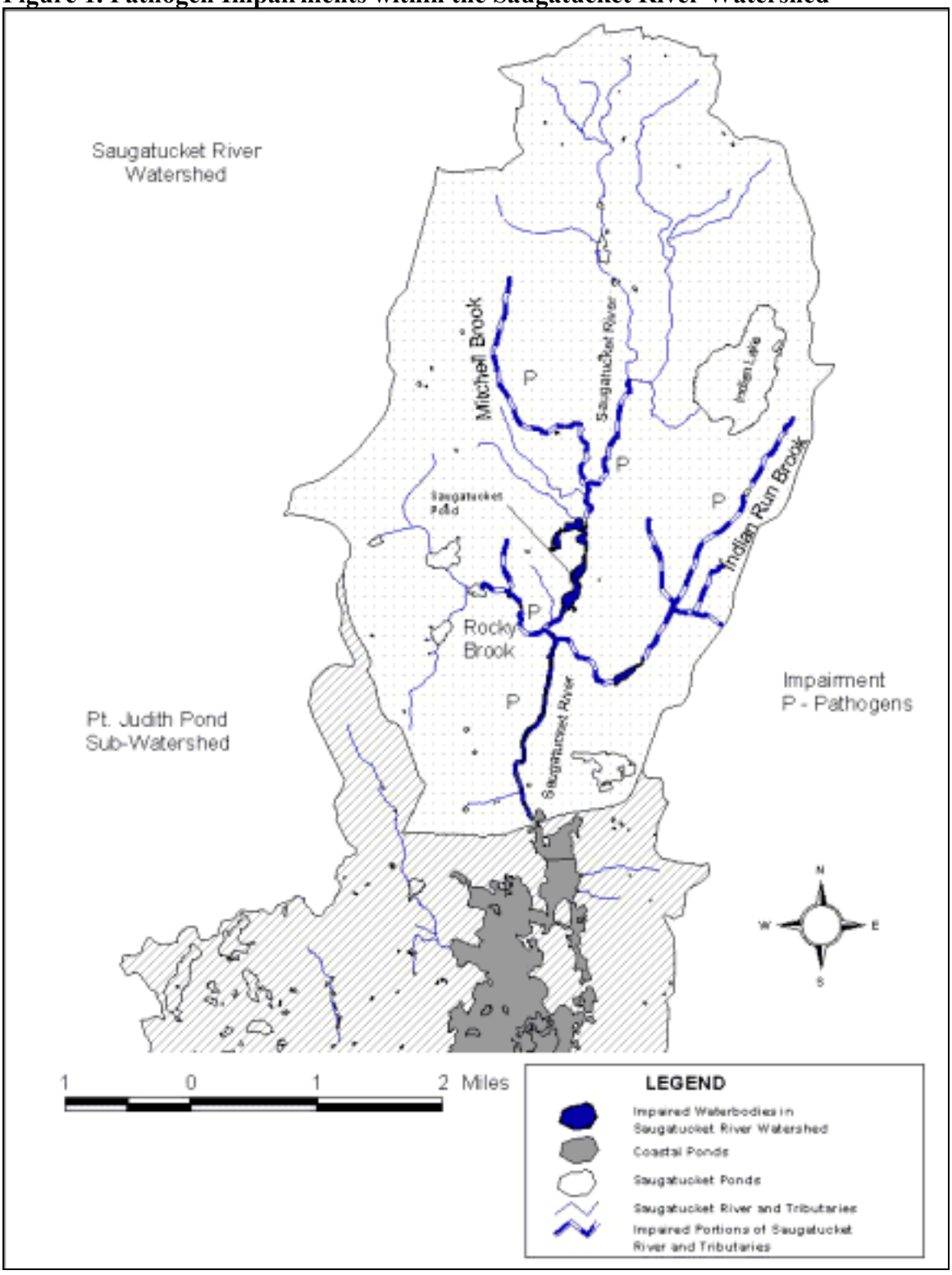
1.2 Pollutant of Concern

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 in Saugatucket River, Indian Run Brook, Rocky Brook, and Mitchell Brook. The length and location of the impairment for each waterbody is shown in Table 4 and Figure 1.

Table 4. Water Quality Impairments within the Saugatucket River Watershed

Waterbody	Size/length of impairment	Impairment
Saugatucket River	1.6 mi.	Pathogen-from Rose Hill Landfill area to the dam at Main Street in Wakefield
Indian Run Brook	4.5mi.	Pathogens- entire waterbody
Rocky Brook	1.8 mi.	Pathogens- entire waterbody
Mitchell Brook	1.4 mi.	Pathogens- entire waterbody

Figure 1. Pathogen Impairments within the Saugatucket River Watershed



1.3 Applicable Water Quality Standards

All surface waters of the state have been categorized according to a system of water quality classification which establishes designated uses 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, designated 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.

Rhode Island's Water Quality Regulations (RIDEM, 1997) classify the following waterbodies found in the Saugatucket River watershed as Class B waters:

- Asa Pond
- Fresh Meadow Brook
- Indian Lake
- Indian Run Brook
- Mitchell Brook
- Peace Dale Reservoir
- Rocky Brook
- Rocky Brook Reservoir
- Saugatucket Pond
- Saugatucket River (headwaters to Main Street Dam)

Though the estuarine portion of the Saugatucket River (downstream of the Main Street bridge), classified as Class SB waters, is not included in this TMDL, its water quality classification must be considered to ensure that the goal for the upstream reach is protective of these downstream uses. Accordingly, this TMDL sets forth the goal that the freshwater reach of the Saugatucket River meet the more stringent SB fecal coliform standard at the point of its discharge to the estuarine reach at the Main Street dam.

1.4 Designated Uses

Section 8.B(1)(b) of the Water Quality Regulations describes Class B waters:

- *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.*

Section 8.B(2)(b) of the Water Quality Regulations describes Class SB waters:

- *These waters are designated for primary and secondary contact recreational activities; shellfish harvesting for controlled relay and depuration; and fish and wildlife habitat. They shall be suitable for aquacultural uses, navigation, and industrial cooling. These waters shall have good aesthetic value.*

1.5 Water Quality Criteria

Rule 8.D of the Water Quality Regulations establishes the physical, chemical, and biological criteria necessary to support the water use classifications of Rule 8.B. In particular, Rule 8.D(2) and 8.D(3) establishes class-specific criterion for fresh and salt waters, respectively.

For waters of the State that are classified as Class B and Class SB, the following fecal coliform criteria apply:

Class B: Fecal coliform concentrations 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.

Class SB: Fecal coliform concentrations not to exceed a geometric mean MPN value of 50 MPN/100ml and not more than 10% of the samples shall exceed an MPN value of 500 MPN/100ml.

2.0 DESCRIPTION OF THE WATERBODIES

2.1 Saugatucket River

The Saugatucket River flows from north to south through South Kingstown and has an overall approximate length of 7.1 miles. This TMDL addresses water quality impairments in the reach extending from the Rose Hill Landfill to the dam at Main Street in Wakefield and one station below the dam adjacent Damon's Hardware (Figure 2). The impacted section is 1.6 miles long. The Saugatucket River drains an area of 16.5m^2 (42.7 km^2, 10,560 ac). The headwaters of the Saugatucket River are in North Kingstown. The Saugatucket River passes through the villages of Peace Dale and Wakefield.

Two impoundments are located on the River as follows:

- The first impoundment is located in the Village of Peace Dale approximately 350-feet north of Kingstown Road (RI Rt. 108). This impoundment is commonly referred to as Saugatucket Pond or Peace Dale Pond and in addition to bacteria impairments, is identified on the 2000 303(d) list as impaired by phosphorus and noxious aquatic plants. These nutrient related impairments are being evaluated contemporaneously, however will be written up in a separate TMDL study report. Saugatucket Pond is approximately 41 acres in size, with a maximum depth of 3 meters (9.8-feet). It is classified as a shallow waterbody (Greene and Herron, 1992). The River enters the Pond approximately 500-feet south of where Saugatucket Road crosses the River. The Pond roughly runs lengthwise parallel to North Road in Peace Dale with the northwestern section bisected by North Road.

- The second impoundment is located approximately 100-feet north of where Main Street crosses the River. This impoundment is known as Wakefield Pond, and is approximately 10.7 acres in size. The impoundment is linear in shape and extends northward to a point near the southern side of Church Street.

The River becomes tidally influenced below the dam at Main Street. After flowing over the dam, the River continues south into the Point Judith Pond.

2.2 Indian Run Brook

Indian Run Brook flows from northeast to southwest through South Kingstown, and has an approximate length of 4.5 miles. The stream originates in a swamp east of Route 1 and adjacent to Indian Lake (Figure 3). The upper portion of Indian Run Brook is located within forest and wetland habitat while the lower portion runs through suburban sections of Wakefield before emptying into the Saugatucket River approximately 300-feet south of the Palisades mill complex. Indian Run Brook has one major impoundment, Indian Run Reservoir, which is 7.7 acres in size. The Reservoir is located east of Kingstown Road in Wakefield and is immediately adjacent to the Old Mountain Field Recreational Area.

Indian Run Brook has a second, smaller impoundment, located immediately north of Saugatucket Road. This impoundment has no name, and is 1.43 acres in size. It is accessible from a dirt parking/turnaround area adjacent Saugatucket Road. A crude dam made of fieldstone is present near its outlet under Saugatucket Road. However, the road appears to be originally built up over the swamp that is associated with the stream, and an undersized culvert running under the road also contributes to ponding of the water.

In addition to the pathogen impairment addressed by this TMDL, Indian Run Brook is also identified on the 2000 303(d) list as impaired by copper, lead, and zinc. A separate TMDL to address these dissolved metal impairments is in preparation.

2.3 Rocky Brook

Rocky Brook (Figure 4) has an approximate length of 1.8 miles. Rocky Brook originates from a swamp located north of Greenwood Drive and west of Kingstown Road. It enters the Saugatucket River near the southwest corner of the Palisades Mill Complex approximately 700-feet upstream from where Indian Run Brook enters the Saugatucket River. Rocky Brook has the most in-stream impoundments of any of the tributaries located in the watershed. It includes two impoundments associated with tributaries of Rocky Brook, and four in-stream impoundments. The two impoundments associated with tributaries of Rocky Brook are located as follows:

Figure 2. Impaired Section of the Saugatucket River, Unnamed Tributaries, and RIDEM Monitoring Segments and Stations

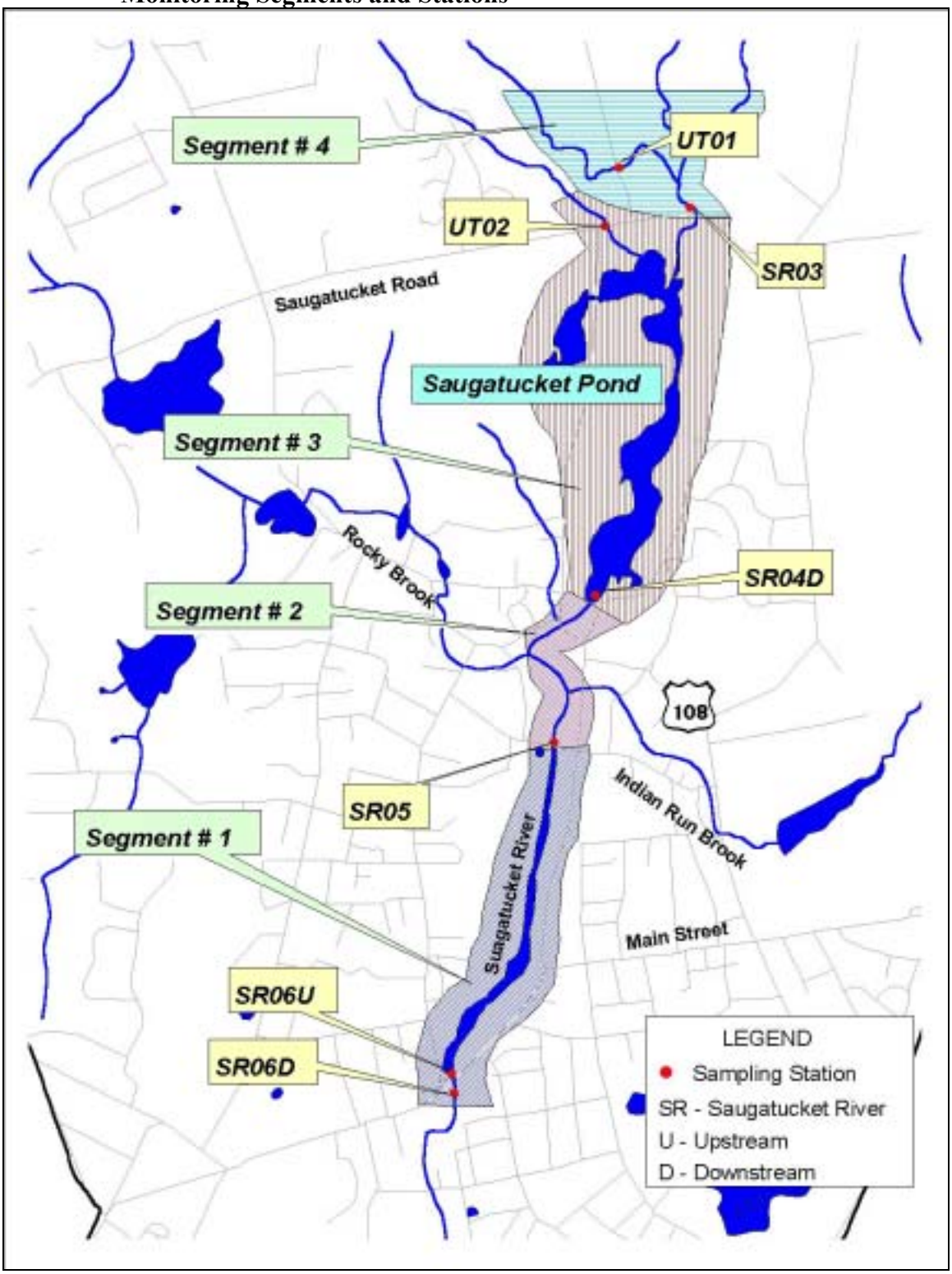
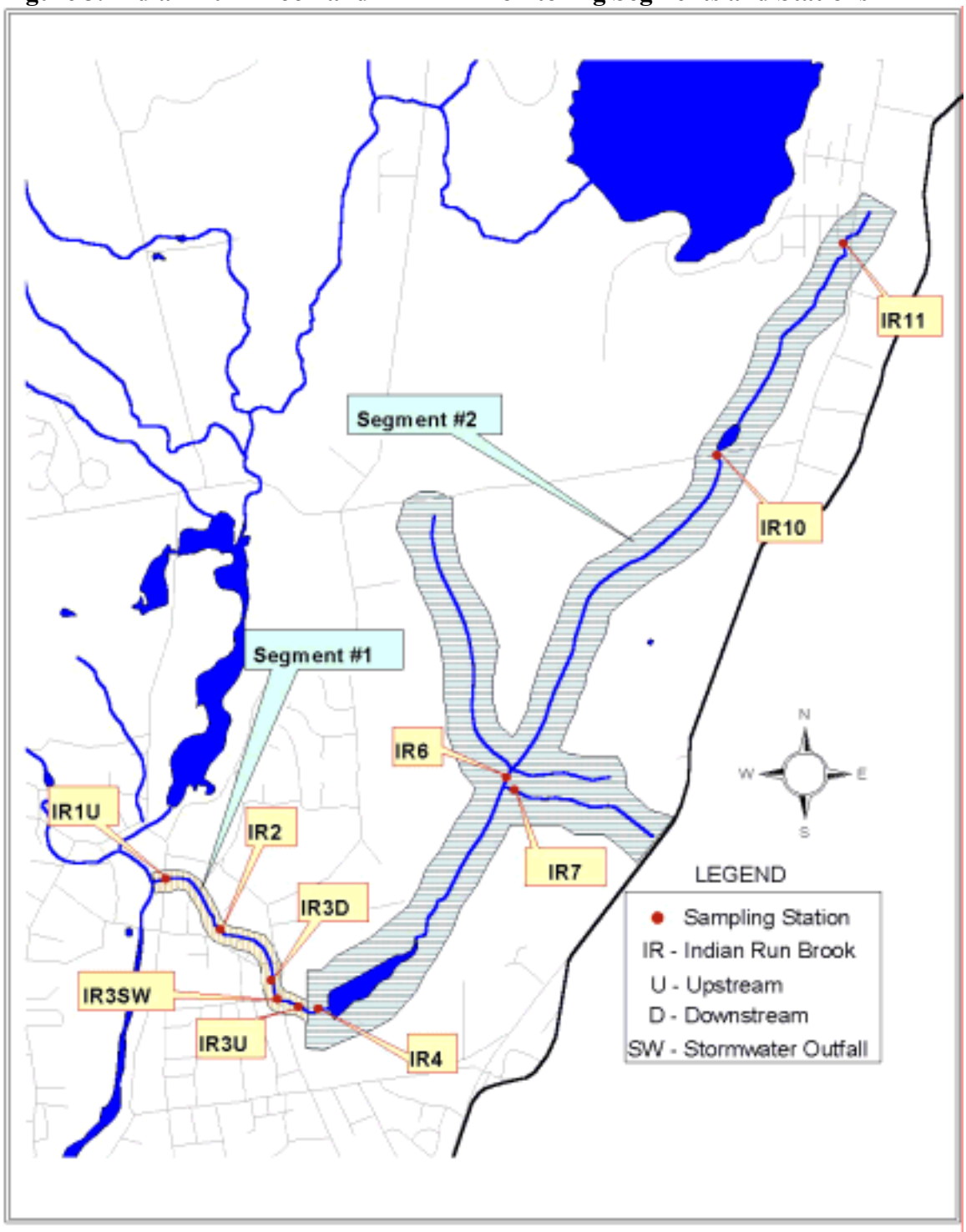


Figure 3. Indian Run Brook and RIDEM Monitoring Segments and Stations



The northernmost tributary impoundment is associated with an unnamed stream that enters Rocky Brook in a wooded swamp just north of Curtis Corner Road. This impoundment is located on town property northwest of the Jr. High School on Curtis Corner Road. It has no name and is approximately 3.3 acres in size.

- The southernmost impoundment on a tributary is called Peace Dale Reservoir (locally known as California Jim's Pond). Peace Dale Reservoir is associated with an unnamed stream that enters Rocky Brook just upstream of Rocky Brook Reservoir and is approximately 11.7 acres in size. In 1998, the reservoir dam collapsed and severely flooded the Village of Peace Dale at Peace Dale Flats (Kingstown Road). The dam was rebuilt and normal water levels were restored in 1999.

The four in-stream impoundments along the main stem of Rocky Brook are as follows:

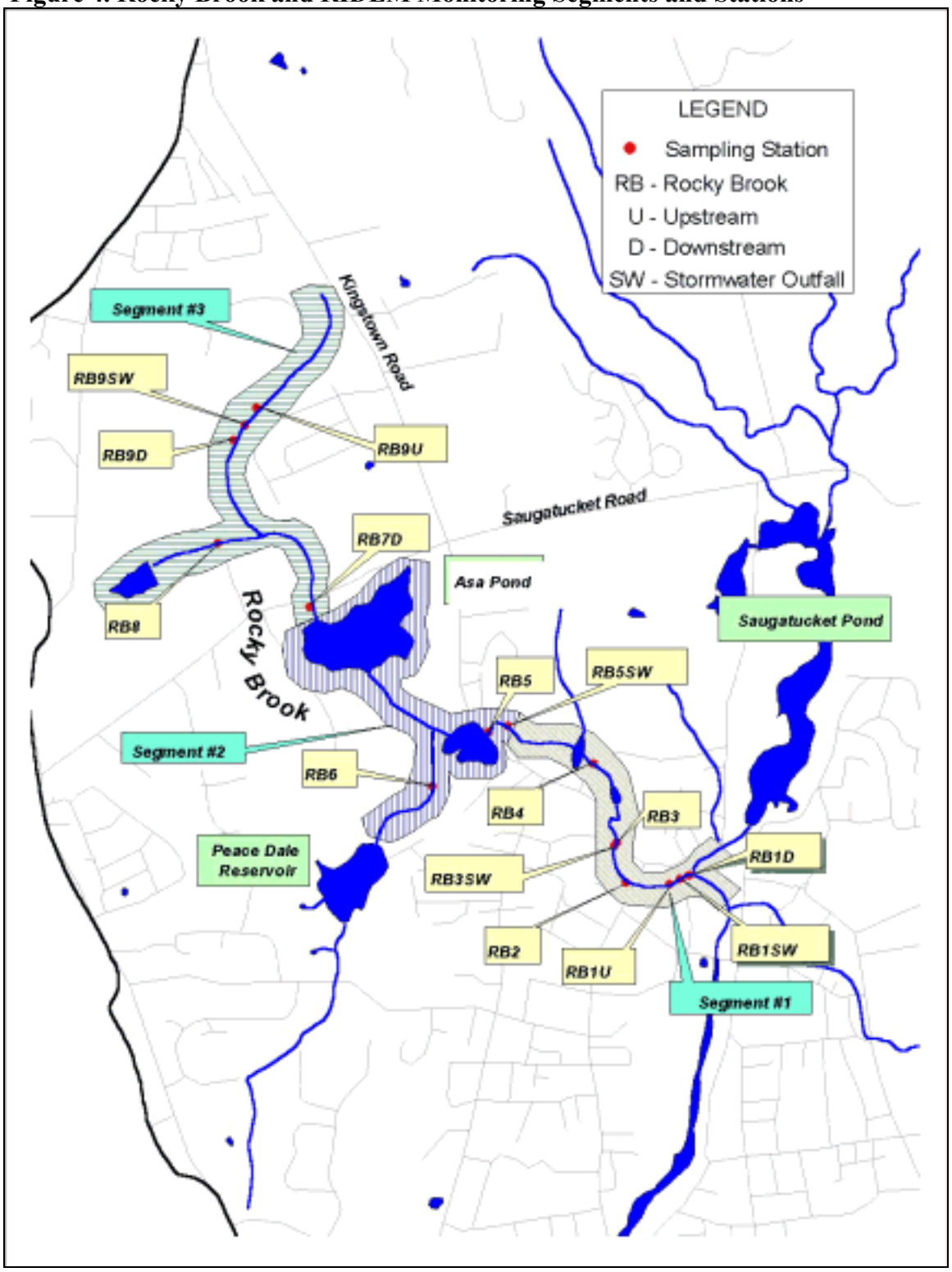
- The most upstream impoundment is Asa Pond, which is located just south of Curtis Corner Road and east of Asa Pond Road. It is approximately 23.8 acres in size. It is accessible from Asa Pond Road where there is a parking area and boat launch.

- The second in-stream impoundment is Rocky Brook Reservoir, which is located immediately west of Kingstown Road and north of Dam Street. It is approximately 5.8 acres in size. It is accessible from a turnaround/parking area adjacent Kingstown Road a few hundred feet north of Dam Street. The reservoir was originally used as a watering point for the Narragansett Pier Railroad in the 1800's, which was a trunk line that ran from Penn Central Conrail in West Kingston to Narragansett Pier in Narragansett. The original water pump house still stands on Dam Street and is now a popular local restaurant. A town park, referred to as the Tri-Pond Park, consists of a large, unfragmented wetland system that includes Asa Pond, Rocky Brook Reservoir, Peace Dale Reservoir, Rocky Brook, and the unnamed tributary.

- The third in-stream impoundment is located north of Kingstown Road and west of Hopkins Lane. This impoundment has no name, and is approximately 1 acre in size. It is accessible from a property located at the corner of Hopkins and Emmett Lanes. An historic mill is still present on the southern side of the brook just downstream of the dam.

- The fourth and southernmost in-stream impoundment is located approximately 200-feet north of Kersey Road and immediately west of the Peace Dale Elementary School. This impoundment also has no name, and is approximately 0.52 acres in size. Children from the Peace Dale Elementary School use nature trails adjacent to the impoundment for access. There is also a viewing platform that is used by the children of the school.

Figure 4. Rocky Brook and RIDEM Monitoring Segments and Stations



2.4 Mitchell Brook

Mitchell Brook originates from a swamp north of Mooresfield Road (RI Rt. 138) in South Kingstown (Figure 5), and flows in a southeasterly direction. The stream has an approximate length of 1.4 miles. For the majority of its course, Mitchell Brook is surrounded by forested habitat. It flows along the lower western half of the Rose Hill Landfill and empties into the Saugatucket River between the Rose Hill Landfill and Saugatucket Road. Mitchell Brook has one small impoundment, located east of Rose Hill Road and west of the Rose Hill Pet Cemetery. This impoundment has no name and is approximately 0.27 acres in size. It is accessible from the road that leads to the Rose Hill Pet Cemetery and Tip Top Dog Kennels.

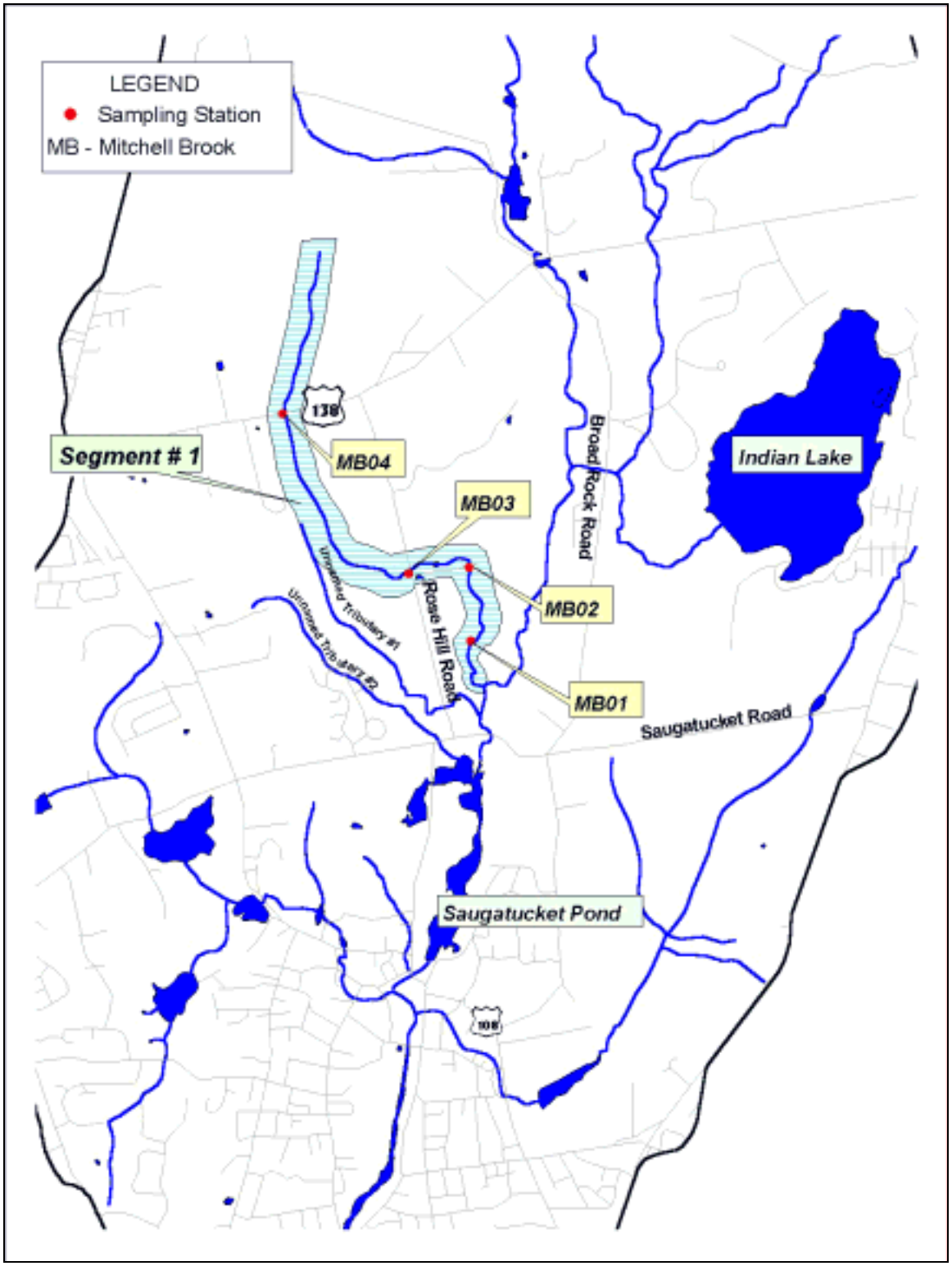
2.5 Unnamed Tributaries

Two unnamed tributaries were also found to have significant flows and were monitored.

- The first unnamed tributary originates from a swamp that is located between Mooresfield Road (RI Rt. 138) and Saugatucket Road (Figure 5). The majority of the stream is located north of Saugatucket Road and west of Rose Hill Road. The stream flows in a southeasterly direction. The upper portion of this stream is surrounded by forest. The middle portion of the stream runs through abandoned farmfield and then empties into an excavated pond where an old gravel operation has been converted to a golf course. The stream then exits the pond, continues through the rest of the gravel operation, reenters forested woodland, and empties into the Saugatucket River just north of Saugatucket Road. The RIDEM water quality monitoring station for this waterbody is shown in Figure 2.

- The second unnamed tributary also originates from a swamp located between Mooresfield Road (RI Rt. 138) and Saugatucket Road (Figure 5). However, the headwater area associated with this stream is located southwest of the headwater area associated with the first unnamed tributary. This tributary also flows in a southeast direction. The stream is located within forested woodland with the exception of a small portion that flows through an open field that lies between a subdivision and the above-mentioned gravel operation. The stream again enters forested woodland and diverges . Specifically, a portion of the stream continues to flow in a southeasterly direction, crosses Saugatucket Road, and eventually empties into Saugatucket Pond west of the Saugatucket River. The other portion of the stream travels in an easterly direction and empties into the first unnamed tributary approximately 250-feet southwest of where it flows under Rose Hill Road. This is an observation that was made in the field and is not shown on the map. The portion of second unnamed tributary that splits from the main channel appears to do so only during high flow conditions, as the channel associated with it is narrow. It is dry during the summer months. The RIDEM water quality monitoring station for this waterbody is shown in Figure 2.

Figure 5. Mitchell Brook Segment and RIDEM Monitoring Stations



3.0 DESCRIPTION OF THE SAUGATUCKET RIVER WATERSHED

The water quality of a water body often reflects the characteristics of the watershed. General land use, precipitation and watershed geology are key factors that influence the water quality. For this reason, a description of watershed characteristics is necessary to the understanding of historic or acute water quality problems.

3.1 Watershed Description and Location

The Saugatucket River Basin is south-centrally located in Rhode Island on the westerly side of Narragansett Bay. The watershed drains approximately 16.5 square miles (10,560 acres) and includes parts of four Rhode Island communities: Exeter, Narragansett, North Kingstown, and South Kingstown. The watershed includes the Saugatucket River and its major tributaries, Indian Run Brook, Rocky Brook, and Mitchell Brook. It is located in the South Shore Coastal Region and is a sub-watershed of the Point Judith Pond watershed, which drains to Block Island Sound. The average length of the Saugatucket River watershed is 6.0 miles and the average width is 3.5 miles. The largest waterbody within the watershed is Indian Lake (impounded in 1850), with an average water depth of 7.5-feet and a surface area of 268 acres. Indian Lake has not been identified as having water quality impairments at this time and thus, is not included in this TMDL.

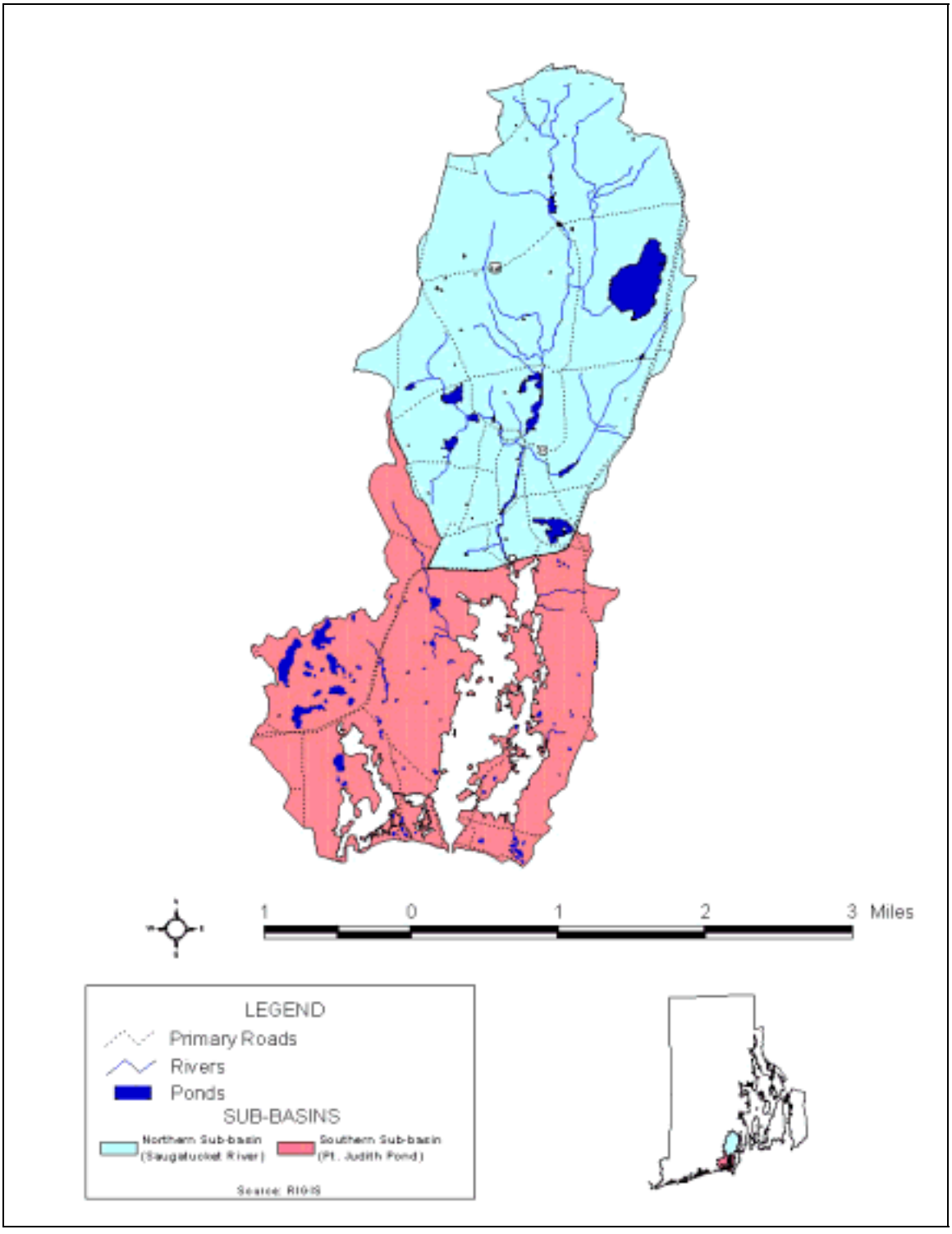
The portion of the Saugatucket River watershed addressed in the current TMDL is located upstream of the dam adjacent to Main Street in Wakefield. This portion of the watershed consists entirely of freshwater, non-tidal habitats (Figure 6).

South of the Main Street dam in Wakefield, the Saugatucket River is tidally influenced and discharges to Point Judith Pond. Pathogen impairments to Point Judith Pond will be addressed by a TMDL project scheduled for completion in the 2005-2007 time frame.

3.2 Topography

The topography of the area is generally flat with gently rolling hills. This is typical for the coastal low lands of the northeastern United States. Elevations within the watershed range from 10-feet (in Wakefield) to a hill at the northern edge of the watershed that is at a height of 250-feet above mean sea level (MSL). Slopes are generally less than 3%. The Saugatucket River falls about 140-feet (43 meters) from the headwaters (150-feet MSL) to the dam at Main Street in Wakefield (10-feet MSL). The slope of the river ranges between 0.001 and 0.05%.

Figure 6. Saugatucket and Point Judith Pond Watersheds



3.3 Climate

The climate in the Saugatucket River basin is variable. The following temperatures, precipitation, snowfalls, and growing season days (freeze-free periods) are based on a thirty year period (1951-1980) of weather data collected at the Agricultural Experimental Station, a National Oceanic and Atmospheric Administration (NOAA) weather station, located at the University of Rhode Island. This station has recorded weather data since 1889 and is located in the northwest portion of the Saugatucket River watershed. The following data was obtained from Wright et. al.. 1999:

Highest monthly temperature average = 70 ^{o} F
Lowest monthly temperature average = 28^{o} F in January
Average annual temperature = 49.2 ^{o} F
Average yearly precipitation = 48 inches
Average yearly snowfall = 32 inches
Average growing season = 138 days

There are normally no seasonal patterns in the frequency and amounts of precipitation during the year, however two major storm patterns exist. Storms that occur between October and May are primarily extratropical cyclones. The most famous are the "northeasters": low-pressure systems that typically develop off the North and South Carolina coasts and move northeast along the Atlantic seaboard, occasionally colliding with colder and drier air (from Canada) 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 hit 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.

3.4 Ecology

3.4.1 Forest Habitat

Most of Rhode Island consists of a mixture of northern and central hardwood forests. Much of the northern half of the watershed is forested. The dominant deciduous (non-evergreen) forest cover species in the Saugatucket River watershed include red, black, and white oaks, hickory, gray, yellow, and black birches, and beech. The primary conifers in the region are white pine and hemlock. Red maple is common on the wetter sites and pitch and red pine are found on the sandy outwash plains.

3.4.2 Wetland Habitat

There are 3 dominant classes of wetland habitats in the Saugatucket River sub-basin. These are: (1) Riverine, (2) Lacustrine, and (3)Palustrine. All information pertaining to Rhode Island wetlands was obtained in Tiner (1989).

The Riverine system encompasses all of Rhode Island's freshwater rivers and their tributaries. These systems are most visible along slow-flowing meandering lower perennial rivers and streams such as the Saugatucket River.

The Lacustrine System is principally a deepwater habitat system of freshwater lakes, reservoirs and deep ponds. These systems are found in the ponds and impoundments along length of the Saugatucket River and include the Saugatucket River above the dam at the intersection of Main Street and High Street (locally known as Wakefield Pond), Saugatucket Pond (also known as Peace Dale Pond), Peace Dale Reservoir (locally known as California Jim's Pond), Asa Pond, Rocky Brook Reservoir, Indian Run Reservoir, and Indian Lake. All of the above-mentioned waterbodies are impoundments.

Palustrine wetlands are the most common wetlands in the Saugatucket River watershed. They represent the most floristically diverse group of wetlands in the watershed and include freshwater marshes, wet meadows, swamps, bogs, and shallow ponds. These systems can be permanently flooded, semi-permanently flooded, seasonally flooded, or saturated. These systems are found in many areas, more often in the headwater sections of the Saugatucket River watershed.

3.4.3 Wetland Wildlife

Wetland habitats in the Saugatucket River watershed support a variety of animal species. Muskrats are perhaps the most typical and widespread wetland mammals. Other fur-bearers inhabiting wetlands include river otter, mink, beaver, raccoon, skunk, red fox, fisher, and weasel. Common reptiles and amphibians in Rhode Island freshwater wetlands, and likely residents of wetlands in the Saugatucket River watershed include the eastern painted, spotted, box, stinkpot, wood, and snapping turtles. Common snakes found in and near wetlands include the northern water, northern redbelly, eastern garter, eastern ribbon, and northern black racer. Among the more common toads and frogs in Rhode Island wetlands are Fowlers toad, American toad, northern spring peeper, green frog, bullfrog, wood frog, pickerel frog, and gray tree frog. There are also several salamander and newt species inhabiting Rhode Island wetlands, and would be typical inhabitants of the Saugatucket watershed

3.5 Geology

In the following sections the general geology and geomorphology of the Saugatucket River watershed is described. This description is based on information of the "Remedial Investigation Final Report" for the Rose Hill Landfill, which was written by Metcalf & Eddy (1994). This report included an extensive summary of the geological features for the Rose Hill Landfill and the Saugatucket River watershed.

3.5.1 Geomorphic Features

The seaboard lowland section of New England is characterized by irregular topography with north trending, elongated and rounded hills, river valleys and swamps. Principal geomorphic features of the Saugatucket watershed include several glacial till moraines, drumlins, and glacio-fluvial deposition structures. These features were created by glacial and depositional processes of the Wisconsin glaciation that began approximately 30,000 years ago and ended 10,000 years

ago. This period altered the original regional bedrock topography that developed during the Acadian and Alleghenian deformation between 390 and 225 million yeas ago.

Two geomorphic features of the watershed are of special interest: the Saugatucket River runs along a glacio-fluvial depositional valley from the very north to the south. Its silt, sand and gravel deposits formed terraces and ridges at the western flank of the river that are mined by several gravel pit operations. The second feature is the drumlins, which are aligned parallel to the southwesterly flow direction of the former glacial flow. These drumlins were formed by the deposition of ground moraine till over bedrock ridges when the glacial ice sheet moved over the irregular bedrock topography. The alignment of these drumlins forces the tributary into a mostly north-south direction.

3.5.2 Geology

Bedrock within the Saugatucket River Basin is classified as Scituate Gneiss. The gray to pink gneiss is characterized by thinly banded biotite and coarse-grained, oval shaped crystals of pink microline. The major rock components are quartz (40-50%), microcline and microperthite (28%), oligoclase (22%), and biotite (7%). The gneissic foliation or banking strikes northeast and dips to the southeast. The Scituate gneiss was emplaced during deformation and regional metaphormism of the Narragansett Basin during the Alleghenian orogeny events 250-million years ago. The Pennsylvanian schists and phyllites (metamorphosed sedimentary rocks) and the Narragansett Pier Granite are also encountered bedrock within the watershed. However, glacial deposits cover most of the bedrock and only a few outcrops are reported (Metcalf & Eddy 1994).

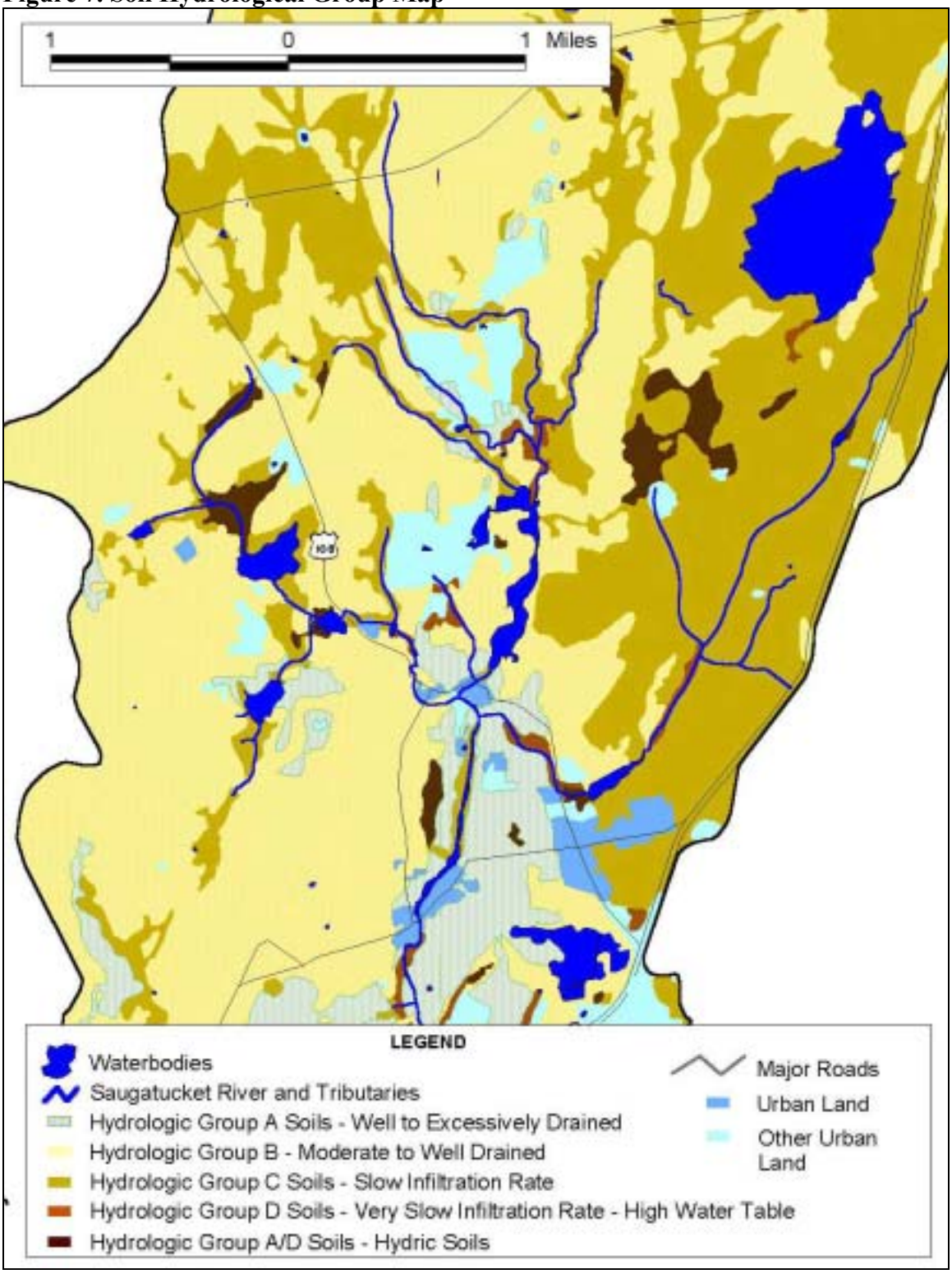
3.5.3 Soils

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 Saugatucket River watershed, are formed.

The principal parent materials of the Saugatucket 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.

Soils are classified into four hydrologic soil groups (U.S. Soil Conservation Service 1964). These groupings give an indication of soil characteristics and infiltration/runoff potentials. Figure 7 displays the different hydrological property groups adjacent the river and tributaries.

Figure 7. Soil Hydrological Group Map



3.6 Land Use

The Rhode Island Geographic Information System (RIGIS) provides various land use information, including various topographical, infrastructure, and demographic data. For this project, land uses in the watershed were categorized into different classes of populated areas, waste disposal areas, pasture, cropland, forest, wetland, and water bodies. Table 5 shows the distribution of these land uses within the Saugatucket watershed.

Forest and wetland cover a major portion of the watershed. The villages of Wakefield and Peace Dale comprise the more populated areas. This divides the watershed into two parts: a rural area with only scattered settlement in the upper two thirds, and a densely populated area is in the lower third of the watershed.

Changes in land use in the Saugatucket 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 area. The conversion of rural land to urban land typically results in an increase in impervious area that is usually accompanied by increases in the discharge and volume of storm runoff, as well as any associated pollutants. Impervious surfaces include roads, sidewalks, parking lots, and buildings. Natural flow paths in the watershed may be replaced or supplemented by paved gutters,
storm sewers, or other elements of artificial drainage. The net effect of urbanization is to increase pollutant export to receiving waterbodies. Mallin (1998) found that the most important anthropogenic factor associated with fecal coliform abundance was percent watershed impervious surface coverage.

It is believed that urban runoff is a potential source of pathogens in the Saugatucket River watershed. Schueler (1987) maintains that bacterial levels in undiluted urban runoff exceed public health standards for water contact recreation almost without exception. Schueler (1987) 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.

3.7 Sanitary Connections, Stormwater System, and Water Supply

3.7.1 Sanitary Connections

The main sewer line in the watershed runs from the University of Rhode Island along Route 108, through Peace Dale and Wakefield to the South Kingstown treatment facility at Westmoreland Street in Narragansett. In both Peace Dale and Wakefield, an extensive network of sewer lines exist (Figure 8). However, it is questionable if every household in the area is connected. The sewer lines were built in the 1970's. Although, it was mandatory to be connected, people tried to avoid connection because of the costs. Today, not every street is shown with a sewer line. For this reason, it can be assumed that some

Table 5. Land Use Distribution Summary

Land Use Description	Total Acreage	% of Total
Forest-Deciduous-Evergreen-Mixed	13,087	57.03
Barren-Brush-Wetlands-Water-Other Undeveloped	3,489	15.21
Med-Med Low Density Undeveloped	1,551	6.76
High-Med high Density Residential	1,415	6.16
Institutions-Cemeteries	916	3.99
Roads	556	2.43
Pasture-Confined Feeding	433	1.89
Agricultural-Croplands-Orchards	412	1.79
Gravel Pits-Quarries	301	1.31
Commercial	214	0.93
Low Density Residential	185	0.81
Idle Agricultural	124	0.54
Waste Disposal-Junkyards	69	0.30
Urban Vacant-Transitional	62	0.27
Commercial-Industrial Mix	45	0.20
Developed Recreation	37	0.16
Industrial	34	0.15
Transportation-Utilities	18	0.08
Total Basin Acreage	22,949	100.00

Source: RIGIS
Data Compiled 1995

private septic systems are still in use (Wright et. al. 1999). In the northern part of the watershed private septic systems are the only sanitary systems. That includes the neighborhoods along Saugatucket Road, Rose Hill Road, and Mooresfield Road
(RI Route 138).

3.7.2 Storm Sewer System

The watershed contains a disconnected system of stormwater lines. Stormdrains are in place in Peace Dale and in Wakefield, and most drain directly into the Saugatucket River and it's tributaries. However, there is no map available that shows existing lines. Furthermore, additional pipes were connected to stormwater discharge pipes during various construction projects without exact knowledge of the pipe's catchment area. Examples of this include two outfalls into Rocky Brook at Railroad Street (Ericson, Personal Communication 1997 in Wright et. al. 1999). Allen's Avenue in Peace Dale was fitted with stormdrains in 1998, which discharge into a swamp at the end of Tucker Avenue. There are no combined sewer outfalls (CSO's) in South Kingstown (Ericson, Personal Communication, 2000). An inventory of storm drain outfalls was recorded by RIDEM personnel field investigations and are shown in Figure 9.

Figure 8. Sanitary Sewer Lines and Pump Stations

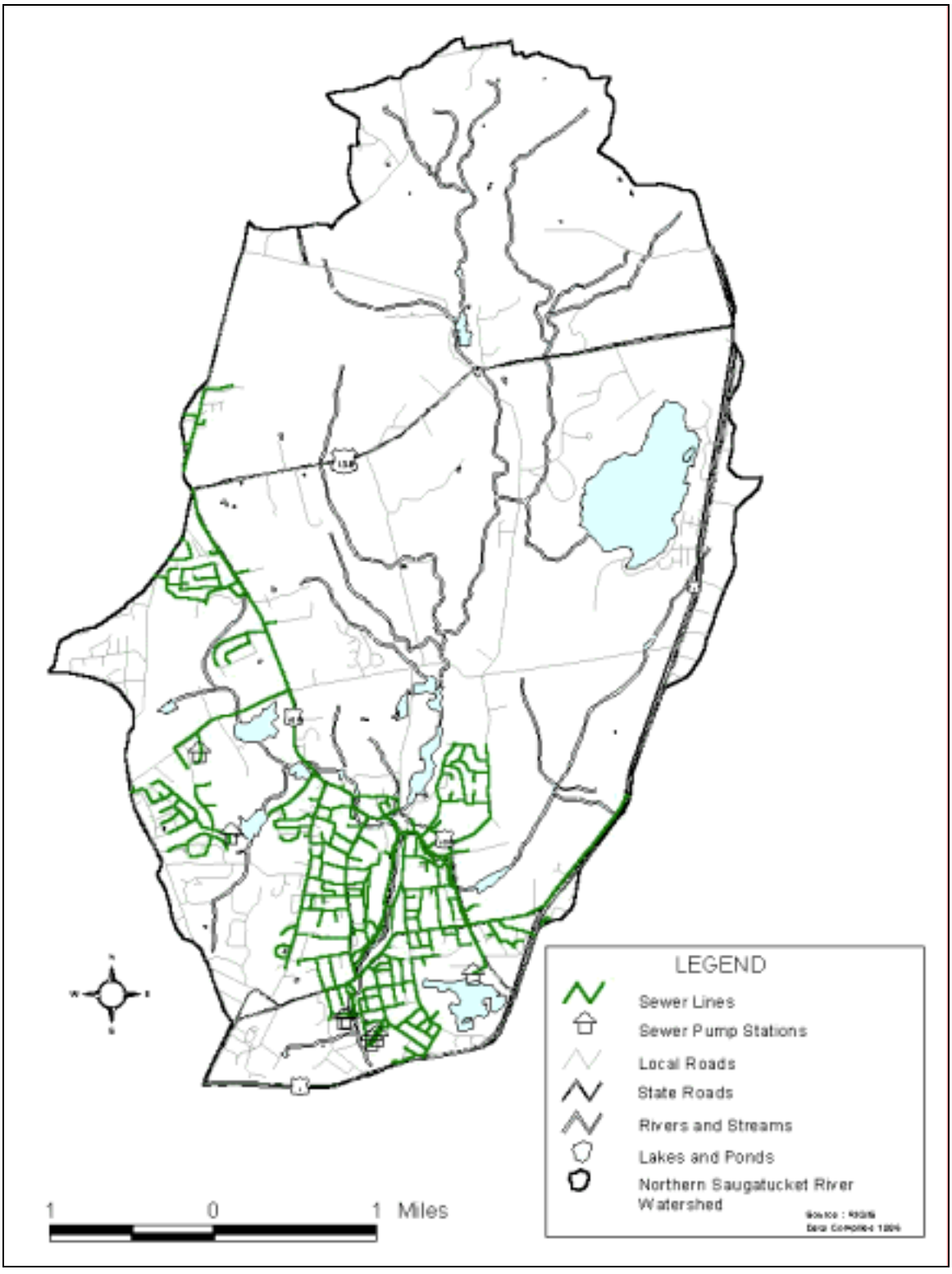
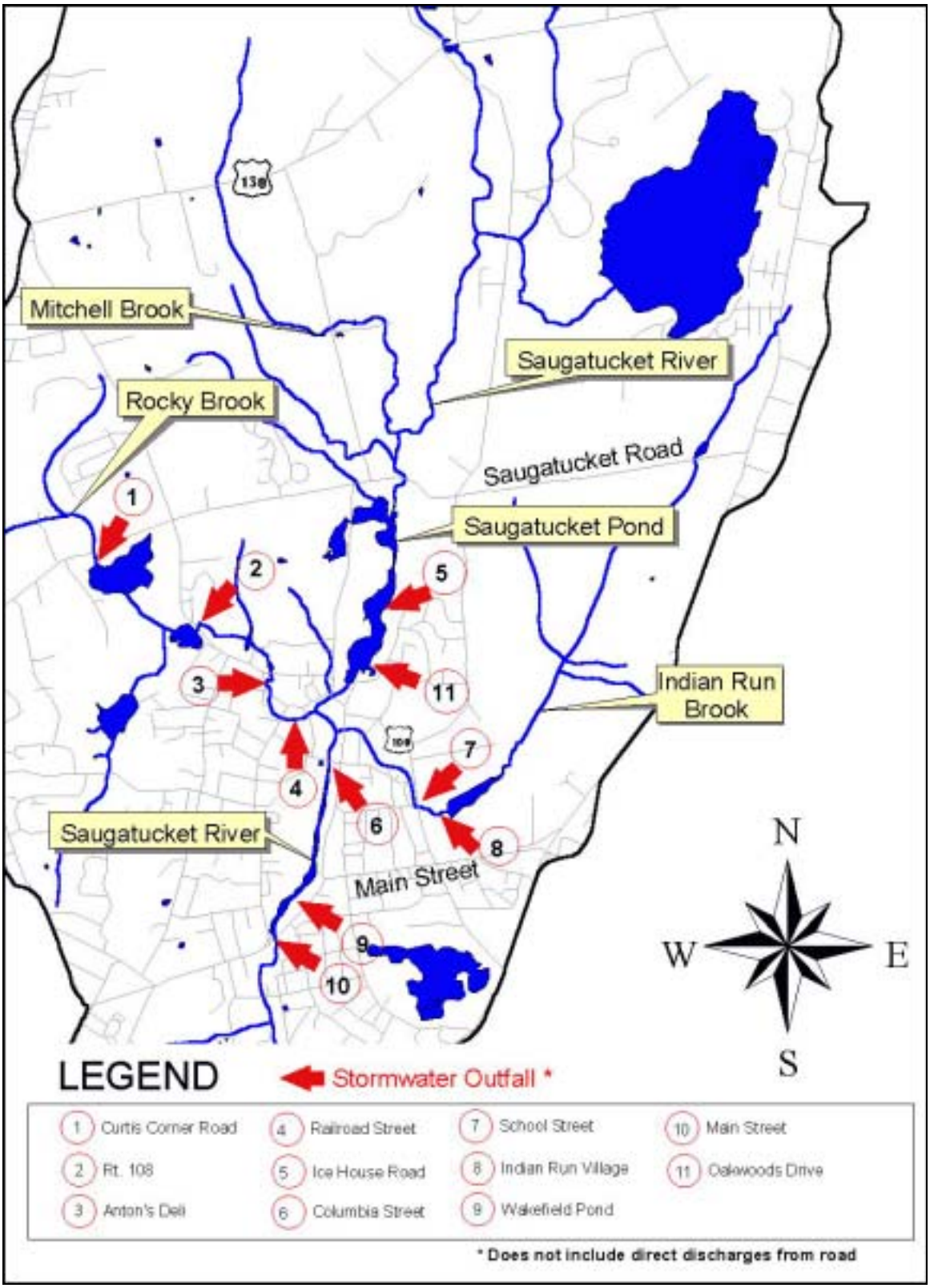


Figure 9. Identified Stormdrain Outfall Locations



3.7.3 Water Supply

In the vicinity of Peace Dale and Wakefield, drinking water supply is mainly supplied by a private water company; United Water-Rhode Island (Figure 10). However, in the middle and northern parts of the watershed residential wells are still in use. Even though the municipal water supply lines were extended along Saugatucket Road and Rose Hill Road in 1985, not everyone in this area wanted to be connected. A survey conducted by Metcalf & Eddy in 1992 revealed that thirty-nine properties are still using private drinking water wells. There are no community water supply wells located within the Saugatucket River watershed.

Within the Saugatucket River watershed, the groundwater is classified as "suitable for public or private drinking water without treatment." However, the groundwater classification by RIDEM in 1992 indicates that the area south of the Rose Hill Landfill and two locations just north are not suitable for drinking water without treatment. Additionally, at locations in Wakefield, the Indian Run Brook headwaters near Rt. 1 and the Tri-Pond area in Peace Dale, groundwater does not meet drinking water standards (Metcalf & Eddy 1994).

4.0 DESCRIPTION OF WATER QUALITY MONITORING ACTIVITIES

Recent efforts to monitor water quality in the Saugatucket River watershed began with a RIDEM-funded water quality study by the URI Department of Engineering from 1996-1999. The results of that study led to the identification of various water quality impairments in the Saugatucket River, Indian Run Brook, Rocky Brook, and Mitchell Brook which were subsequently included on the 1998 List of Impaired Waters. More recently, RIDEM conducted supplemental monitoring in 2000 to support the development of this TMDL. The results of these studies are summarized below.

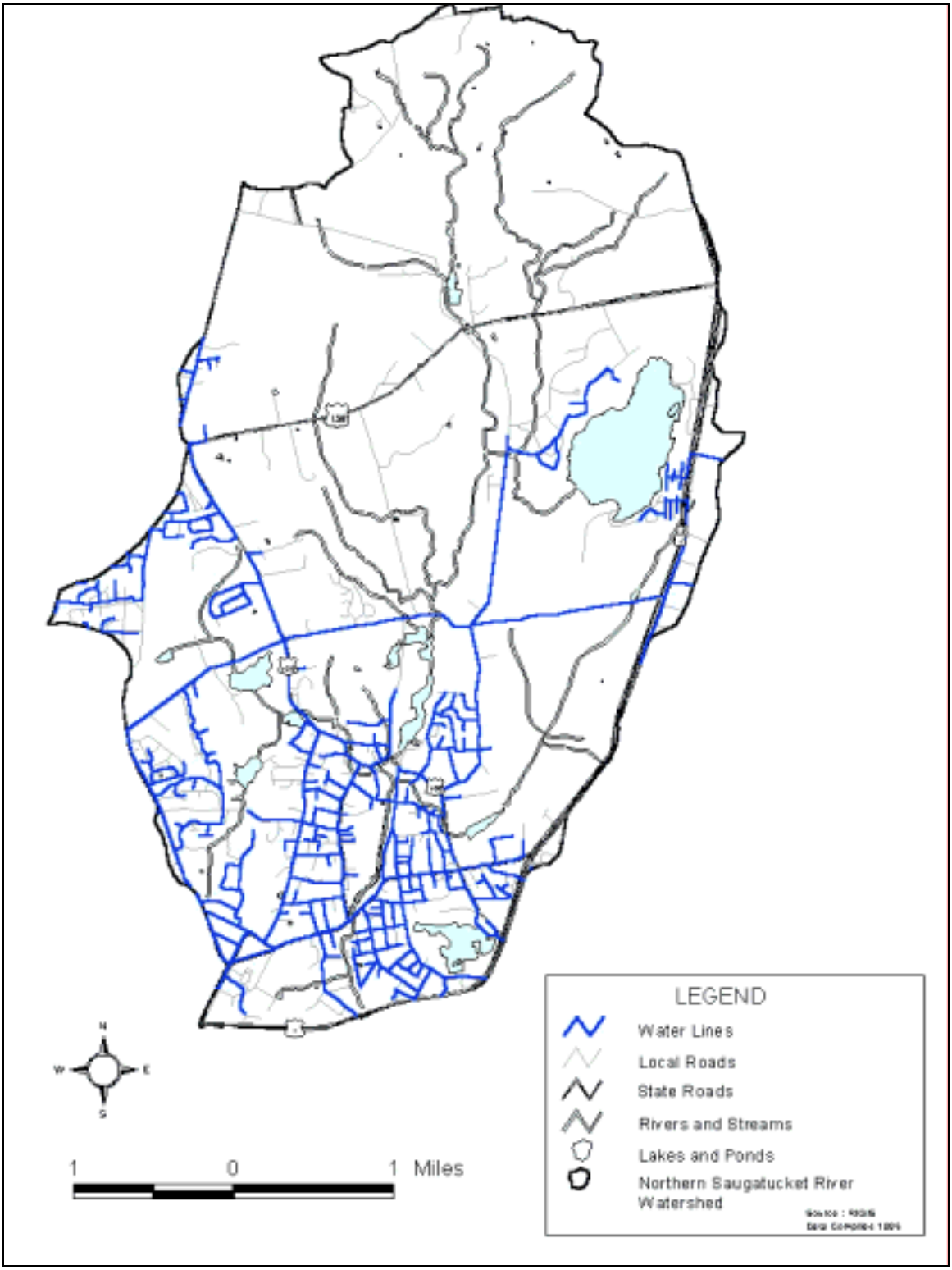
4.1 1996-1999 URI Study

A comprehensive water quality study of the Saugatucket River was conducted in 1996 by the URI Civil and Environmental Engineering Department. This study identified several pathogen sources in the watershed. Analysis of this data has allowed RIDEM to conduct a more focused sampling program aimed at isolating pathogen sources in the watershed, as well as establishing links between pathogen sources and instream water quality.

The main objectives of the URI study were as follows:

- To monitor the water quality of the Saugatucket River for both dry and wet weather conditions using three water quality surveys for each condition.
- To measure key water quality constituents during these surveys including dissolved oxygen (DO), nutrients, trace metals, and fecal coliform.
- To develop stage-discharge relationships at each water quality station.
- To calibrate and validate a dissolved oxygen and nutrient fate and transport model.
- To obtain information about the time of concentration through dye studies for the mainstem of the Saugatucket River.

Figure 10. Town Water Supply Lines



- To estimate sediment oxygen demands for the mainstem of the Saugatucket River at five sites.
- To calculate existing pollutant loadings and identify significant environmental problems.
- To calculate annual pollutant loading rates.

The results of the project were used to calibrate and validate a water quality model for the river and Saugatucket Pond. Parameters monitored in the study include pH, conductivity, temperature, fecal coliform, 5-day biological oxygen demand, ammonia, nitrate as N, orthophosphate, total Kjeldahl nitrogen, total phosphate, dissolved oxygen, chlorophyll a, total suspended solids, volatile suspended solids, sodium, calcium, magnesium, chloride, chromium, nickel, copper, lead, cadmium, and zinc.

4.1.1 Dry Weather Fecal Coliform Data

Dry weather data was collected in March, July, and October of 1996. The pathogen water quality standard was not violated in the March or October monitoring events. However, fecal coliform levels during the July monitoring event were above the water quality standard at stations located in the Saugatucket River at Saugatucket Road (SR03), Church Street (SR05), above the Main Street Dam (SR06), and in Indian Run Brook at the Peace Dale Guild (IR01). When the discrete data are combined, the resulting geometric mean concentration is below the water quality criteria. What should be noted is that fecal coliform concentrations are elevated during the expected normal critical period in summer (i.e. July) and not elevated during expected non-critical periods (i.e. March and October).

Table 6 shows discrete monitoring data taken during these monitoring events. Runs 1-4 are the four separate sampling runs done for that particular day. This means that each water quality sampling station was sampled four times per monitoring event. Figure 11 shows the locations of both dry and wet weather monitoring locations.

4.1.2 Wet weather Fecal Coliform Monitoring

Wet weather monitoring was conducted during three wet weather events. These include storms monitored on April 28, 1997 (Wet weather event # 1), August 21, 1997 (Wet weather event #2), and September 28, 1997 (Wet weather event #3). The total rainfall and duration for each storm were 0.64 inches/14 hours, 2.39 inches/23.5 hours, and 0.38 inches/12.5 hours, respectively.

In general, fecal coliform levels were found to be above the water quality standard at all stations, with the exception of the station above Saugatucket Pond Dam (SR04), which only had elevated fecal coliform levels during the August 21, 1997 event. Tables 7-9 shows discrete monitoring data taken during these monitoring events. The base run plus runs 1-11 are the twelve separate sampling runs done for that particular day. This means that each water quality sampling station was sampled twelve times per monitoring event, with the exception of wet weather event number three (Table 8), which only had nine sampling runs.

Table 6: URI dry weather fecal coliform concentration data

Date		Concentration (MPN/100ml						
	STATION	SR03	SR04	SR05	SR06	IR01	RB01	RH01
	LOCATION	Saugatucket Road	Above Saugatucket Pond Dam	Church Street	Above Main Street Dam	Peace Dale Guild	Railroad Street	Rose Hill Road
25-Mar-96	RUN 1	2	2	25	31	61	4	2
25-Mar-96	RUN 2	0.5	0.5	17	6	46	2	8
25-Mar-96	RUN 3	2	0.5	23	6	33	3	1
25-Mar-96	RUN 4	2	1	39	11	44	4	1
Mar geomean		1	1	25	11	45	3	2
10-Jul-96	RUN 1	250	130	1100	740	1100	150	2200
10-Jul-96	RUN 2	160	100	970	650	680	70	1100
10-Jul-96	RUN 3	99		120	670	520	110	1100
10-Jul-96	RUN 4	86	80	1100	600	630	70	760
Jul geomean		147	102	1100	666	832	102	1193
27-Oct-96	RUN 1	20	10	140	110	27	29	58
27-Oct-96	RUN 2	11	8	98	110	16	54	24
27-Oct-96	RUN 3	25	11	150	91	12	31	50
27-Oct-96	RUN 4	15	7	160	68	6	40	63
Oct geomean		17	9	135	93	13	37	46
min all		1	1	17	6	6	2	1
geomean all		15	7	127	87	75	22	48
std dev all		79	47	443	305	370	47	704
max all		250	130	1100	740	1100	150	2200

Figure 11. URI Water Quality Monitoring Stations

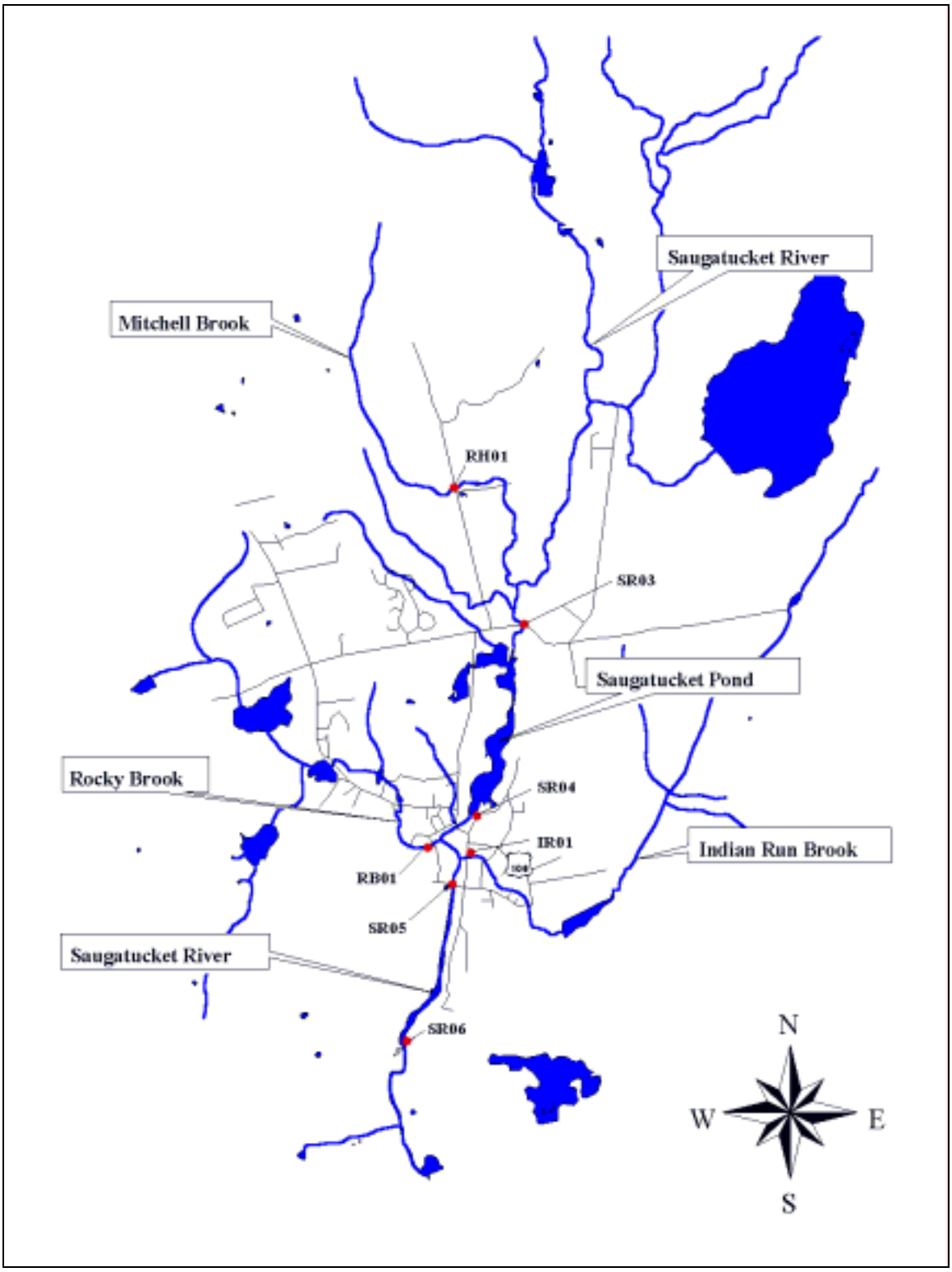


Table 7. Wet weather event #1 (4/28/97) fecal coliform concentration data

	Concentration (MPN/100ml)						
STATION	SR03	SR04	SR05	SR06	IR01	RB01	RH01
LOCATION	Saugatucket Road	Above Saugatucket Pond Dam	Church Street	Above Main Street Dam	Peace Dale Guild	Railroad Street	Rose Hill Road
BASE	3	6	56	35	14	6	1
RUN 1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RUN 2	15	3	1510	47	91	40	80
RUN 3	19	5	410	51	1510	700	12
RUN 4	15	2	980	103	540	1040	46
RUN 5	100	6	590	460	400	540	270
RUN 6	180	4	360	530	380	400	420
RUN 7	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RUN 8	550	6	145	470	107	115	360
RUN 9	280	4	87	139	128	51	88
RUN 10	100	39	146	107	107	63	19
RUN 11	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Apr geomean	53	5	287	135	183	134	52

*N/A indicates that samples were not taken.

4.1.3 Interim Survey

In addition to fecal coliform sampling at the stations outlined above, three interim surveys were conducted in the vicinity of the Palisades Mill Complex between stations SR04 and SR05 in order to identify a suspected source of fecal coliform bacteria (Figure 12).

The Palisades Mill Complex divides the Saugatucket River into two separate channels, which combine downstream of the Complex. The Saugatucket River is split at the impoundment dam for Saugatucket Pond where a portion of the River flows over the dam and along it's natural streambed and a portion of the River flows into a channel that transports water directly into the Complex. Once within the Complex, the channel splits again - one channel discharging to the lower section of the River via a culvert pipe and the other channel discharging into the lower section of the River via a fish ladder.

Additional sampling stations were created for the interim surveys (RT108, RT108A, SR04A, SR04B, SR04C, SR04I, SR04II, SR04III, SR04IV, and SR04V), and existing stations SR04, SR05, IR01, and RB01 were sampled as well (Figure 12). Results of the interim surveys revealed that the unnamed tributary, along with street stormwater runoff demarcated by stations RT108 and RT108A, were not a significant source of fecal coliform. The major source, it was concluded, was somewhere in the channel that was diverted directly into the Complex. A flock of pigeons was found to be roosting within the culvert leading to the fish ladder that is a part of the diverted channel. Guano associated with the pigeons was observed to be littering the culvert floor. URI concluded that the most likely source of fecal coliform loadings to the Saugatucket River at this location were the pigeons.

Table 8. Wet weather event #2 (8/21/97) fecal coliform concentration data

	Concentration (MPN/100ml)						
STATION	SR03	SR04	SR05	SR06	IR01	RB01	RH01
LOCATION	Saugatucket Road	Above Saugatucket Pond Dam	Church Street	Above Main Street Dam	Peace Dale Guild	Railroad Street	Rose Hill Road
BASE	230	31	1300	160	160	140	3700
RUN 1	N/A	N/A	N/A	N/A	N/A	N/A	NA
RUN 2	350	61	4400	190	4100	2600	3300
RUN 3	1400	48	7600	580	3700	6600	4300
RUN 4	4800	82	6200	1000	2100	6700	3300
RUN 5	7000	870	5200	2700	3700	6800	4900
RUN 6	N/A	180	3200	3300	1200	4600	N/A
RUN 7	2600	72	740	910	1400	770	850
RUN 8	N/A	88	770	490	1700	290	N/A
RUN 9	560	580	760	480	1100	460	410
RUN 10	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RUN 11	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Aug geomean	1276	118	2319	686	1574	1550	2254

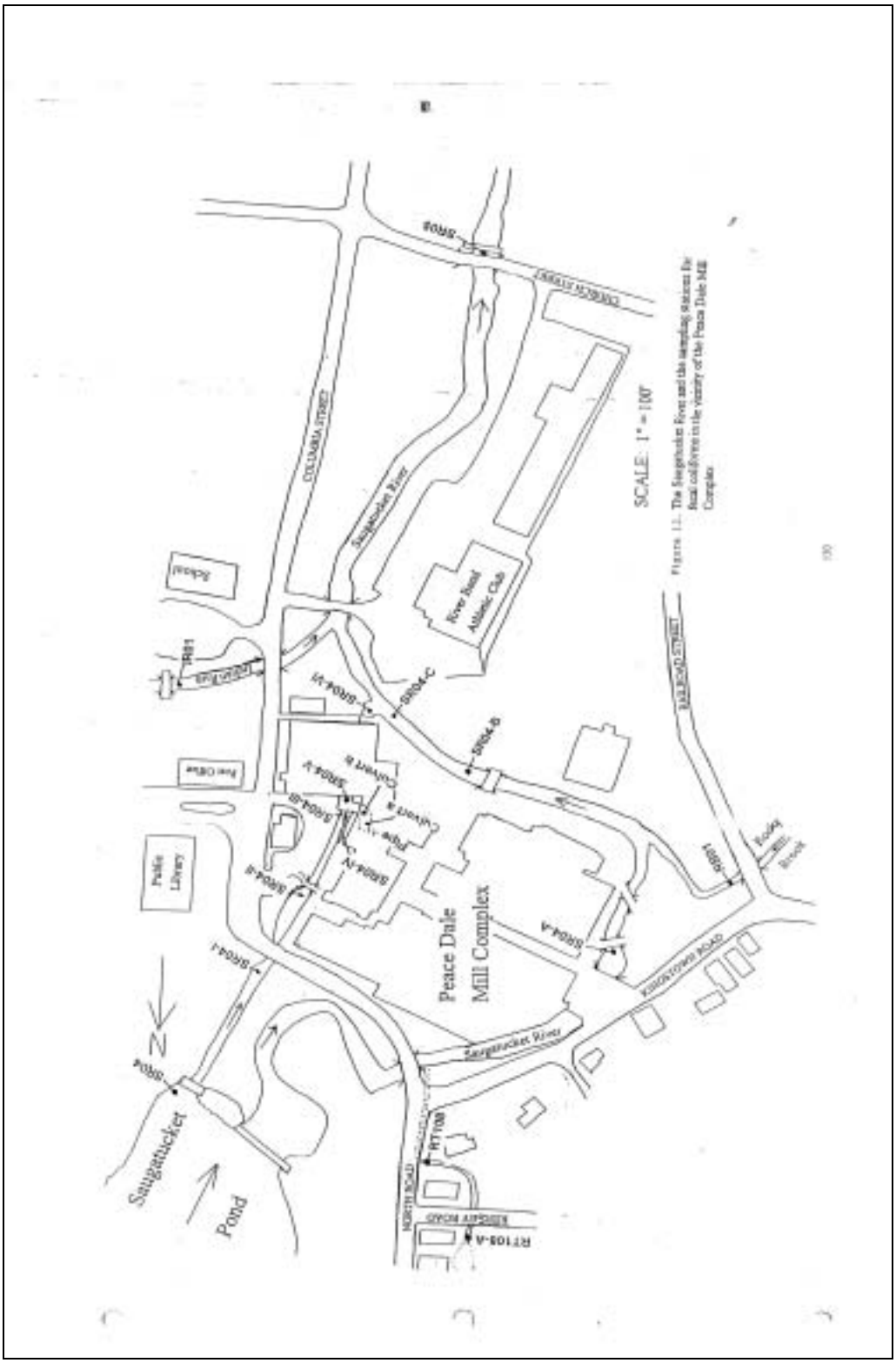
*N/A indicates that samples were not taken.

Table 9. Wet weather #3 (9/28/97) fecal coliform data

	Concentration (MPN/100ml)						
STATION	SR03	SR04	SR05	SR06	IR01	RB01	RH01
Location	Saugatucket Road	Above Saugatucket Pond Dam	Church Street	Above Main Street Dam	Peace Dale Guild	Railroad Street	Rose Hill Road
BASE	29	6	610	77	59	30	
RUN 1	47	7	2200	73	5400	9800	
RUN 2	110	11	2900	100	6900	4200	
RUN 3	230	110	3600	82	12000	8300	
RUN 4	390	15	3600	390	7400	2100	
RUN 5	3800	17	1000	430	3500	500	
RUN 6	4500	5	990	71	3100	330	
RUN 7	630	12	820	81	1300	150	
RUN 8	140	7	930	61	1300	120	
Sep geomean	301	12	1498	112	2482	737	

*N/A indicates that samples were not taken.

Figure 12. URI Interim Fecal Coliform Monitoring Stations



4.2 RIDEM Supplementary Monitoring (2000)

In 2000, RIDEM staff conducted supplemental monitoring in the Saugatucket River watershed to support the development of fecal coliform TMDLs for the Saugatucket River. This effort included ambient monitoring for fecal coliform at 36 sampling stations (Figures 2-5) located along the mainstem of the Saugatucket River and its major tributaries. Sampling locations and monitoring protocol are further described in Appendix 1. Dry weather samples were collected for six dry weather events during the summer and fall of 2000 (July 5, July 25, August 21, August 24, and October 17).

Wet weather samples were collected from one storm, which occurred from September 14 to September 18, 2000. 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 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.

4.2.1 Dry Weather Data

For the Saugatucket River watershed, high levels of fecal coliform bacteria were measured at 28 locations along the mainstem and tributaries. The RIDEM dry weather monitoring focused on the Saugatucket River, Indian Run Brook, Rocky Brook, Mitchell Brook, and two unnamed tributaries. The results of the RIDEM 2000 dry weather data are presented in Table 10.

Five stations within the Saugatucket River were sampled for fecal coliform bacteria during dry weather conditions. The lowest concentrations were measured at station SR04D, located at the outlet of Saugatucket Pond. The dry weather geometric mean concentration at this station was 19 fc/100ml. The highest measured dry weather concentrations were located at stations SR05 and SR06D. Measured concentrations at station SR05 ranged from 130 fc/100ml during dry weather survey #3, to 560 fc/100ml during dry weather survey #2. The dry weather geometric mean for that station was 311 fc/100ml. A large population of pigeons roosting under the Palisades Mill Complex were identified upstream of station SR05. These pigeons deposit large amounts of fecal matter directly into the stream. This bacteria source, along with contributions from Rocky Brook and Indian Run, is thought to be responsible for the elevated levels of bacteria measured at station SR05.

Measured concentrations at station SR06D ranged from 20 fc/100ml during dry weather survey #3 to 940 fc/100ml during dry weather survey #2. The geometric mean concentration was 452 fc/100ml. A second flock of pigeons roosting and nesting under the Main Street Bridge deposits large amounts of fecal matter directly into the stream. This bacteria source is likely responsible for the elevated levels of bacteria measured at station SR06D.

Two unnamed tributaries were sampled, UT01U and UT02, that drain to the Saugatucket River and Saugatucket Pond, respectively. Geometric mean concentrations within these tributaries were under the standard of 200fc/100ml. A maximum individual concentration of 280 fc/100ml was observed at station UT02, and a minimum value of 50 fc/100ml was observed at station UT01U.

Fecal coliform concentrations were measured at seven locations in Indian Run Brook and one location on its tributaries. Station IR4, located at the outlet of Indian Run Brook Reservoir, had the lowest geometric mean concentration (15 fc/100ml) for this waterbody. The highest geometric mean concentrations were at stations IR6 and IR2 with concentrations of 182 fc/100ml and 169 fc/100ml, respectively.

Fecal coliform concentrations were measured at six locations in Rocky Brook and two locations on its tributaries. Not one location in Rocky Brook or its tributaries exceeded the geometric mean criteria of 200 fc/100ml. Individual concentrations ranged from a low of 8 fc/100ml at station RB8 (a tributary) at the Jr. High School to a high of 330 at station RB7D at Curtis Corner Road.

Fecal coliform concentrations were measured at 4 locations in Mitchell Brook. The uppermost station, MB04, had the lowest geometric mean concentrations with 37 fc/100ml. Station MB03 had the highest concentrations, with 1357fc/100ml. A small farm with several cows is located upstream of this station. Cows were observed directly utilizing the stream at this location. Geometric mean concentrations at MB02 and MB01 were 220 and 246 fc/100ml, respectively.

4.2.2 Wet Weather Data

Wet weather samples were collected from September 14 through September 18, with 1.61 inches of rainfall falling on September 15. Rainfall began at approximately 5:00 a.m. on September 15 and ended at approximately 9:30 a.m. the same day. A total of 36-stations in the Saugatucket River watershed were sampled during this wet weather event, of which six were stormwater outfalls. Bacteria samples were collected from the Saugatucket River, Indian Run Brook, Rocky Brook, Mitchell Brook, and the two unnamed tributaries. RIDEM data clearly show higher fecal coliform concentrations in the Saugatucket River basin during wet weather events.

Table 10. Summary of RIDEM 2000 Dry Weather Fecal Coliform Data (in fc/100ml).

Waterbody/ Segment	Station ID	Location	DW1 7/5/00	DW2 7/25/00	DW3 8/21/00	DW4 8/24/00	DW5 9/14/00	DW6 10/17/00
Rocky Brook	RB9D	Greenwood Dr.	17	280	83	190	120	160
3	RB8	Jr. High School	28	8	44	10	83	9
	RB7D	Curtis Corner Rd.	330	260	78	110	280	23
	RB6	End of Dam St.	25	12	28	30	51	16
2	RB5U	Rocky Brook outlet	36	10	3	17	40	78
	RB4	Hopkins Ln.	92	17	44	23	29	11
1	RB2	Patsy's Liquors	50	44	30	40	42	4
	RB1D	Railroad St.	180	80	120	70	210	46
Indian Run Brook	IR11	Route 1		40	25	30		
	IR10U	Saugatucket Rd.	750	13	37	63	190	26
2	IR7	St. Dominics	10	Dry	Dry	Dry	330	33
	IR6	St. Dominics	320	330	85	140	420	70
	IR4	Above Indian Run Reservoir outlet	5	57	12	13	300	1
1	IR3U	Kingstown Rd. at Rt. 108	520		87	130	380	54
	IR2	Amos St.	330	730	120	130	370	51
	IR1U	Peace Dale Guild	450	110	330	200		79
Mitchell Brook	MB04	Route 138	43	65	16	24	67	
	MB03	Rose Hill Rd	480		1600	2600	1300	970
	MB02	Rose Hill Pet Cemetery	170	380	230		460	
1	MB01	Rose Hill Transfer Station	170	380	230		460	

Saugatucket River	UT01	Rose Hill Rd.	240	170	160	140	130	50
4	SR03U	Saugatucket Road			67	78		46
	SR03D	Saugatucket Road	58	48	74	96	190	
	UT02	Saugatucket Road	280	84	35	54	470	66
3	SR04U	Mid-Saugatucket Pond		6	60			
	SR04D	Above Saugatucket Pond Dam		19	29	6	62	26
2	SR05	Church St.	480	560	130	140	280	210
	SR06U	Above Main St. Dam			46	58	110	44
1	SR06D	Below Main St. Dam (Damon's Hardware)	650	940	20	200	170	230

The RIDEM data show elevated wet weather concentrations of fecal coliform bacteria at all stations in the Saugatucket River watershed (Tables 11-14). Stations are documented by the hour after the storm began. For example, station RB9U-12 means Rocky Brook, station 9U, 12 hours after the storm began. For most sampling stations, fecal coliform increased significantly up to hour 4, and then gradually fell towards pre-storm levels.

The first wet weather water quality samples were taken four hours after the storm began. Stormwater outfalls were sampled in order to determine fecal coliform sources. Table 15 shows the hour-four concentrations of sampled stormwater outfalls in the watershed. Since the storm lasted approximately 4.5-hours, this is the reason why stormwater outfalls were only sampled once. Since this was near the end of the storm, the hour-four stormwater outfall concentrations more closely resemble peak flow than first flush conditions.

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 the wet weather event. Figure 13 shows the relative source strengths, in geometric mean values, for Saugatucket River mainstem stations and tributary mouth stations for the wet weather event.

Table 11. RIDEM 2000 In-Stream Wet Weather Event Data for Rocky Brook.

Waterbody/ Segment	SAMPLE	LOCATION	COLLECTION DATE	COLLECTION TIME	FECAL COLIFORM CONCENTRATION (fc/100 ml)
Rocky Brook	RB9U-prestorm	Greenwood Dr.	9/14/00	1550	120
	RB9U-4		9/15/00	1025	6400
	RB9U-8		9/15/00	1322	2200
	RB9U-12		9/16/00	1725	930
	RB9U-24		9/16/00	0706	150
	RB9U-24 Dup		9/16/00	0706	290
	RB9U-48		9/17/00	0800	10
	Geomean				**353**
	RB9D-prestorm	Greenwood Dr.	9/14/00		
	RB9D-4		9/15/00	1026	7500
	RB9D-4 Dup		9/15/00	1026	6100
	RB9D-8		9/15/00		
	RB9D-12		9/16/00		
	RB9D-24		9/16/00		
	RB9D-48		9/17/00		
	Geomean				**6764**
	RB8-prestorm	Jr. High School	9/14/00	1531	83
1	RB8- prestorm R		9/14/00	1530	84
	RB8-4		9/15/00	1011	1800
	RB8-8		9/15/00	1330	220
	RB8-12		9/16/00	1735	210
	RB8-24		9/16/00	0714	1500
	RB8-48		9/17/00	0751	220
	Geomean				**282**
	RB7D- prestorm	Curtis Corner Rd.	9/14/00	1544	280
	RB7D-4		9/15/00	1035	54000
	RB7D-8		9/15/00	1335	22000
	RB7D-8R		9/15/00	1335	19000
	RB7D-12		9/16/00	n/s	n/s
	RB7D-24		9/16/00	0717	640
	Geomean				**3820**
	RB6- prestorm	End of Dam St.	9/14/00	1520	51
	RB6-4		9/15/00	0956	26000
	RB6-8		9/15/00	1305	1300
2	RB6-12		9/16/00	n/s	n/s
	RB6-24		9/16/00	0725	170
	RB6-48		9/17/00	0733	110
	Geomean				**471**

	RB5U- prestorm	Rocky Brook	9/14/00	1610	40
	RB5U-4	Reservoir outlet	9/15/00	1004	18000
	RB5U-8		9/15/00	n/s	n/s
2	RB5U-12		9/16/00	1715	2400
	RB5U-24		9/16/00	n/s	n/s
	RB5U-48		9/17/00	0739	30
	Geomean				**477**
	RB4- prestorm	Hopkins Ln.	9/14/00	1515	29
	RB4-4		9/15/00	0950	50
	RB4-4R		9/15/00	0950	450
	RB4-12		9/16/00	1705	1700
	RB4-24		9/16/00	0730	1300
	RB4-48		9/17/00	0729	80
	Geomean				**478**
	RB3- prestorm	Anton's Deli	9/14/00	1616	40
	RB3-4		9/15/00	0945	6800
	RB3-8		9/15/00	1343	3900
	RB3-12		9/16/00	1704	3000
	RB3-24		9/16/00	0743	570
	Geomean				**1126**
	RB2- prestorm	Patsy's Liquors	9/14/00	1620	42
	RB2-4		9/15/00	1042	3600
	RB2-4R		9/15/00	1042	3800
	RB2-8		9/15/00	1345	4800
	RB2-8R		9/15/00	1345	4600
	RB2-12		9/16/00	1700	4400
	RB2-24		9/16/00	0744	520
	RB2-48		9/17/00	0722	80
	Geomean				**1234**
1					
	RB1U- prestorm	Railroad St.	9/14/00	1508	240
	RB1U-4		9/15/00	0939	8200
	RB1U-8		9/15/00	1350	4800
	RB1U-12		9/16/00	1820	3400
	RB1U-24		9/16/00	0746	630
	RB1U-48		9/17/00	0719	160
	RB1U-72		9/18/00	0733	210
	Geomean				**1174**
	RB1D- prestorm	Railroad St.	9/14/00	1508	210
	RB1D-4		9/15/00	0939	34000
	RB1D-8		9/15/00	1350	1300
	RB1D-12		9/16/00	1720	2500
	RB1D-12		9/16/00	1720	2400
	RB1D-24		9/16/00	0721	520
	Geomean				**1752**

n/s= Not sampled

Table 12. RIDEM 2000 In-Stream Wet Weather Event Data for Indian Run Brook

Waterbody/ Segment	SAMPLE	LOCATION	COLLECTION DATE	COLLECTION TIME	FECAL COLIFORM CONCENTRATION (fc/100 ml)
Indian Run Brook	IR11-prestorm	Route 1	9/14/00	n/s	n/s
	IR11-4		9/15/00	1015	11000
	IR11-8		9/15/00	1345	1900
	IR11-12		9/16/00	1710	1000
	IR11-24		9/16/00	0630	330
	IR11-48		9/17/00	0816	80
	Geomean				**888**
	IR10- prestorm	Saugatucket Rd.	9/14/00	1720	190
	IR10-4		9/15/00	0955	19000
	IR10-8		9/15/00	1355	14000
	IR10-12		9/16/00	1805	8000
	IR10-24		9/16/00	0720	3800
	IR10-48		9/17/00	0820	180
	Geomean				**2552**
	IR7- prestorm	St. Dominics	9/14/00	1715	330
	IR7- prestorm D		9/14/00	1715	380
2	IR7-4		9/15/00	1010	44000
	IR7-8		9/15/00	1310	3400
	IR7-12		9/16/00	n/s	n/s
	IR7-24		9/16/00	0753	520
	IR7-48		9/17/00	0855	270
	Geomean				**1179**
	IR6- prestorm	St. Dominics	9/14/00	1710	420
	IR6-4		9/15/00	1010	28000
	IR6-8		9/15/00	1310	9000
	IR6-12		9/16/00	n/s	n/s
	IR6-24		9/16/00	0520	1300
	IR6-48		9/17/00	0853	300
	Geomean				**2447**
	IR4- prestorm	Above Indian	9/14/00	1655	300
	IR4-4	Run Reservoir	9/15/00	1025	16000
	IR4-8	outlet	9/15/00	1325	3400
	IR4-12		9/16/00	1538	720
	IR4-24		9/16/00	0738	4300
	IR4-48		9/17/00	0840	620
	Geomean				**1558**

	IR3U- prestorm	Kingstown Rd	9/14/00	1650	380
	IR3U-4	at Route 108	9/15/00	1035	13000
	IR3U-8		9/15/00	1335	4400
	IR3U-12		9/16/00	1545	1600
	IR3U-24		9/16/00	0733	3100
	IR3U-48		9/17/00	0838	730
	Geomean				**2070**
	IR3D- prestorm		9/14/00	1640	320
	IR3D-0R	Intersection	9/14/00	1640	290
	IR3D-4	of Route 108,	9/15/00	1045	7600
	IR3D-8	School St., and	9/15/00	1345	3800
	IR3D-12	Indian Run Rd.	9/16/00	n/s	n/s
	IR3D-24		9/16/00	n/s	n/s
	IR3D-48		9/17/00	0834	690
	Geomean				**1200**
	IR2- prestorm	Amos St.	9/14/00	1630	370
	IR2-4		9/15/00	1115	7400
	IR2-4R		9/15/00	1115	6900
	IR2-8		9/15/00	1350	8400
	IR2-12		9/16/00	1555	1700
	IR2-24		9/16/00	0728	2500
	IR2-48		9/17/00	0828	700
	Geomean				**2307**
	IR1U- prestorm	Peace Dale	9/14/00		
	IR1U-4	Guild	9/15/00	1055	1200
	IR1U-8		9/15/00	1400	9100
	IR1U-12		9/16/00	1615	11000
	IR1U-24		9/16/00	n/s	10000
	IR1U-48		9/17/00	n/s	1800
	IR1U-72		9/18/00	0750	520
	IR1U-72R		9/18/00	0750	390
	Geomean				**2318**

n/s= Not sampled

Table 13. RIDEM 2000 In-Stream Wet Weather Event Data for Mitchell Brook

Waterbody/ Segment	SAMPLE	LOCATION	COLLECTION DATE	COLLECTION TIME	FECAL COLIFORM CONCENTRATION (fc/100 ml)
	MB04- prestorm	Route 138	9/14/00	1645	67
	MB04-4		9/15/00	1005	12000
	MB04-8		9/15/00	1340	2500
	MB04-12		9/16/00	1750	610
	MB04-24		9/16/00	0658	200
	MB04-48		9/17/00	0807	180
	Geomean				**594**
	MB03- prestorm	Cow farm at Rose Hill Road	9/14/00	1650	1300
	MB03-4		9/15/00	0955	16000
	MB03-8		9/15/00	1330	6100
	MB03-12		9/16/00	1755	1600
	MB03-24		9/16/00	0654	420
	MB03-24R		9-16-00	0654	310
	MB03-48		9/17/00	0848	270
	MB03-48		9/17/00	0848	260
	Geomean				**1057**
1					
	MB02- prestorm	Rose Hill Pet Cemetery	9/14/00	n/s	n/s
	MB02-4		9/15/00	0950	3500
	MB02-8		9/15/00	1325	18000
	MB02-12		9/16/00	1750	4200
	MB02-24		9/16/00	0651	1100
	MB02-48		9/17/00	0841	540
	Geomean				**2750**
	MB01- prestorm	Rose Hill Transfer Station	9/14/00	1636	460
	MB01-4		9/15/00	0940	18000
	MB01-8		9/15/00	1320	22000
	MB01-12		9/16/00	n/s	n/s
	MB01-24		9/16/00	0735	1600
	MB01-48		9/17/00	n/s	n/s
	MB01-72		9/18/00	0835	190
	MB01-72R		9/18/00	0835	320
	Geomean				**1615**

n/s= Not sampled

Table 14. RIDEM 2000 In-Stream Wet Weather Event Data for Saugatucket River

Waterbody/ Segment	SAMPLE	LOCATION	COLLECTION DATE	COLLECTION TIME	FECAL COLIFORM CONCENTRATION (fc/100 ml)
Saugatucket River (w/ unnamed tributaries)	UT01- prestorm		9/14/00	1700	130
	UT01-4		9/15/00	1045	16000
	UT01-8		9/15/00	1315	56000
	UT01-8R		9/15/00	1315	42000
	UT01-12		9/16/00	1753	12000
	UT01-12R		9/16/00	1753	8500
	UT01-24		9/16/00	0647	720
	UT01-48		9/17/00	0837	160
	UT01-72		9/18/00	0824	150
	Geomean				**1459**
4					
	SR03-prestorm		9/14/00	n/s	n/s
	SR03U-4		9/15/00	1030	7400
	SR03U-4R		9/15/00	1030	8600
	SR03U-8		9/15/00	1400	16000
	SR03U-12		9/16/00	1808	11000
	SR03U-24		9/16/00	0640	1600
	SR03U-48		9/17/00	0824	140
	SR03U-72		9/18/00	0828	120
	Geomean				**3265**
	UT02- prestorm		9/14/00	1705	470
	UT02-4		9/15/00	1055	33000
	UT02-8		9/15/00	1410	43000
	UT02-8R		9/15/00	1410	50000
	UT02-12		9/16/00	1815	12000
	UT02-24		9/16/00	0645	1000
	UT02-48		9/17/00	0832	190
3	UT02-72		9/18/00	0817	170
	Geomean				**3265**
	SR04D- prestorm		9/14/00	1620	62
	SR04D-4		9/15/00	n/s	n/s
	SR04D-8		9/15/00	n/s	n/s
	SR04D-12		9/16/00	n/s	n/s
	SR04D-24		9/16/00	0621	1500
	SR04D-48		9/17/00	0818	770
	SR04D-72		9/18/00	0805	270
	Geomean				**437**

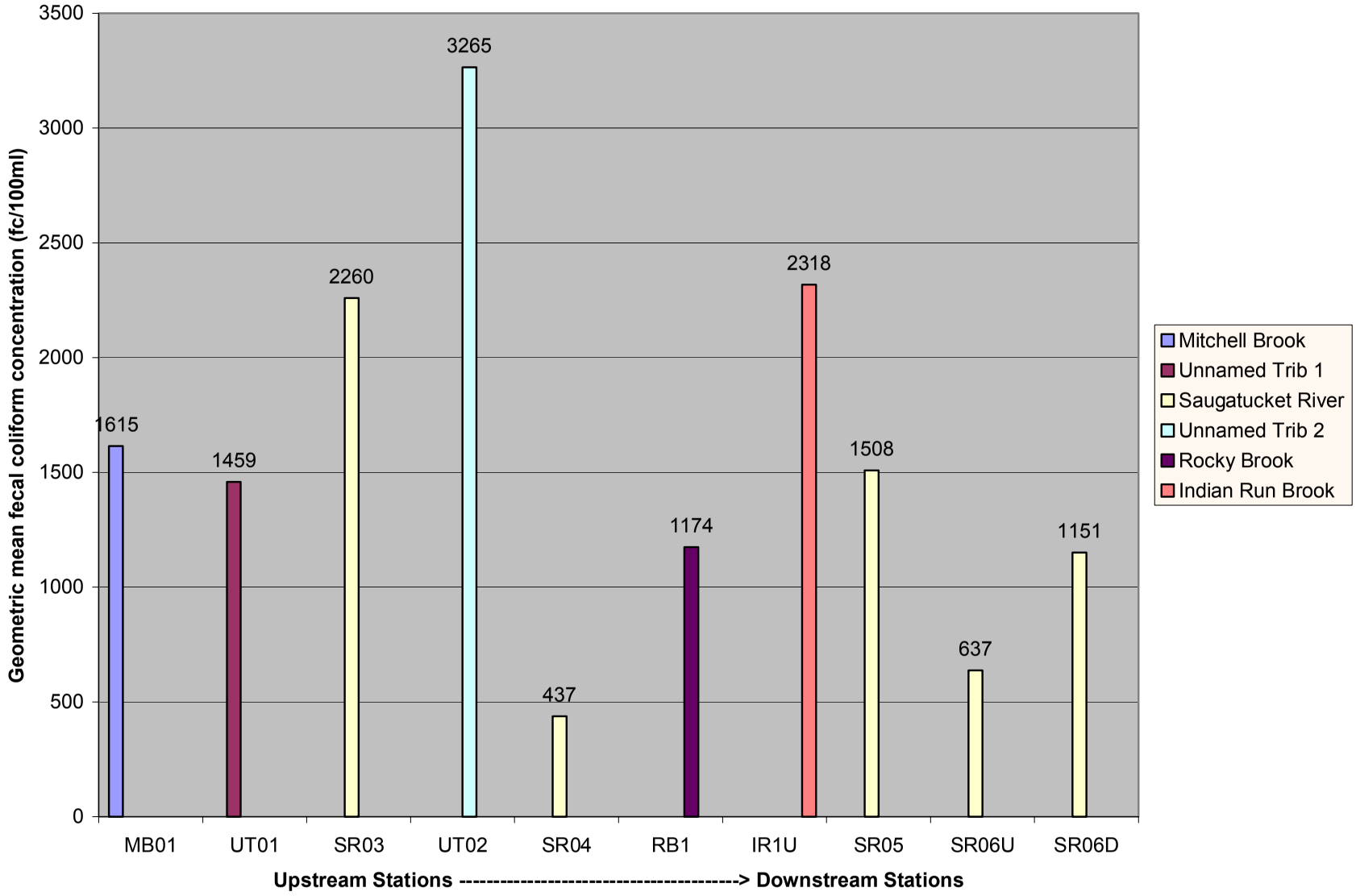
	SR05- prestorm		9/14/00	1503	280
	SR05-4		9/15/00	0932	26000
	SR05-8		9/15/00	1347	3100
2	SR05-12		9/16/00	1830	940
	SR05-24		9/16/00	0749	1700
	SR05-48		9/17/00	0715	1200
	SR05-72		9/18/00	0740	410
	Geomean				**1508**
	SR06U- prestorm		9/14/00	1555	110
	SR06U-4		9/15/00	1125	2000
	SR06U-8		9/15/00	1420	10000
	SR06U-12		9/16/00	n/s	n/s
	SR06U-24		9/16/00	0710	630
	SR06U-48		9/17/00	0800	480
1	SR06U-72		9/18/00	0726	100
	Geomean				**637**
	SR06D- prestorm		9/14/00	1545	170
	SR06D-4		9/15/00	1130	3100
	SR06D-8		9/15/00	1425	8000
	SR06D-12		9/16/00	1628	4100
	SR06D-24		9/16/00	0714	1100
	SR06D-48		9/17/00	0755	540
	SR06D-72		9/18/00	0722	260
	Geomean				**1151**

n/s= Not sampled

Table 15 . RIDEM 2000 Stormwater Outfall Data for Wet Weather Event # 1.

Waterbody/ Segment	SAMPLE ID	LOCATION	COLLECTION DATE	COLLECTION TIME	FECAL COLIFORM CONCENTRATION (fc/100 ml)
Indian Run Brook					
2	IR3SW	Intersection of Route 108, School St. and Indian Run Rd.	9/15/00	1055	8200
Rocky Brook					
3	RB9SW	Greenwood Dr.	9/15/00	1025	17000
2	RB5SW	Below Rocky Brook Reservoir outlet	9/15/00	1004	8500
1	RB3SW	Anton's Deli	9/15/00	0945	26000
	RB1SW	Railroad St.	9/15/00	0939	34000
Saugatucket River					
2	SR05SWE	Church St. bridge-east side	9/15/00	1047	3900
	SR05SWW	Church St. bridge-west side	9/15/00	1050	7600

Figure 13. Relative source strengths for selected stations (RIDEM 2000 wet weather survey)



5.0 WATER QUALITY CHARACTERIZATION

The database used for this TMDL includes over 600 fecal coliform samples collected by both RIDEM (2000) and URI (1996-1997). Both dry and wet weather data were used to characterize water quality conditions in the Saugatucket 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.

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 exceedance part of the criteria, an 80^{th} percentage value was calculated at that given station. Both of these approaches are described below.

5.1 Dry Weather Characterization

5.1.1 URI 1997 Water Quality Study

The URI dry weather monitoring results are not included in this TMDL. RIDEM sampled 6 dry weather events in the summer of 2000, making this data more representative of current water quality conditions. Furthermore, the combined URI and RIDEM data set did not show a significant difference in water quality conditions (i.e. no violations of the weighted mean were found) for dry weather conditions.

5.1.2 RIDEM Supplementary Monitoring (2000)

The most recent assessment of the Saugatucket River basin (RIDEM 2000) included ambient monitoring for fecal coliform bacteria at a total of 5 sampling stations located along the mainstem of the Saugatucket River and 23 stations on its tributaries (Figures 2-5). Each station was sampled six (6) times during dry weather in the summer and fall of 2000. A brief description of the stations, their locations and purpose is given in Appendix 1.

The 2000 assessment found that some sections of the Saugatucket River and its tributaries do not fully support the designated uses for Class B waterbodies during dry weather conditions. Furthermore, the monitoring station located in the Saugatucket River below the Main Street Dam does not fully support the designated use for Class SB waterbodies. Data are summarized for the mainstem Saugatucket River stations and tributary stations in Table 20.

Table 16. Summary of RIDEM 2000 Dry Weather Fecal Coliform Data (in fc/100 ml).

Waterbody/Segment	Station ID	Location	No. of samples	Minimum value	Maximum value	Geometric mean
Rocky Brook	RB9D	Greenwood Dr	7	17	280	114
3	RB8	Jr. High School	7	8	44	21
	RB7D	Curtis Corner Rd	6	78	330	165
	RB6	End of Dam St.	7	12	30	22
2	RB5U	Rocky Brook Reservoir outlet	6	3	36	12
	RB4	Hopkin's Lane	6	17	92	35
1	RB2	Patsy's Liquors	7	30	51	42
	RB1U	Railroad St.	8	70	200	119
Indian Run Brook	IR11	Route 1	3	25	40	31
	IR10	Saugatucket Rd	6	13	750	69
	IR7	St. Dominics	3	10	10	10
2	IR6	St. Dominics	6	85	330	188
	IR4	Indian Run Reservoir outlet	6	5	57	15
	IR3U	Intersection of Route 108,	5	87	520	181
1		School St., and Indian Run Rd.				
	IR2	Amos St.	7	120	730	**248**
	IR1U	Peace Dale Guild	6	110	450	159
Mitchell Brook	MB04	Rt. 138	5	16	65	32
	MB03	Cow farm at Rose Hill Rd.	6	480	2600	**1357**
1	MB02	Rose Hill Pet Cemetery	5	110	710	**220**
	MB01	Rose Hill Transfer Station	4	170	380	**246**
Saugatucket River	UT01	Unnamed Trib 1 at Rose Hill Road	6	140	240	174
4	SR03	Saugatucket Rd.	3	67	78	72
	UT02	Unnamed Trib. 2 at	6	35	280	82
3		Saugatucket Rd.				
	SR04D	Saugatucket Pond	6	6	29	13
2	SR05	Church St. Bridge	8	130	590	**289**
1	SR06U	Above Main St. dam	4	46	58	52
	SR06D	Below Main St. dam at Damon's Hardware	7	200	940	**452**

5.2 Wet Weather Characterization

5.2.1 URI Water Quality Study (1997)

Three wet weather events were monitored: April 28, 1997 (WWS#1), August21, 1997 (WWS#2), and September 29, 1997 (WWS#3). The total rainfall and duration for each storm was 0.64 inches/14 hrs, 2.39 inches/23.5 hrs, and 0.38 inches/12.5 hrs, respectively. Nine stations were sampled for fecal coliform during wet weather conditions, seven of which were duplicated by RIDEM's wet weather monitoring stations.

Stations SR01 and SR02 were not included in the RIDEM study because violations of the weighted mean average were not discovered in the URI study. Eight of the nine stations had wet weather fecal coliform geometric mean values that exceeded the class specific criteria for that waterbody (Table 17). The URI wet weather data show elevated levels of fecal coliform bacteria in the Saugatucket River, Rocky Brook, Indian Run Brook, and Mitchell Brook. The elevated wet weather concentrations of fecal coliform bacteria measured in the Saugatucket River downstream of station SR04 likely reflect sources from the tributaries. However, URI researchers did not feel that they were the only sources, as an interim study conducted at the Palisades Industrial Complex revealed pigeons roosting in culverts and contributing pathogens to the river.

Table 17. Summary of URI (1996-1997) Wet Weather Data.

Station	Location	Waterbody	No. of samples	Minimum value	Maximum value	Geometric mean
SR01	Rt. 138	Saugatucket River	25	3	28000	**342**
SR02	Broad Rock Rd	Saugatucket River	25	5	5400	**202**
SR03	Saugatucket Rd.	Saugatucket River	25	3	7000	**242**
SR04	Saugatucket Pond	Saugatucket River	28	2	870	20
SR05	Church St	Saugatucket River	28	56	7600	**999**
SR06	Above Main St Dam	Saugatucket River	28	35	3300	**218**
IR01	Peace Dale Guild	Indian Run Brook	28	14	12000	**894**
RB01	Railroad St	Rocky Brook	28	6	9800	**535**
RH01	Rose Hill Rd	Mitchell Brook	16	1	4900	**272**

* Geometric mean values in bold represent a violation of the water quality standard**.**

5.2.2 RIDEM Supplementary Monitoring (2000)

Wet weather samples were collected from one storm: September 14-18, 2000. This assessment found that most of the Saugatucket River and its tributaries do not meet water quality standards during wet weather conditions (Tables 11-14).

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 Saugatucket River watershed is unquestionable. Violations of the state's fecal coliform standard were observed at all 34 (28 in-stream, 6 stormwater outfall) water quality stations during the wet weather event.

5.2.3 URI & RIDEM Combined Data Sets

Since RIDEM replicated URI sampling stations SR03, SR04, SR05, SR06, IR01, RB01, and RH01, these data sets were combined in order to determine the wet weather geometric mean concentrations only, as stated in section 5.1.1. The dry and wet weather data sets were then used to determine the weighted average geomean for that particular station. The weighted average approach is discussed in section 5.3.

5.3 Other Water Quality Data

The University of Rhode Island Watershed Watch Program has monitored water quality in Saugatucket Pond from May through October since 1992. The sample station is located approximately 300-ft north of the impoundment dam at a point equally distant from each bank. This is the deepest part of the pond, with a depth of approximately three meters. Table 18 lists the yearly fecal coliform geometric mean concentrations from data acquired from 1992-2000.

Since the URI Watershed Watch monitoring results are consistent with data acquired by RIDEM for dry weather monitoring, they are not used to ascertain the TMDL. RIDEM sampled 6 dry weather events in the summer of 2000, making this data more representative of current water quality conditions. Furthermore, the combined URI Watershed Watch and RIDEM data set did not show a significant difference in water quality conditions (i.e. no violations of the weighted mean were found) for dry weather conditions. This methodology is consistent with that of the 1996-1997 URI dry weather Water Quality Study (section 5.1.1).

Table 18. Yearly geomean fecal coliform concentrations for Saugatucket Pond

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Fecal coliform (fc/100mL)	-	8	43	23	13	39	42	6	47

5.4 Weighted Average Approach

In order to develop an overall assessment of water quality conditions in the watershed, the RIDEM dry weather and URI and RIDEM wet weather data sets were combined, where appropriate. 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 Saugatucket 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 wet weather days) x (Wet weather geomean) + (% of dry weather days) x (Dry weather geomean)

Any precipitation event in the watershed that produces runoff was considered to be a "wet" weather condition. According to data from 15 years of rainfall data from the Kingston Agricultural Experiment Station in Kingston, RI, the frequency of occurrence for a rainfall event greater than 0.25-inches was 15%. The frequency of occurrence was determined for rainfall events greater than or equal to 0.15,0.20, 0.25, 0.3, 0.4, 0.5, and 0.75 inches of rainfall in a 24-hr period.

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 B criteria of 200 fc/100ml). It was not necessary to compute decay equations for the RIDEM wet weather data because sampling continued, for most stations, until fecal coliform concentrations dropped to acceptable levels.

Analysis of wet weather data for the Saugatucket River watershed show that, in general, two days beyond the day of rain are needed for the tributaries and three days beyond the day of rain are required for the Saugatucket River main-stem fecal coliform concentrations to drop to either pre-storm levels or the Class B criteria of 200 fc/100ml. For each additional day of recovery needed beyond the first day, the percentage of wet weather days was increased by 15%, making the percent of wet weather days equal to 45% (15% X 3) for the tributaries and 60% (15% X 4) for the Saugatucket River. 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 55% for the tributaries, and 40% for the Saugatucket River.

Therefore, the weighted average geometric mean for the mainstem Saugatucket River can be calculated as:

Weighted Avg. Geomean (for each WQ station) = (0.60)(Wet weather geomean) + (0.40)(Dry weather geomean)

Similarly, the weighted average calculation for the tributaries, can be calculated as:

Weighted Avg. Geomean (for each WQ station) = (0.45)(Wet weather geomean) + (0.55)(Dry weather geomean)

The results of these calculations are shown in Table 19. 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.

5.5 Calculation of the Percent Exceedance Value

State water quality standards require that, for Class B waters, not more than 20% of the samples shall exceed a value of 500 MPN/100ml and for Class SB waters, not more than 10% of the

samples shall exceed a value of 500 MPN/100ml. In order to determine compliance with this portion of the standard, the wet weather data set from the URI study and the data set from the RIDEM dry and wet weather studies were combined into one data set for applicable stations. The applicable percentile value was then determined for each station from the total data set of concentration values.

6.0 WATER QUALITY IMPAIRMENTS

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

Both dry and wet weather data were used to characterize water quality conditions in the Saugatucket 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.

Table 19. Weighted Average and Percent Exceedance (80th Percentile) Calculations.

Waterbody/ Segment	Station ID	Location	DW Geometric mean (fc/100ml)	WW Geometric mean (fc/100ml)	Weighted Geometric Mean Concentration (fc/100ml)	Calculated 80th Percentile
Rocky Brook	RB9U	Greenwood Dr.	-	353	n/a	2200
	RB9D	Greenwood Dr.	114	6764	3107	6100
3	RB8	Jr. High School	22	282	139	220
	RB7D	Curtis Corner Rd.	130	3820	1791	640
	RB6	End of Dam St.	22	471	224	170
2	RB5U	Rocky Brook outlet	20	477	226	78
	RB4	Hopkins Ln.	28	478	231	1300
	RB3	Anton's Deli	-	1126	n/a	3900
1	RB2	Patsy's Liquors	30	1234	383	3800
	RB1U	Railroad St.	119	-	n/a	222
	RB1D	Railroad St.	97	733	383	3400
Indian Run Brook	IR11	Route 1	31	888	417	1000
	IR10	Saugatucket Rd.	69	2552	1186	8000
	IR7	St. Dominics	48	1179	557	1200
2	IR6	St. Dominics	182	2447	1201	5200
	IR4	Above Indian Run Reservoir outlet	15	1558	709	3400
	IR3U	Kingstown Rd. at Rt. 108	165	2070	1022	3100
	IR3D	Intersection of Rt. 108, School St. & Indian Run Rd.	-	1200	n/a	3800
1	IR2	Amos St.	169	2307	1131	2500
	IR1U	Peace Dale Guild	159	2318	1131	3700
Mitchell Brook	MB04	Route 138	37	594	288	610
	MB03	Rose Hill Rd	1274	407	884	3300
1	MB02	Rose Hill Pet Cemetery	204	2750	1350	3500
	MB01	Rose Hill Transfer Station	288	1615	885	1600
Saugatucket River	UT01	Tributary @ Rose Hill Rd.	135	1459	731	12000
4	SR03	Saugatucket Road	80	495	329	4500
3	UT02	Tributary @ Saugatucket Road	106	3265	1528	12000
	SR04D	Above Saugatucket Pond Dam	19	32	27	
2	SR05	Church St.	289	1190	768	2900
	*SR06U	Above Main St. Dam	60	265	183	1000
1	*SR06D	Below Main St. Dam (Damon's Hardware)	357	1151	833	4100

- * Indicates station was evaluated using Class SB standards (90th percentile value shown); % reduction is based upon meeting SB criteria
- n/a indicates that the weighted geomean was not applicable because station was used for wet weather bracketing only

This TMDL addresses the different segments of the Saugatucket River watershed as defined by the 34 water quality monitoring stations (28 in-stream & 6 stormwater outfalls) 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 Saugatucket River stations or tributary stations (Rocky Brook, Indian Run Brook, Mitchell Brook, and the two Unnamed Tributaries).

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, spoke with area residents regarding potential sources of bacteria pollution.

6.1 Rocky Brook

6.1.1Rocky Brook Segment 3 (Headwaters to Curtis Corner Road)

Station RB9D (Rocky Brook at Greenwood Drive)

Water Quality Impairments
Station RB9D is located approximately 1,800-feet west of the intersection of Greenwood Drive and Kingstown Road and 50-feet downstream of a stormwater outfall. Fecal coliform data collected this location does not show any dry weather impairments, as the geometric mean value is 114 fc/100ml. Wet weather geometric mean concentrations increased from 353 fc/100ml, just upstream of a stormwater outfall at station RB9U, to 6,764 fc/100ml approximately 50-feet downstream of the outfall at station RB9D during the RIDEM wet weather sampling event. The resulting weighted average geomean at station RB9D is 3,107 fc/100ml.

Pollution Source Identification
Untreated stormwater runoff, particularly from Greenwood Drive and Kingstown Road north of Greenwood Drive, is thought to have a significant impact on water quality in this waterbody during wet weather. The fecal coliform geometric mean value of stormwater was 17,000 fc/100ml. Field reconnaissance of year 2000 aerial photographs show no dry weather anthropogenic sources of fecal coliform bacteria in this section of Rocky Brook. Furthermore, the Greenwood Drive and Kingstown Road areas are sewered.

Station RB8 (Tributary of Rocky Brook at Jr. High School)

Water Quality Impairments
Station RB8T is located adjacent to an access road that runs between the South Kingstown Junior High School and athletic fields, and is approximately 1,200-feet upstream of its confluence with Rocky Brook. RIDEM fecal coliform data collected at do not show any dry weather impairments, as the dry weather geometric mean concentration is 21 fc/100ml. The wet weather geometric mean concentration is 265 fc/100ml. The resulting weighted average geomean for this station is 139 fc/100ml, and therefore is not considered impaired.

Station RB7D (Rocky Brook at Curtis Corner Road)

Water Quality Impairments

Station RB7D is located immediately downstream of where Rocky Brook flows under Curtis Corner Road. Fecal coliform data collected at RB7D do not show any dry weather impairments, as the geometric mean value is 130 fc/100ml. Wet weather fecal coliform concentrations at this station were high, with a range of 180 fc/100ml to 54,000 fc/100ml, and a geometric mean of 3,820 fc/100ml. The weighted average geomean for this station was 1,791 fc/100ml.

Pollution Source Identification
Elevated wet-weather bacteria concentrations are thought to be impacted by untreated stormwater runoff from Curtis Corner Road and cumulative impacts upstream sources, including wildlife. Field reconnaissance and review of year 2000 aerial photographs show no dry weather anthropogenic sources of fecal coliform bacteria in this section of the watershed. Curtis Corner Road, including the Jr. High School, is sewered. An adequate forested buffer (ranging from 150-300-feet in width) exists between the recreational fields and Rocky Brook.

6.1.2 Rocky Brook Segment 2 (Curtis Corner Road to Rocky Brook Reservoir outlet)

Station RB6 (Tributary of Rocky Brook at bike path)

Water Quality Impairments
Station RB6 is located immediately north (downstream) of the South County Bike Path and approximately 50-feet west of the terminal end of Dam Street. Fecal coliform data collected at RB6 do not show any dry weather impairments, as the geometric mean value is 22 fc/100ml. The wet weather geometric mean value at this station is 471 fc/100ml, with a peak concentration of 26,000 fc/100ml. The resulting weighted geomean for this station is 224 fc/100ml.

Pollution Source Identification
Station RB6 is located in a forested area that is absent of stormwater discharges. California Jim's Pond, an impoundment, is located approximately 800-feet upstream of this station. Runoff from South County Bike Path and Dam Street does not reach this tributary. Dam Street is sewered, as is all development immediately surrounding California Jim's Pond. Therefore, fecal coliform levels at this station are most likely due to natural background sources, such as wildlife.

Station RB5U (Rocky Brook Reservoir outlet at Kingstown Road)

Water Quality Impairments
Station RB5U is located immediately west (upstream) of Kingstown Road where the Rocky Brook Reservoir discharges to Rocky Brook. Fecal coliform data collected at RB5U do not show any dry weather impairments, as the geometric mean value is 20 fc/100ml. The wet weather geometric mean value at this station is 477 fc/100ml, with a peak concentration of 18,000 fc/100ml. The resulting weighted geomean for this station is 226 fc/100ml.

Pollution Source Identification
Stormwater runoff does not appear to directly affect fecal coliform concentration at this station as no outfalls were observed discharging to Rocky Brook Reservoir or to Rocky Brook in the upstream vicinity of this station. Wildlife, including waterfowl, have been observed utilizing Rocky Brook Reservoir. The areas adjacent to Kingstown Road and other roads near this sampling station are sewered. A stormwater swale was sampled downstream of station RB5U on the opposite side of Kingstown Road (station RB5SW). The fecal coliform concentrations within this swale were measured at 8,500, 3,300, and 520 fc/100ml. An in-stream

sample was not taken downstream from the swale for bracketing purposes due to access limitations. Fecal coliform levels at this station are most likely due to natural background sources, such as wildlife.

6.1.3 Segment 1(Rocky Brook Reservoir outlet to Railroad St.)

Station RB4 (Rocky Brook at Hopkins Lane)

Water Quality Impairments
Station RB4 is located at Hopkins Lane approximately 425-feet east of Kingstown Road. Data collected at RB4 do not show any dry weather impairments, as the dry weather geometric mean concentration is 28 fc/100ml. The wet weather geometric mean value at this station is 478 fc/100ml, with a peak concentration of 5,700 fc/100ml. The resulting weighted geomean for this station is 231 fc/100ml.

Pollution Source Identification
Suspected sources include cumulative impacts from upstream sources. Stormwater runoff does not appear to directly affect fecal coliform concentration at this station.

Station RB3 (Rocky Brook at Anton's Deli)

Water Quality Impairments
Station RB3 is located immediately upstream of where Rocky Brook flows under Kingstown Road and next to Anton's Deli. The Peace Dale Rotary is located approximately 400-feet east of station RB3. This station was used for wet weather water quality monitoring only. The wet weather fecal coliform geometric mean concentration at this station was 1,126 fc/100ml. The peak concentration at this station was 6,800 fc/100ml. A concentration of 2,600 fc/100ml was measured at a stormdrain immediately upstream of this station. The stormdrain appears to receive runoff from the street and parking lots of Anton's Deli and two other commercial buildings along Route 108 north of the deli. Other runoff affecting fecal coliform levels at this station include runoff from Kersey Road, located north station RB3 and south of Hopkins Lane. All buildings in this area are sewered.

Pollution Source Identification
Suspected sources include cumulative impacts from upstream sources and elevated concentrations in untreated stormwater originating from the culvert pipe.

Station RB2 (Rocky Brook behind Patsy's Liquor Store)

Water Quality Impairments
Station RB2 is located approximately 200-feet downstream (south) of station RB3. The wet weather geometric mean concentration at this station was 1,234 fc/100ml, with a peak of 4,800 fc/100ml. Fecal coliform data collected at RB2 do not show any dry weather impairments, as the geometric mean concentration was 30 fc/100ml. The weighted geometric mean was 391 fc/100ml.

Pollution Source Identification
During wet weather, upstream sources, as measured at station RB3, appear to be affecting fecal coliform concentrations at this station.

Station RB1D (Rocky Brook at Railroad Street)

Water Quality Impairments
Station RB1D is located where Rocky Brook flows under Railroad Street and approximately 200-feet upstream of the confluence of Rocky Brook and the Saugatucket River. Fecal coliform data collected at RB1D does not show impairments during dry weather, as the geometric mean concentration is 97 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station was 733 fc/100ml (RIDEM & URI combined data). The resulting weighted average geometric mean is 383 fc/100ml.

Pollution Source Identification
Inputs from a stormwater outfall immediately upstream from this station appear to contribute significantly to wet weather impairments at this station. The fecal coliform level from the stormwater outfall was 8,200 fc/100ml, with an in-stream peak of 34,000 fc/100ml. Stormwater runoff from Kingstown Road and Railroad Street is suspected as contributing to elevated levels of fecal coliform bacteria at this station. Stormwater runoff from High Street that flows into Rocky Brook approximately 600-feet upstream of station RB1D is also a potential source. Cumulative impacts from other upstream sources, such as the stormwater outfall at station RB3 and Kersey Road, are also contributors.

6.2 Indian Run Brook

6.2.1 Segment 2 (Headwaters to Indian Run Reservoir outlet)

Station IR11 (Indian Run Brook at Route 1)

Water Quality Impairments
Station IR11 is located approximately 50-feet west of the Route 1 southbound lane, and approximately 550-feet south of the intersection of Route 1 and Arrowhead Trail. This station represents the most upstream location of Indian Run Brook. The brook receives runoff from a stormwater outfall originating from Route 1, which had a fecal coliform concentration of 290 fc/100ml during wet weather. Fecal coliform data collected at IR11 do not show any dry weather impairments, as the geometric mean value is 31 fc/100ml. The wet weather geometric mean value at this station is 888 fc/100ml, with a peak concentration of 11,000 fc/100ml. The resulting weighted average geomean for this station is 417 fc/100ml.

Pollution Source Identification
The only possible sources of fecal coliform at this station are runoff from Route 1, and natural background concentrations from wildlife.

Station IR10 (Indian Run Brook at Saugatucket Road)

Water Quality Impairments
Station IR10 is located immediately north of Saugatucket Road, approximately 1,100-feet west-southwest of the intersection of Saugatucket Road and Tower Hill Road (US Route 1). Fecal

coliform data collected at IR10 do not show any dry weather impairments, as the geometric mean value is 69 fc/100ml. The wet weather geometric mean value at this station is 2552 fc/100ml, with a peak concentration of 19,000 fc/100ml. The resulting weighted average geomean for this station is 1,186 fc/100ml.

Pollution Source Identification
Station IR10 is near the headwaters of Indian Run Brook and located at the outlet of a small impounded wetland complex located immediately upstream of Saugatucket Road. A horse farm is located approximately 500-feet to the northeast of the impoundment. However, an adequate forested buffer (ranging from 150-450-feet in width) exists between Indian Run Brook and the farm. Fecal coliform levels at this station are most likely due to natural background sources, such as wildlife. This portion of Indian Run Brook receives stormwater runoff from Route 1. Therefore, the stream may also be impacted by that stormwater loading.

Station IR7 (Indian Run Brook Tributary at St. Dominics)

Water Quality Impairments
Station IR7 is located at the mouth of an intermittent stream that runs in a westerly direction parallel with a sewer easement. Fecal coliform data collected at IR7 do not show any dry weather impairments, as the geometric mean value is 48 fc/100ml. The wet weather geometric mean value at this station is 1,179 fc/100ml, with a peak concentration of 44,000 fc/100ml. The resulting weighted average geomean for this station is 557 fc/100ml.

Pollution Source Identification
Station IR7 is located within a forested swamp and drains to Indian Run Brook approximately 50-feet downstream of station IR6. A review of year 2000 aerial photographs shows no anthropogenic sources of fecal coliform bacteria in this portion of Indian Run Brook. Wet weather contributions cannot be attributed to the sewer line as it was newly constructed and not yet in use during the time of the monitoring study. Therefore, wildlife contributions as natural background stemming from the surrounding swamp and upstream tributaries are the only suspected source in this area.

Station IR6 (Indian Run Brook at St. Dominics)

Water Quality Impairments
Station IR6 is located approximately 1,300-feet east of the paved end of St. Dominics Road where Indian Run Brook flows under an unpaved road (cart path) now used as a sewer line easement. Fecal coliform data collected at IR6 does not show any dry weather impairments, as the geometric mean concentration is 182 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 2,447 fc/100ml, and the resulting weighted average geomean concentration is 1,201 fc/100ml.

Pollution Source Identification
Other than downstream impacts from Route 1 and Saugatucket Road, a review of year 2000 aerial photographs shows no anthropogenic sources of fecal coliform bacteria in this portion of Indian Run Brook. A peak of 28,000 fc/100ml was observed at this station during the wet weather survey. Wet weather contributions cannot be attributed to the sewer line as it was newly constructed and not yet in use during the time of the monitoring study. Therefore, wildlife

contributions as natural background stemming from the surrounding swamp and upstream tributaries is the only suspected source in this area.

Station IR4 (Indian Run Reservoir outlet)

Water Quality Impairments
Station IR4 is located at the outlet to Indian Run Reservoir. Fecal coliform data collected at IR4 does not show any dry weather impairments, as the geometric mean concentration is 15 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 1,558 fc/100ml, and the resulting weighted average geomean concentration is 709 fc/100ml.

Pollution Source Identification
A review of 2000 aerial photographs shows no anthropogenic sources of fecal coliform bacteria in this portion of Indian Run Brook. A peak of 16,000 fc/100ml was observed at this station during the wet weather survey. Wildlife contributions as natural background stemming from the surrounding swamp and upstream tributaries are a suspected source in this area. People have been observed walking dogs along the reservoir. Therefore, pet waste is a possible source of elevated fecal coliform concentrations, though probably not significant.

6.2.2 Segment 1 (Indian Run Reservoir outlet to Indian Run Brook mouth at Peace Dale Guild)

Station IR3U (Indian Run Brook upstream of Route 108)

Water Quality Impairments
Station IR3U is located immediately upstream of the Route 108 culvert bridge. Fecal coliform data collected at IR3U does not show any dry weather impairments, as the geometric mean concentration is 165 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 2,070 fc/100ml, and the resulting weighted average geomean concentration is 1,022 fc/100ml. An outfall and connecting swale drains stormwater from commercial parking lots in the Dale Carlia corner area between stations IR4 and IR3U. This swale drains to Indian Run Brook approximately 600-feet upstream of Route 108. The outfall's drainage area includes the parking lots of Wakefield Liquors, At My Uncle's Restaurant, The Print Source print shop, and the Ocean State Job Lot.

Pollution Source Identification
Parking lot runoff is suspected to be the primary source at this location. No other anthropogenic sources were identified in this portion of the stream.

Station IR3D (Indian Run Brook at School Street)

Water Quality Impairments
Station IR3D is located at the intersection of Kingstown Road, School Street, and Indian Run Road approximately 50-feet downstream of a large stormwater outfall (Station IR3SW). This station was used for wet weather water quality monitoring only. During the RIDEM wet weather sampling event, fecal coliform concentrations increased from 380 fc/100ml at the Kingstown Road culvert bridge to 7,600 fc/100ml at station IR3D . The geometric mean of fecal coliform concentrations in the water flowing directly from the stormwater outfall was 8,367 fc/100ml, with a peak concentration of 14,000 fc/100ml.

Pollution Source Identification
In addition to upstream sources, suspected sources of runoff and wet weather impacts to this section of Indian Run Brook include the commercial areas, parking lots, and streets that drain to the large seven-foot by 3-foot box culvert that discharges to the stream at the intersection of Rt. 108, School Street, and Indian Run Road. This drainage area includes a portion of Route 1, portions of Kingstown Road, Main Street, Old Tower Hill Road, and adjacent businesses and parking lots. Further, Indian Run Brook runs through a swampy area between station IR4 and IR3U, which may contribute fecal coliform loadings from wildlife.

Station IR2 (Indian Run Brook at Amos Street)

Water Quality Impairments
Station IR2 is located approximately 100-feet south of the terminal end of Amos Street. Fecal coliform data collected at IR2 do not show any dry weather impairments, as the geometric mean concentration is 169fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 2,307 fc/100ml, with a resulting weighted average geomean concentration of 1,131 fc/100ml.

Pollution Source Identification
No sources, other than those upstream, have been identified as impairing station IR2 during wet weather. Stormwater runoff does not enter the stream at or near this location.

A sanitary sewer line runs the length of Amos Street and crosses under Indian Run Brook approximately 100-feet upstream of station IR2. However, one would expect higher concentrations than those exhibited at this station if there were a sewer line leak or failure.

Station IR1U (Indian Run Brook at Columbia Street)

Water Quality Impairments
Station IR1U is located where Indian Run Brook flows under the Columbia Street Bridge. RIDEM and URI wet weather data were combined at this station. Fecal coliform data collected at IR1U do not show any dry weather impairments, as the combined geometric mean concentration is 159 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 2,318 fc/100ml, with a resulting weighted average geomean concentration of 1,131 fc/100ml.

Pollution Source Identification
Sources at or near this station include stormwater runoff from Columbia Street, and upstream sources. A small, paved swale conveys stormwater from Columbia Street to Indian Run Brook at station IR1U. Fecal coliform levels measured at this swale had a concentration of 4,800 fc/100ml. Three outfalls were discovered during a storm event between Columbia Street and Spring Street; an 8-inch stormwater outfall approximately 300-feet upstream of station IRIU, and two 12-inch stormwater outfall approximately 500 and 550-feet upstream of station IR1U, respectively. The first outfall drains the parking lot for the Peace Dale Neighborhood Guild. The second outfall drains an area of unknown origin. The third outfall drains Spring Street. Although these outfalls were not monitored during the wet weather event, it is suspected that they contribute fecal coliform bacteria to Indian Run Brook.

6.3 Mitchell Brook

6.3.1 Segment 1 (Headwaters to Rose Hill Transfer Station)

Station MB04 (Mitchell Brook at Rt. 138)

Water Quality Impairments
Station MB04 is located immediately south (downstream) of Rt. 138, approximately 1,600-feet southwest of the intersection of Rose Hill Road and Rt. 138. Fecal coliform data collected at MB04 do not indicate a dry weather impairment, as the geometric mean concentration is 37 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 594 fc/100ml, with a resulting weighted average geomean concentration of 288 fc/100ml.

Pollution Source Identification
No pollution sources upstream of this station have been identified. Stormwater runoff from Rt. 138 was not observed entering the stream at this location, and the surrounding land use consists of swamp and forest. Therefore, suspected sources at this location include wildlife as natural background.

Station MB03 (Mitchell Brook at Rose Hill Road)

Water Quality Impairments
Station MB03 is located immediately upstream of where Mitchell Brook flows under Rose Hill Road. Samples collected station MB03 showed elevated levels of fecal coliform bacteria during both dry and wet weather. Dry weather fecal coliform geometric mean concentrations at this location is 1,274 fc/100ml. The geometric mean of the combined URI & RIDEM wet weather data is 407 fc/100ml. The resulting weighted average geomean is 884 fc/100ml.

Pollution Source Identification
A small cow farm located approximately 450-feet southwest of where Mitchell Brook flows under Rose Hill Road was identified as a significant dry and wet weather contributor of fecal coliform bacteria in this sub-watershed. RIDEM staff observed cows gaining direct access to Mitchell Brook. The area the cows are using to access the stream is unvegetated and muddy. This area slopes toward the stream, ensuring that runoff will transport manure and eroded soils directly into the stream.

Station MB02 (Mitchell Brook at the Rose Hill Pet Cemetery)

Water Quality Impairments
Station MB02 is located at a wooden footbridge that crosses Mitchell Brook at the entrance to the Rose Hill Pet Cemetery, approximately 1,200-feet east of station MB03. Samples collected station MB03 showed elevated levels of fecal coliform bacteria during both dry and wet weather. Dry weather fecal coliform geometric mean concentrations at this location is 204 fc/100ml. The wet weather geometric mean concentration is
2,750 fc/100ml. The resulting weighted average geomean is 1,305 fc/100ml.

Pollution Source Identification
No anthropogenic sources, other than those upstream of station MB03, have been identified as impairing station MB02 during wet or dry weather. In fact, the wetland in this segment may act as a sink for pathogens during dry weather. During wet weather, the elevated flows may turn the wetland into a source. Similar situations have been observed in other watersheds throughout the state as well.

Station MB01 (Mitchell Brook at the Rose Hill Transfer Station)

Water Quality Impairments
Station MB01 is located just downstream of the access road to the Rose Hill Landfill Transfer Station. Mitchell Brook is located approximately 700-feet east of Rose Hill Road. Samples collected at station MB01 showed elevated levels of fecal coliform bacteria during both dry and wet weather. The dry weather fecal coliform geometric mean concentration at this location is 288 fc/100ml. The wet weather geometric mean is 1,615 fc/100ml. The resulting weighted average geomean is 686 fc/100ml.

Pollution Source Identification
No anthropogenic sources, other than those upstream of station MB02, have been identified in this segment as impairing station MB01 during wet or dry weather. Stormwater runoff does not enter the stream at this location, and runoff was not observed to enter the stream at the access road.

6.4 Saugatucket River & Unnamed Tributaries

6.4.1 Segment 4 (Headwaters to Saugatucket Road)

Station UT01U (Unnamed Tributary 1 at Rose Hill Road)

Water Quality Impairments
Station UT01U is located just upstream of Rose Hill Road approximately 650-feet north of the intersection of Saugatucket Road and Rose Hill Road. There is no dry weather violation of water quality standards at this station, as the geometric mean concentration was 135 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this station is 1,459 fc/100ml, with a resulting weighted average geomean of 885 fc/100ml.

Pollution Source Identification

Field reconnaissance and review of recent aerial photographs reveals no anthropogenic sources of fecal coliform bacteria in this subwatershed. No stormwater runoff was observed to impact this section of the tributary. Watson Farm, a subdivision located north of Saugatucket Road and southwest of the tributary, operates on Individual Sewage Disposal Systems and has two large stormwater detention areas. The subdivision is relatively new, being built in the 1990's. Therefore, the chance of widespread pathogen loadings from failed or failing septic systems at this time is not expected.

Station SR03U (Saugatucket River at Saugatucket Road)

Water Quality Impairments
Station SR03U is located where the River flows under Saugatucket Road. There is no dry weather violation of water quality standards at this station, as the geometric mean concentration was 80 fc/100ml. However, the combined URI & RIDEM wet weather geometric mean concentration at this station is 495 fc/100ml, with a resulting weighted average geomean of 731 fc/100ml.

Pollution Source Identification
No sources, other than inputs from upstream tributaries (e.g. Mitchell Brook) have been identified as impacting this station. A review of 2000 aerial photographs shows no anthropogenic sources of fecal coliform bacteria in this section of the Saugatucket River.

Elevated wet weather fecal coliform levels are likely to be a direct result of upstream loadings from Unnamed Tributary 1, Mitchell Brook, and the Saugatucket River upstream of these two inputs. Stormwater runoff from Saugatucket Road was not observed to impact this section of the Saugatucket River.

6.4.2 Segment 3 (Saugatucket Road to Saugatucket Pond outlet at gatehouse)

Station UT02 (Unnamed Tributary 2 at Saugatucket Road)

Water Quality Impairments
Station UT02 is located on Saugatucket Road between North Road and Rose Hill Road. There is no dry weather violation of water quality standards at this station, as the geometric mean

concentration was 106 fc/100ml. However, the wet weather fecal coliform geometric mean concentration at this monitoring station was 3,265 fc/100ml, with a resulting weighted average geomean of 1,528 fc/100ml.

Pollution Source Identification
Field reconnaissance and review of recent aerial photographs revealed that waterfowl and seagulls utilize a small pond approximately 200-feet from University of Rhode Island Experimental Agricultural Station's entrance. The pond discharges to the unnamed tributary at its headwaters. The clarity of the water in the pond is poor, bird guano litters the lawn surrounding the pond, and bare spots in the lawn occur where the waterfowl have grazed. Bird guano is suspected to enter the stream near its headwaters and may contribute to the elevated fecal coliform concentrations found at this station. Other sources may include wildlife.

Station SR04D (Saugatucket Pond outlet at gatehouse)

Water Quality Impairments
Station SR04D is located at the southwestern corner of Saugatucket Pond at the gatehouse water level control structure. Combined RIDEM & URI fecal coliform data collected at SR04D do not show any dry or wet weather impairments, as the dry weather geometric mean concentration is 19 fc/100ml and the wet weather geometric mean concentration is 265 fc/100ml. The resulting weighted average geomean for this station is 27 fc/100ml.

Pollution Source Identification
Because the weighted average geomean is less than 200 fc/100ml, this segment of the river is not considered impaired. The impoundment appears to have a positive water quality affect in regards to pathogens.

6.4.3 Segment 2 (Saugatucket Pond outlet at gatehouse to Church Street)

Station SR05 (Saugatucket River at Church Street)

Water Quality Impairments
Station SR05 is located underneath the Church Street Bridge on the western bank of the Saugatucket River. Samples collected at station SR05 show elevated levels of fecal coliform bacteria during both dry and wet weather. The dry weather fecal coliform geometric mean concentration at this location is 289 fc/100ml. The combined URI and RIDEM wet weather concentration is 1,088 fc/100ml. The resulting weighted average geomean is 768 fc/100ml.

Pollution Source Identification
Large numbers of pigeons roost under the Palisades Mill Complex and in culverts coming from the complex. The mill is approximately 900 feet upstream of station SR05. Large amounts of bird droppings were observed on rocks and culverts adjacent the channel. Fecal matter is deposited directly into the stream and dry weather fecal coliform concentrations reflect these concentrations. The URI investigators performed three interim surveys (Figure 14) of the area around the mill complex and found that fecal coliform levels at the location where the pigeons were roosting were as high as 195,000 fc/100ml. No other dry weather sources of fecal coliform were identified in that area. The fecal matter deposited in, and adjacent to, the channel during dry weather accumulate and become a significant wet weather source of bacteria to the Saugatucket River.

Rocky Brook and Indian Run Brook converge with the Saugatucket River 1,400 and 700-feet upstream of station SR05, respectively. URI and RIDEM combined wet weather geometric mean fecal coliform concentrations were 733 fc/100ml at station RB01, and 978 fc/100ml at station IR01. Inputs from these tributaries during wet weather have a cumulative impact on fecal coliform concentrations at station SR05.

6.4.4 Segment 1 (Church Street to Damon's Hardware)

Station SR06U (Saugatucket River at Main Street Dam)

Water Quality Impairments
Station SR06U is located on the west side of the Main Street Dam upstream of the bridge. Combined RIDEM & URI fecal coliform data collected at SR06U do not show any dry weather impairments, as the geometric mean concentration is 60 fc/100ml. The wet weather geometric mean concentration is 265 fc/100ml. The resulting weighted average geomean for this station is 183 fc/100ml.

Pollution Source Identification
Similar to conditions observed at Saugatucket Pond, bacteria levels decline within the impoundment. Though the weighted average geomean does not exceed the Class B standard, to be protective of downstream uses, the goal for this reach of the river at its point of discharge to the estuarine portion at the Main Street Dam is the more stringent Class SB fecal coliform standards. Stormwater outfalls were identified between station SR05 and SR06U.

Station SR06D (Saugatucket River at Damon's Hardware)

Water Quality Impairments
Station SR06D is located approximately 150-feet downstream of the Main Street Bridge. Samples collected at station SR06D show elevated levels of fecal coliform bacteria during both dry and wet weather. The dry weather fecal coliform geometric mean concentration at this station is 357 fc/100ml. The URI and RIDEM combined wet weather concentration is 1,151 fc/100ml. The resulting weighted average geomean is 833 fc/100ml.

Pollution Source Identification
Large numbers of pigeons were found to roost under the Main Street Bridge. Bird droppings are deposited directly into the stream, and the elevated dry weather fecal coliform concentrations reflect these loadings. No other dry weather sources of fecal coliform were identified. Elevated wet weather levels are suspected to originate from upstream sources during wet weather, as fecal coliform concentrations ranged from 100 to 10,000 fc/100ml at station SR06U. Further, although not monitored due to access constraints, a stormwater outfall located at the base of the northeastern side of the bridge is suspected as being a wet weather source.

6.5 Summary of Pollutant Sources

A common theme can be seen among the identified and potential sources of fecal coliform bacteria among waterbodies in the watershed. Wet weather concentrations were higher than dry weather concentration, in which stormwater runoff played an important role. Unless a specific source, such as the cow farm and pigeons, was found, dry weather fecal coliform concentrations were below the standard. In the more rural areas where anthropogenic impacts, such as

stormwater runoff, were not evident, the only sources that could be extrapolated were wildlife and/or domestic pets. In the unsewered areas of the watershed, ISDS failures also represent a potential though currently unconfirmed source of fecal coliform. Table 20 summarizes the known and potential fecal coliform sources in the major waterbodies of the Saugatucket River watershed.

Table 20. Summary of dry and wet weather sources of fecal coliform bacteria in the Saugatucket River watershed.

Location	Dry weather sources	Wet weather sources
Saugatucket River	Inputs from Mitchell Brook and contributions from pigeons	Stormwater runoff, inputs from Indian Run Brook, Rocky Brook, and Mitchell Brook, contributions from pigeons, waterfowl, pet waste and wildlife
Indian Run Brook	Contributions from wildlife	Stormwater runoff, contributions from waterfowl and other wildlife
Rocky Brook	Contributions from wildlife	Stormwater runoff, contributions from pet waste and wildlife
Mitchell Brook	Cow farm, contributions from wildlife	Stormwater runoff, dairy farm, wildlife contributions

6.5.1 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 Saugatucket River. However, due to the limited amount of information 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 TOTAL MAXIMUM DAILY LOAD ANALYSIS

As described in EPA guidelines, a TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards (40 C.F.R. 130.2). The TMDL is often defined as the sum of loads allocated to point sources (i.e. waste load allocation, WLA), loads allotted to nonpoint sources, including natural background sources (i.e. load allocation, LA), and a margin of safety (MOS). The loadings are required to be expressed as mass per time, toxicity, or other appropriate measures (40 C.F.R. 130.2[I]). For the allocation of fecal coliform sources, USEPA Region 1 has stated that the TMDL may alternatively be expressed in concentration units (mass per unit volume). Rationale for this approach is provided below:

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

- 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.

- 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 dependent upon flow conditions.

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

Accordingly, the Saugatucket River watershed TMDL is based directly on the state's two part fecal coliform standard.

7.1 Establishing a numeric water quality target

MOS (Margin of Safety)
The MOS may be incorporated into the TMDL in two ways. One can implicitly incorporate the MOS using conservative assumptions to develop the allocations or explicitly allocate a portion of the TMDL as the MOS. 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.

- No allowances were made for bacterial decay.

- The dilution effects of groundwater infiltration were not considered when calculating receiving water fecal coliform concentrations

- The data used to calculate the 80^{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.

- The weighted geometric mean values were developed using annual averages for the number of wet and dry weather days. However, the actual monitoring data used in the calculations were from warm weather when fecal coliform concentrations are typically much higher. As a result, the weighted average geometric mean and related reductions are conservative in nature

Seasonal Variation/Critical Conditions

Water quality monitoring carried out by RIDEM in past years has shown that fecal coliform concentrations in streams and rivers tend to be at their highest during the summer months. In addition, past monitoring has shown that fecal coliform levels increase significantly during wet weather and high flow events. Monitoring conducted in support of this TMDL focused on the critical summer season and included both wet and dry weather conditions. Therefore, the Saugatucket River TMDL is protective of all seasons.

Numeric Water Quality Target

The water quality target for the Saugatucket River and its tributaries is set at the state's Class B fecal coliform standard, which is a geometric mean of 200 fc/100 ml with an 80th percentile concentration no greater than 500 fc/100 ml. Additionally, in order to be protective of downstream water quality, the Saugatucket River must meet the more stringent Class SB fecal coliform standard (geometric mean of 50 fc/100 ml with a 90th percentile concentration of 500 fc/100 ml) at the point of discharge to the estuarine portion of the river located immediately below the Main Street Dam

7.2 Establishing the Allowable Loading (TMDL)

The loading capacity for this TMDL is expressed as a concentration set equal to the state water quality standard. Extensive field surveys, water quality monitoring, and review of aerial photos/topographic maps were used to establish the link between pollutant sources and in-stream concentrations.

The reduction goal for each segment was determined by comparing current fecal coliform concentrations to the applicable water quality target, then calculating the percent reduction required to reach that target. Since the water quality regulations specify both a geometric mean criterion and the 80th or 90th percent criterion, two calculations are made at each location. The three step process is outlined below.

Comparison of the weighted geometric mean to the geometric mean standard
Current bacterial conditions in the Saugatucket River and its tributaries were determined as a "weighted geometric mean" value that is the sum of the wet and dry weather geometric means, weighted by their probability of occurrence. This approach is explained further in Section 5.3 of this report. This value was then compared to the geometric mean portion of the applicable standard to determine if a violation had occurred.

Comparison of the combined data set's 80th or 90th percentile value to the percent exceedence standard
The second part of the fecal coliform standard states that, in Class B waters, "*not more than 20% of the samples shall exceed a value of 500 MPN/100ml*," and in Class SB waters, *"not more than 10% of the samples shall exceed a value of 500 MPN/100ml."* To address the second portion of fecal coliform standard, a second calculation was made. The applicable 80th or 90th percentile value at each water quality monitoring station was calculated from the combined set of wet and dry weather sample results using manual mathematical methods. This value was then compared to the applicable target to determine if a violation had occurred.

Calculation of required reductions

The weighted geometric mean and applicable 80th or 90th percentile were calculated as described above. These values were then compared to the applicable SB or B portions of the standard. Required reductions were specified that ensured each Saugatucket River and/or tributary met both parts of the standard (i.e. the more conservative of those two values is the one upon which the TMDL is based).

7.3 Required reductions (Load Allocation/Waste Load Allocation)

Other than storm sewer outfalls, there are no point sources discharging to the Saugatucket River, Mitchell Brook, Rocky Brook or Indian Run. The required fecal coliform reductions are calculated from observed concentrations at in-stream stations and represent a reduction goal that is applicable to the composite of all point and nonpoint sources contributing to the water quality impairment. Due to the unavailability of data to accurately differentiate point sources (storm water outfalls) and nonpoint sources, it was not possible to calculate a separate waste load allocation. Per US EPA guidance, the reductions called for in this TMDL are to be considered as waste load allocations, with some portion of the allocation allotted for nonpoint sources. The required reductions for each reach were determined by selecting the station within each reach having the largest violation relative to both parts of the state's fecal coliform standard, as presented in Table 21. The numbers in bold represent the required reduction for each stream segment.

It is assumed that fecal coliform loads are directly related to observed fecal coliform concentrations in the receiving water and that required percent reductions in waterbody concentrations will be achieved by an equal percent reduction in source loads. It should be noted that reductions required of specific sources may be larger than the prescribed overall percent reductions as determined from in-stream concentrations depending on the proportion of the overall load a specific source comprises.

7.4 Strengths and Weaknesses in the TMDL Process.

The Saugatucket River TMDL was developed using RIDEM-2000 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. Linkages between pollution sources and the high fecal coliform counts identified by RIDEM field monitoring were confirmed by subsequent site visits to the watershed.

Strengths:

- Approach utilized extensive knowledge of land use in the watershed.
- TMDL based on extensive dry and wet weather monitoring conducted over a multi-year period.
- Runoff and recovery parameters were derived from extensive databases, validated with field observations, and determined to be appropriate, yet conservative, for this application.

Weaknesses:

Absence of flow data and stage-discharge relationships for waterbodies.

Table 21. Reductions Needed to Meet the Weighted Geomean and Percent Exceedance Part of the Standard

Waterbody/Segment	Station ID	Location	Weighted Average Geometric Mean (fc/100ml)	% Reduction Needed to meet Geometric Mean Standard (200 fc/100ml)	Calculated 80th Percentile Value	% Reduction Needed to meet Percent Exceedance (> 20% exceed 500 fc/100ml)
Rocky Brook	RB9U	Greenwood Dr	3107	**94**	2200	77
3	RB8	Jr. High School	100	0	220	0
	RB7D	Curtis Corner Rd	1791	89	640	22
	RB6	End of Dam St.	224	**11**	170	0
2	RB5U	Rocky Brook Reservoir	226	11	78	0
	RB4	Hopkins Lane	231	13	1300	62
1	RB2	Patsy's Liquors	572	65	3800	**87**
	RB1D	Railroad St.	383	48	3400	85
Indian Run Brook	IR11D	Route 1	417	52	1000	50
	IR10U	Saugatucket Rd	1186	83	8000	**94**
2	IR7	St. Dominics	557	64	1200	58
	IR6	St. Dominics	1201	83	5200	90
	IR4	Indian Run Reservoir outlet	709	72	3400	85
1	IR2	Amos St.	1132	82	2500	80
	IR1U	Peace Dale Guild	1131	82	3700	**86**
Mitchell Brook	MB04U	Rt. 138	288	30	610	18
1	MB03U	Cow farm at Rose Hill Rd.	884	77	3300	85
	MB02	Rose Hill Pet Cemetery	1350	85	3500	**86**
	MB01	Rose Hill Transfer Station	885	77	1600	69

Saugatucket River	UT01	Unnamed Trib 1 at Rose Hill Road	731	73	12000	**96**
3	SR03D	Saugatucket Rd.	329	39	4500	89
3	UT02	Unnamed Trib. 2 at Saugatucket Rd.	1528	87	12000	**96**
	SR04D	Saugatucket Pond	27	0	82	0
2	SR05	Church St. Bridge	768	74	2900	**83**
1	*SR06U	Above Main St. dam	183	0	1000	50
	*SR06D	Below Main St. dam at Damon's Hardware	833	**94**	4100	88

- Percent reduction for SR06U and SR06D based on Class SB standard (90th percentile value and <10% exceed 500 fc/100ml)
- RB3 and IR3D are not included as they are wet weather stations only; used for purposes of bracketing sources
- Highlighted value represents load reduction for that segment

8.0 IMPLEMENTATION

This TMDL addresses water quality impairments due to bacteria contamination in the Saugatucket River and its tributaries. To simplify the water quality characterization, the Saugatucket River and its tributaries were divided into segments (Figures 2-5). Segment delineations were chosen to group similar land uses and/or sources. Water quality data were assessed, load allocations set, and BMPs recommended for each of the segments.

This TMDL relies upon phased implementation to reach its water quality goals. Upon implementation of the TMDL's recommended measures, RIDEM will conduct water quality monitoring to determine the effectiveness of these actions in meeting water quality goals.

In almost every stream segment of Saugatucket River, untreated stormwater runoff from roads, streets, and residential/commercial land uses impacts water quality. The effective management of stormwater in these existing developed areas will require a watershed-wide approach which combines pollution prevention activities with structural best management practices to reduce the discharge of pollutants and runoff volumes. The stormwater management plans required by the RIPDES Phase II Stormwater permit should set forth the specific actions and schedule for accomplishing the TMDL's goals. It is imperative that RIDEM, RIDOT, and the Town of South Kingstown work cooperatively towards achieving these goals.

In addition to the recommendations outlined below, other areas of concern were noted within the watershed. The streambank is eroded in Indian Run Brook from a seven-foot by three-foot stormwater outfall (RIDEM station IR3SW) to where the stream flows under Church Street. The outfall is located at the intersection of Route 108, School Street, and Indian Run Road and drains the Dale Carlia Corner area. The streambank of Indian Run Brook is also eroded from Spring Street to Columbia Street. High, flashy stormwater flows discharging from station IR3SW, coupled with mowing practices up to the water's edge in both segments have led to extensive erosion. It is recommended that streambank stabilization BMPs be implemented to stabilize these two segments of Indian Run Brook. Both areas are located on Town of South Kingstown Property. Also, as development and redevelopment of commercial properties occurs within the watershed, it is recommended that the Town of South Kingstown require stormwater attenuation that promotes on-site detention and/or infiltration of runoff. This recommendation especially applies to commercial properties in the catchment area which includes Dale Carlia Corner and Old Tower Hill Road that contribute stormwater runoff to the box culvert at the intersection of Route 108, School Street, and Indian Run Road.

8.1 Rocky Brook

8.1.1 Segment 3 (Headwaters to Curtis Corner Road)

Required Reduction
Based on the weighted average geometric mean, a reduction of 94% is required in this segment.

Proposed BMPs
A combination of structural and non-structural control measures are recommended for this reach. Non-structural control measures include more frequent street cleaning, stormdrain maintenance,

a pet-waste ordinance, and ISDS maintenance. Additionally, this TMDL calls for the Town of South Kingstown, RIDOT, and responsible property owners to reduce wet weather fecal coliform loads to the maximum extent technically feasible through the use of structural BMPs that promote the detention and/or infiltration of runoff from roadways and commercial properties within the catchment area and/or at the outfall located off Greenwood Drive. More specifically, there appears to be adequate space within the storm sewer right-of-way off Greenwood Drive (Station RB9) to construct an infiltration basin to detain and/or reduce the volume of water that reaches the stream.

8.1.2 Segment 2 (Curtis Corner Road to Rocky Brook Reservoir Outlet)

Required Reduction
Based on the percent exceedance portion of the standard, an 11% reduction is required in this segment.

Proposed BMPs
Non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, stormdrain maintenance, and a pet-waste ordinance. ISDS maintenance is not included in the recommendations for this segment since the area is sewered.

8.1.3 Segment 1 (Rocky Brook Reservoir outlet to Rocky Brook mouth at Railroad St.)

Required Reduction
Based on the geometric mean, an 87% reduction in fecal coliform concentrations is required in this segment.

Proposed BMPs
A combination of structural and non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, stormdrain maintenance, and a pet-waste ordinance. ISDS maintenance is not recommended since this segment of the watershed is sewered. Additionally, this TMDL calls for the Town of South Kingstown, RIDOT and responsible property owners to reduce wet weather fecal coliform loads to the maximum extent technically feasible through the use of structural BMPS that promote the detention and/or infiltration of runoff from roadways and commercial or industrial properties within the catchment areas and/or the outfalls at the following locations: the Kingstown Road stormwater swale below Rocky Brook Reservoir (Station RB5U), Kingstown Road at Anton's Deli, and Railroad Street.

8.2 Indian Run Brook

8.2.1 Segment 2 (Headwaters to Indian Run Brook Reservoir outlet)

Required Reduction
Based on the weighted average geometric mean, a 94% reduction in fecal coliform concentration is required for this segment.

Proposed BMPs

The predominant sources of fecal coliform to this reach are believed to be wildlife, for which no control measures are recommended. Non-structural control measures recommended for this segment include more frequent street cleaning, storm sewer maintenance, ISDS maintenance and a pet-waste ordinance.

8.2.2 Segment 1 (Indian Run Brook at Indian Run Reservoir Outlet to Peace Dale Guild)

Required Reduction

Based on the percent exceedance part of the standard, a 94% reduction in fecal coliform concentration is required for this segment.

Proposed BMPs

A combination of structural and non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, stormdrain maintenance, a pet-waste ordinance, and ISDS maintenance. Additionally, this TMDLs calls for the Town of South Kingstown, RIDOT, and responsible property owners to reduce wet weather fecal coliform loads to the maximum extent technically feasible through the use of structural BMPs that promote the detention and/or infiltration of runoff from roads and commercial properties within the 102 acre catchment area and/or outfall that drains the Dale Carlia Corner intersection and Old Tower Hill Road, and discharges to the box culvert located at the intersection of Route 108, School Street and Indian Run Road.

8.3 Mitchell Brook

8.3.1 Segment 1(Headwaters to Rose Hill Transfer Station)

Required Reduction
Based on the percent exceedance part of the standard, a reduction of 86% is required in this segment.

Proposed BMPs
Elevated wet weather fecal coliform levels in this segment are thought to be primarily a result of loadings from the cow farm and contributions from wildlife. The RIDEM Division of Agriculture has investigated a cow farm upstream of station MB03 and has made recommendations that specify that the farmer feed the cows and stockpile manure away from Mitchell Brook. This TMDL further provides that fencing be erected to exclude the cows from Mitchell Brook.

Other potential sources include runoff from Rose Hill Road. Non-structural control measures recommended for this segment include more frequent street cleaning, storm sewer maintenance, ISDS maintenance, and a pet waste ordinance. .

8.4 Saugatucket River

8.4.1 Segment 4 (Headwaters to Saugatucket Road)

Required Reduction
Based on the percent exceedance part of the standard, a 96% reduction in fecal coliform concentrations is required in this segment. This segment includes unnamed tributary 1.

Proposed BMPs
Non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, storm sewer maintenance, a pet-waste ordinance, and ISDS maintenance. Elevated wet weather fecal coliform levels in this segment are thought to be primarily a result of upstream loadings, including wildlife. A 9-hole golf course was finished in 2001 within this watershed, and uses three impoundments created from unnamed tributary 1 as a water hazard. Because the golf course encompasses a portion of the unnamed tributary, RIDEM recommends that fecal coliform levels be sampled at the stream outlet of the golf course as part of any follow up monitoring plan. Unless subsequent investigations identify pollution sources, no additional BMPs are proposed for this portion of the watershed.

8.4.2 Segment 3 (Saugatucket Road to Saugatucket Pond Dam)

Required Reduction
Since fecal coliform levels in Saugatucket Pond are below the water quality criteria, no reductions are necessary. However, since fecal coliform levels in the unnamed tributary exceed the water quality criteria, a 96% reduction is required for this stream.

Proposed BMPs
A combination of structural and non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, storm sewer maintenance, and a pet-waste ordinance. Elevated wet weather fecal coliform levels in this segment are thought to be primarily a result of upstream loadings, including wildlife. This TMDL calls for the reduction of waterfowl populations utilizing the pond at the University of Rhode Island's Agricultural Experiment Station on Route 108 (East Farm). The planting of shrubs around the perimeter of the pond along with signage to discourage the feeding of waterfowl, or similar such measures are recommended to discourage waterfowl.

8.4.3 Segment 2 (Saugatucket Pond Dam to Church Street Bridge)

Required Reduction
Based on the percent exceedance part of the standard, a reduction of 83% is required in the fecal coliform concentrations in this segment.

Proposed BMPs
A combination of structural and non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, storm sewer maintenance, and a pet-waste ordinance. ISDS maintenance is not recommended since this segment of the watershed is sewered. Rocky Brook and Indian Run Brook contribute to the elevated concentrations at SR05. However, the pigeons roosting above the river in the Palisades Industrial Complex are thought to have the largest impact on fecal coliform levels in this stream segment. Pigeon deterrent BMPs are necessary to discourage pigeons from nesting in and around the Palisades Industrial Complex. Should bacteria levels remain elevated following the implementation of the previously identified BMPs, this TMDL calls for the Town of South Kingstown to reduce wet weather fecal coliform loads to the maximum extent technically feasible through the use of structural BMPs that promote the detention and/or infiltration of runoff from roadways and other impervious surfaces within the catchment area and/or outfall located at Church and Columbia Streets.

8.4.4 Segment 1 (Saugatucket River from Church Street Bridge to the Main Street Dam)

Required Reduction
Based on the weighted geometric mean concentration, a reduction of 94% is required in the fecal coliform concentrations in this segment to meet the more stringent Class SB standards of 50 fc/100ml, with no more than 10% of all samples exceeding 500 fc/100ml immediately below the Main Street dam.

Proposed BMPs
A combination of structural and non-structural control measures are recommended for this segment. Non-structural control measures include more frequent street cleaning, storm sewer maintenance, and a pet-waste ordinance. ISDS maintenance is not recommended since segment of the watershed is sewered. Reductions in upstream fecal coliform concentrations associated with Indian Run Brook, Rocky Brook, and the Palisades Industrial Complex are expected to reduce concentrations in this segment. However, RIDEM also recommends that RIDOT

implement pigeon deterrent BMPs underneath the Main Street bridge to discourage pigeons from roosting above the river.

8.5 Watershed-Wide Stormwater Management Issues

Public Outreach/Public Involvement

In addition to the recommended BMPs in Table 3, RIDEM recommends the implementation of a public outreach program in the Saugatucket River watershed.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. This effort should be a component of the public outreach program required by the Phase II Stormwater Management Regulations described later in this section. The Town of South Kingstown is encouraged to work with the Rhode Island Department of Transportation, as an operator of MS4s in the watershed, and the Saugatucket River Watershed Coordinating Council in carrying out this program.

The public outreach program in the Saugatucket 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, as well as any other required components of a Phase II Permit.

The Town 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.

Birds, wildlife, and pet wastes

Mitigation of these types of sources can best be addressed by the application of nonstructural BMPs or "good housekeeping" measures. Important actions include policing pet wastes, minimizing fertilizer applications, minimizing impervious cover and restoring the beneficial value of destroyed or degraded wetlands. Pet wastes should be disposed away from the river, tributary streams and all storm water conveyances. The application of fertilizers and pesticides to gardens and lawns should be limited to recommended doses and avoided prior to rain events. Impervious surfaces in the watershed should be minimized to decrease the volume of runoff generated during storm events.

There are several measures that residents can take to minimize bird-related impacts. They can allow tall, coarse vegetation to grow along the banks of the river segments frequented by waterfowl. Waterfowl, especially grazers like geese, desire easy access from the water to the riverbanks. Leaving an uncut vegetated buffer will make the habitat less desirable to geese and encourage migration. As an alternative, residents along the waterfront can also install commercially available fencing specifically designed for this purpose. Residents should also stop feeding the birds. Eliminating this practice should also help to decrease summer bird populations and make the area less attractive to the year-round residence of migratory birds.

Storm sewer discharges

Storm water runoff is the largest wet weather source of bacteria to the Saugatucket River and its tributaries. Storm sewers magnify the problem by rapidly collecting, concentrating and directly routing polluted runoff to receiving waters. They supply the majority of the fecal coliform load to the river during wet weather. Consistent with the goals of this TMDL, outfalls are targeted for water quality best management practices to mitigate pollutant loadings to the maximum extent technically feasible.

"End-of-pipe" structural BMPs designed to treat current flows and pollutant loadings at the storm sewer outfalls would necessarily be rather expensive and/or require substantial land area. RIDEM suggests that a multi-faceted storm water management strategy be incorporated by the Town of South Kingstown and RIDOT that utilizes a combination of end-of-pipe structural BMPs, smaller-scale structural retention/infiltration BMPs located up-gradient within the catchment areas and the implementation of nonstructural BMPs throughout the watershed.

As mandated by EPA, RIDEM has amended the existing Rhode Island Pollution Discharge Elimination System (RIPDES) regulations to include Phase II Storm Water Regulations (effective March 19, 2002). Automatically designated municipalities must develop a storm water management program plan (SWMPP) that describes the Best Management Practices (BMPs) for each of the following minimum control measures:

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

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

Operators of municipal separate storm sewer systems (MS4s) within urbanized areas (UAs) or densely populated areas (DPAs) will be required to develop a SWMPP and obtain a permit (for those portions within the UA or DPA) by March 10, 2003. DPAs include places that have equal to or greater than 1,000 people per square mile and have, or are part of, a block of contiguous census designated places with a total population of at least 10,000 people, as determined by the latest Decennial Census. Operators of MS4s located outside of UAs and DPAs and that discharge to Special Resource Protection Waters (SRPWs), Outstanding National Resource Waters (ONRWs), or impaired waters will also be required to obtain a permit (or expand permit coverage throughout the jurisdiction) by March 10, 2008, unless the operator has demonstrated

effective protection of water quality to the satisfaction of the Director. The Director will also require permits for MS4s that contribute to a violation of a water quality standard, are significant contributors of pollutants to waters of the state or that require storm water controls based on waste load allocations (WLAs) determined through a TMDL.

The MS4s that discharge to the Saugatucket River are owned and operated by the Town of South Kingstown, or by the Rhode Island Department of Transportation (RIDOT). As noted in the RIPDES Regulations, year 2000 census data shows that portions of the Saugatucket River watershed in the villages of Wakefield and Peace Dale meet the criteria of a UA or a DPA. Accordingly, the Town of South Kingstown will be required to apply for a RIPDES permit for portions of their MS4's located within the appropriate UA or DPA by March 10, 2003. The remaining South Kingstown and RIDOT storm sewer outfalls within the watershed are part of MS4s that are not located in a UA or DPA. However, because they discharge significant loadings to an impaired waterbody (which is also a SRPW), because these loadings contribute to a violation of a water quality standard, and because it has been determined through this TMDL that storm water controls are necessary to restore water quality, the operators will be required to obtain a RIPDES permit (or expand coverage of an existing permit). These areas include MS4s that drain to Mitchell Brook and the portion of Indian Run Brook upstream of Saugatucket Road.

RIDEM will continue to work with the Town of South Kingstown, Rhode Island Department of Transportation (RIDOT), and the Saugatucket River Heritage Corridor Coalition (SRHCC) to identify funding sources and to evaluate locations and designs for storm water control BMPs throughout the watershed. In accordance with the requirements of this phased TMDL, monitoring of the Saugatucket River watershed water quality will continue so that the effectiveness of ongoing remedial activities can be gauged.

Urban stormwater runoff from roads and residential/commercial land uses impacts water quality in several portions of the Saugatucket 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 Town of South Kingstown to highlight these concerns and by supporting their stormwater management planning, including the construction of BMPs where needed.

8.6 Structural Best Management Practice (BMP) Information

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). Even though 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 Tables 22 and 23.

Table 22. 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.

9.0 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 at the dairy farm in the Mitchell Brook sub-watershed. RIDEM will also seek to have the performance of other BMPs monitored as they are installed throughout the Saugatucket 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 IR1U, RB1, MB01, UT01, UT02, SR03, SR04D, SR05, SR06U, and SR06D. Grab samples will be collected bi-monthly (every two months) during warm weather months (from May to September). Monitoring would begin once a significant number of BMPs have been implemented and become fully functional.

Table 23 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* and approximately 50% removal of fecal coliform.
NRCS Nutrient and 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, biological, and chemical processes for the removal of sediment and nutrients.	Livestock and pasture runoff as well as urban stormwater runoff	Removes 90-100% of TSS*.
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 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.

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

10.0 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 January 31, 2001. 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. Also, an informal public meeting was held with the Saugatucket River Heritage Corridor Coalition (SRHCC) on April 4, 2002. The purpose of the meeting was to provide an overview of TMDL dry and wet weather monitoring results, percent reductions necessary for specific stream segments, and to discuss how the SRHCC may participate in the TMDL process from that point forward.

A second public meeting was held on April 2, 2003, which also initiated the 30-day public comment period.

APPENDIX 1

Sampling locations and monitoring protocol for Rocky Brook, Indian Run Brook, Mitchell Brook, Saugatucket River and Unnamed Tributaries.

Waterbody/Segment	Station ID	Location	Sampling Description	Purpose
Rocky Brook	RB9U	Greenwood Dr.	In-stream: Access across from residence at 172 Greenwood Dr. Collect sample upstream of SW outfall.	Identify fecal coliform sources upstream of Greenwood Drive
3	RB9D	Greenwood Dr.	In-stream: Access across from residence at 172 Greenwood Dr. Collect sample downstream of SW outfall (wet weather only)	Isolate in-stream fecal coliform concentrations from street runoff
	RB8	Jr. High School	In-stream: On road to multi-purpose field	Determine fecal coliform concentrations from tributary
	RB7D	Curtis Corner Rd.	In-stream: Downstream of bridge. Use dipstick to collect sample.	Identify fecal coliform sources upstream of Curtis Corner Road
2	RB6	End of Dam St.	In-stream: Downstream of bridge, Access by road in front of Pump House Restaurant. Use dip stick to collect sample.	Determine if tributary flowing from Peace Dale Reservoir is a significant fecal coliform source.
	RB5U	Rocky Brook Reservoir outlet	In-stream: Upstream of bridge. Use dipstick to collect sample.	Identify fecal coliform concentrations downstream from Rocky Brook Reservoir
1	RB4	Hopkins Ln.	In-stream	Isolate fecal coliform sources from pond near school.
	RB3	Anton's Deli	In-stream: Upstream of bridge (wet weather only)	Isolate fecal coliform sources in vicinity of Rt. 108 and sources from the pond near the school
	RB2	Patsy's Liquors	In-stream. Use dip stick to collect sample.	Isolate fecal coliform sources in vicinity of Rail Road St.
	RB1U	Railroad St.	In-stream: Upstream of bridge	Isolate fecal coliform sources in vicinity of Rail Road St.
	RB1D	Railroad St.	In-stream: Downstream of bridge (wet weather only)	Isolate fecal coliform sources from street runoff.
Indian Run Brook	IR11	@ Indian Run @ Route 1	In-Stream: Upstream of culvert (wet weather only)	Isolate fecal coliform sources from highway runoff.
	IR10U	Indian Run @ Saugatucket Road	In-Stream: Upstream of culvert (wet weather only)	Determine fecal coliform concentrations between Route 1 and Saugatucket Road.
2	IR7	Indian Run	Tributary flowing into Indian Run	Determine impact on

		Tributary (St. Dominics)	from the east downstream of bridge. Sample location approx. 40 yards up by the road.	concentrations from tributary
	IR6	Indian Run at access road (St. Dominics)	In-Stream: Downstream of access road bridge and tributary inputs	Isolate sources upstream of access road
	IR4	Indian Run @ Indian Run Reservoir dam	In-Stream at dam spillway	Isolate sources from Indian Run Reservoir
	IR3U	Indian Run @ Rt. 108	In-stream: Upstream of bridge (wet weather only)	Isolate fecal coliform sources between Route 108 and the reservoir.
1	IR3D	Indian Run @ Rt. 108, School St. and Indian Run Road	In-Stream: Downstream of bridge and SW outfall	Isolate fecal coliform sources from street runoff.
	IR2	Indian Run @ end of Amos Street	In-Stream	Isolate fecal coliform source between Columbia St. and Route 108
	IR1U	Indian Run @ Columbia St. (URI station)	In-Stream: Upstream of Columbia Street bridge	Isolate fecal coliform source in the vicinity of Columbia Street
Mitchell Brook	MB01	Mitchell Brook @ Transfer Station access road	In-Stream: Downstream of culvert. Use dip stick to collect sample.	Isolate fecal coliform sources downstream of MB02.
	MB02	Mitchell Brook @ pet cemetery footbridge	In-Stream: Downstream of culvert Use dip stick to collect sample.	Isolate fecal coliform sources downstream of MB03.
1	MB03	Mitchell Brook @ Rose Hill Road	In-Stream: Upstream of culvert Use dipstick to collect sample.	Isolate fecal coliform sources downstream of MB04.
	MB04	Mitchell Brook @ Rt. 138	In-Stream: Upstream of culvert (wet weather only)	Isolate fecal coliform sources from upstream sources.
Saugatucket River	UT01U	Unnamed Trib @ Rose Hill Road	In-stream: Upstream of culvert located approximately 0.2 miles north of Saugatucket Road.	Isolate fecal coliform sources in trib prior to confluence with river.
4	SR03	Saugatucket River @ Saugatucket Road	In-stream: Downstream of bridge	Isolate fecal coliform sources upstream and add to existing URI DW data.

3	UT02	Unnamed Trib #2 @ Saugatucket Road	In-stream: Upstream of road culvert located between North Road & Rose Hill Road	Isolate fecal coliform and nutrient sources in tributary prior to confluence with river.
	SR04D	Saugatucket Pond @ Outfall	Down-stream of pump house within canal.	Estimate fecal coliform sources from Saugatucket Pond
2	SR05	Saugatucket River @ Church Street	In-stream: Downstream of bridge. Use dipstick to collect sample	Isolate loadings from Rocky Brook, Indian Run Brook, and Palisades. Add to URI dry weather data
1	SR06U	Wakefield Pond @ Dam	In-Pond: Downstream of bridge. Use dipstick to collect sample.	Estimate fecal coliform sources above dam. Add to URI dry weather data
	SR06D	Saugatucket River @ Main Street Bridge	In-stream: Upstream of bridge above dam. Use dipstick to collect sample.	Isolate fecal coliform sources downstream of dam

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