TOTAL MAXIMUM DAILY LOAD ANALYSIS FOR Buckeye Brook Watershed

Fecal Coliform and Enterococci Bacteria Impairments

Final Report
December 2008

303(d) listings addressed in this study:
Old Mill Creek (RI0007024E-02): Pathogens
Buckeye Brook (RI0007024R-01): Pathogens
Parsonage (Knowles) Brook (RI0007024R-02): Pathogens
Lockwood Brook (RI0007024R-03): Pathogens
Warner Brook (RI0007024R-04): Pathogens
Tribs to Warwick Pond (RI0007024R-05): Pathogens

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

Bypass means diversions of waste streams from any portion of a treatment works

Code of Federal Regulations (CFR). Document that codifies all rules of the executive departments and agencies of the federal government. It is divided into fifty volumes, known as titles. Title 40 of the CFR (referenced as 40 CFR) lists all environmental regulations

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

Fecal coliform bacteria are 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, disease-causing organisms.

Loading capacity means the maximum amount of loading that a surface water can receive without violating water quality standards.
Margin of Safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody.

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

Municipal Separate Storm Sewer System (MS4) A conveyance or system of conveyances, including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, catch basins, curbs, gutters, ditches, man-made made channels, or storm drains owned or operated by a State, city, town, county, or other public body.

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

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

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

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

Rhode Island Geographic Information System (RIGIS) A consortium of government and private organizations employing computer and communications technology to manage and use a collective database of comprehensive geographically related information.

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

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

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

Storm water means precipitation-induced runoff.

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

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

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

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

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

1.0 INTRODUCTION

1.1 Purpose

This Total Maximum Daily Load (TMDL) plan addresses pathogen impairments to Buckeye Brook and its tributaries, Lockwood Brook, Warner Brook, and Knowles Brook, and the estuarine waters to which it discharges, Old Mill Creek, located in the City of Warwick, Rhode Island. These waters are listed on Rhode Island's 2008 303(d) List of Impaired Waters with a scheduled TMDL completion date of 2008. These waters do not support their designated uses that are associated with the fecal coliform bacteria and enterococci criteria, which include primary recreation for all waters and shellfish harvesting for those waters classified as SA.

The State of Rhode Island Department of Environmental Management (RIDEM) has identified water quality impairments in Buckeye Brook. 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 Total Maximum Daily Loads (TMDL's) for waterbodies that are not meeting designated uses. The Buckeye Brook watershed is impaired for pathogens, as confirmed by elevated levels of fecal coliform bacteria. RIDEM has also identified a biodiversity impairment for Buckeye Brook, as confirmed by macro-invertebrate sampling results; this impairment will be the focus of a separate TMDL analysis.

A TMDL is a tool for implementing state water quality standards in the affected waterbody. The TMDL establishes the allowable pollutant loading to a waterbody and provides a framework for identifying specific actions needed to reach water quality standards. The ultimate goal of the TMDL process is to reduce pollutant loadings to a waterbody in order to improve water quality to the point where state water quality standards are met.

One of the major components of a TMDL is to establish instream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. Instream numeric endpoints represent the water quality goals that are to be achieved by implementing the load or pollutant reductions specified in the TMDL. The endpoints allow for a comparison between current instream water quality conditions and those conditions that are expected to restore beneficial uses. The endpoints are usually based on either the narrative or numeric criteria available in state water quality standards.

1.2 Study Area

The study area is the watershed for Buckeye Brook, a small watershed north of Greenwich Bay in the central part of the state. The watershed includes Buckeye Brook, as well as its tributaries, Lockwood Brook, Warner Brook, and Parsonage (Knowles) Brook, and a smaller stream system above Warwick Pond identified in this TMDL as Tribs to Warwick Pond. Old Mill Creek estuary is also considered to be part of the watershed as this is the where the brook discharges into prior to flowing into Narragansett Bay. The watershed also includes Warwick Pond, which does not have identified bacteria impairments and is not included in this TMDL analysis. Figure

1.1 shows the watershed and the surrounding area. Table 1.1 contains a list of waterbodies in the Buckeye Brook watershed with their water quality classifications, and their identified impairments as reported in the state's 2008 303(d) list.

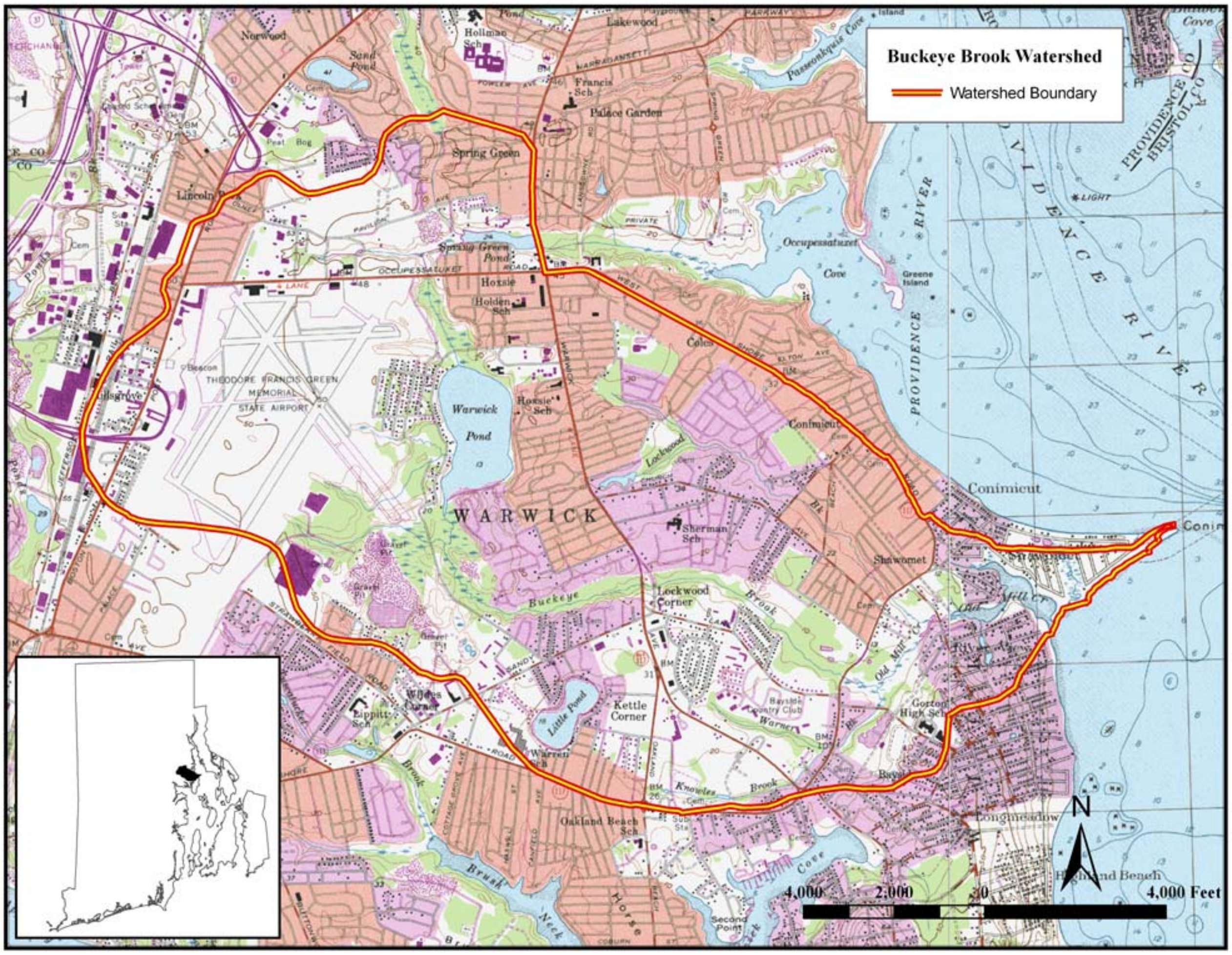

Figure 1.1 Study Area Location.

Table 1.1 Applicable Waterbodies Within Buckeye Brook Watershed

Waterbody ID Number	Waterbody Description	Water Quality Classification	Water Quality Impairment
R10007024R-01	Buckeye Brook, Warwick, RI	B	Biodiversity, Pathogens
R10007024R-02	Parsonage (Knowles) Brook, Warwick, RI	B	Pathogens
R10007024R-03	Lockwood Brook, Warwick, RI	B	Pathogens
R10007024R-04	Warner Brook, Warwick, RI	B	Pathogens
R10007024R-05	Tribs to Warwick Pond, Warwick, RI	B	Pathogens
R10007024E-02	Old Mill Creek, Warwick, RI	SA	Pathogens

1.3 Pollutants of Concern

The pollutants of concern are fecal coliform and Enterococci, parameters used by Rhode Island as indicators of potential pathogen contamination. Fecal coliform is used as the shellfishing criteria, while Enterococci is used as the primary contact recreation /swimming criteria. These criteria are set forth in the state's Water Quality Regulations promulgated by RIDEM's Office of Water Resources.

1.4 Priority Ranking

Buckeye Brook, Parsonage (Knowles) Brook, Warner Brook, Lockwood Brook, and Old Mill Creek are in the 2008 303(d) List of Impaired Waters. The TMDL completion date for these waterbodies is 2008.

1.5 Applicable Water Quality Standards

As stated in 40 CFR 131.2, "[water quality] standards serve the dual purposes of 1) establishing the water quality goals for a specific waterbody and 2) serving as the regulatory basis for the establishment of water-quality based treatment controls and strategies beyond the technology-based levels of treatment required by section 301(b) and 306 of the Act." The primary aim of a TMDL is to bring a waterbody back into compliance with applicable water quality regulations. Therefore, it is important to know exactly which regulations apply to the waterbody for which a TMDL is developed. The relevant portions of the state's Water Quality Regulations are described below.

1.5.1 Designated Uses

Section 8.B of the Water Quality Regulations (RIDEM, 2006) describes the water use classification. All surface waters shall be assigned to a class that is defined by the designated uses, which are the most sensitive, and therefore, governing water uses which it is intended to protect. Surface waters may be suitable for other beneficial uses, but shall be regulated to protect and enhance the designated uses. In no case shall waste assimilation or waste transport be considered a designated use.

Section 8.C(3) states that all freshwaters hydrologically connected to and upstream of Class B, B1, SB, SB1, C, or SC waters shall be Class B unless otherwise identified in the regulations. Buckeye Brook is listed as Class B. Lockwood Brook, Warner Brook and Parsonage (Knowles) Brook are all tributaries to Buckeye Brook, and as such, they are listed as Class B waters as well.

The following excerpt from Rule 8.B (1) of the Regulations describes Class B freshwaters:

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) of the Water Quality Regulations (RIDEM, 2006) describes the water use classification for seawater. Old Mill Creek is classified as Class SA waters. The following excerpt from Rule 8.B(2)(a) of the Regulations describes Class SA seawaters:

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

1.5.2 Numeric Water Quality Criteria

Rule 8.D of the Water Quality Regulations establishes physical, chemical, and biological criteria as parameters of minimum water quality necessary to support the water use classifications of Rule 8.B. Therefore, sections of Rule 8.D are also applicable. In particular, Rule 8.D(2) establishes class-specific criterion for freshwaters. The following bacteria criteria apply to Class B waters:

Fecal Coliform

Primary Contact Recreational/Swimming Criteria:

Not to exceed a geometric mean value of 200 MPN/100 ml and not more than 10% of the total samples taken shall exceed 400 MPN/100 ml, applied only when adequate enterococci data are not available.

Enterococci

Primary Contact Recreational/Swimming Criteria:

Non-Designated Bathing Beach Waters Geometric Mean Density:	*54 colonies/100 ml*
Designated Bathing Beach Waters Geometric Mean Density:	*33 colonies/100 ml*
Single Sample Maximum:*	*61 colonies/100 ml*

** Criteria for determining beach swimming advisories at designated beaches as evaluated by the Department of Health.*

Rule 8.D of the Water Quality Regulations establishes physical, chemical, and biological criteria as parameters of minimum water quality necessary to support the water use classifications of Rule 8.B. Rule 8.D(3) establishes class-specific criterion for seawaters. The following bacteria criteria apply for Class SA seawaters:

Fecal Coliform

Shellfishing Criteria:

Not to exceed a geometric mean MPN value of 14 and not more than 10% of the samples shall exceed an MPN value of 49 for a three-tube decimal dilution.

Primary Contact Recreational/Swimming Criteria:
Not to exceed a geometric mean value of 50 MPN/100 ml and not more than 10% of the total samples taken shall exceed 400 MPN/100 ml, applied only when adequate enterococci data are not available.

Enterococci
Primary Contact Recreational/Swimming Criteria:

Geometric Mean Density:	*35 colonies/100 ml*
Single Sample Maximum:*	*61 colonies/100 ml*

** Criteria for determining beach swimming advisories at designated beaches as evaluated by the Department of Health.*

2.0 DESCRIPTION OF THE STUDY AREA

2.1 Buckeye Brook Stream System

The primary stream system in this study is Buckeye Brook, a third order stream system that originates northeast of T.F. Green Airport in Warwick, Rhode Island. This smaller stream system north of the airport includes Spring Green Pond and small tributary streams that drain an agricultural area located north of Airport Road. This northern section of the watershed is identified as Tribs to Warwick Pond in this TMDL. Buckeye Brook has its origins at the southern most point of Warwick Pond, and flows in a southeast direction from the pond outlet into Old Mill Creek, which is south of Conimicut Point, and ultimately into Narragansett Bay. Buckeye Watershed has three tributaries, Lockwood Brook, Warner Brook and Parsonage (Knowles) Brook. Knowles Brook is a small tributary that flows into Warner Brook prior to Warner Brook passing under West Shore Road (Route 117). Warner Brook is south of the mainstem of Buckeye Brook, with the confluence in the salt marsh area west of Tidewater Drive, 0.4 miles prior to the point where Buckeye Brook flows into Old Mill Creek estuary. Lockwood Brook begins due east of Warwick Pond, and travels southeast parallel to Buckeye Brook for 1.8 miles. The confluence of Lockwood Brook and Buckeye Brook is in the same salt marsh area west of Tidewater Drive, and just 200 feet prior to Buckeye's entrance into Old Mill Creek. Figure 2.1 shows the applicable waterbodies within the hydrologic boundaries of the Buckeye Brook watershed.

The highly urbanized watershed is 6.53 mi^2 and is the site of Rhode Island's primary airport, T.F. Green. The current land use in the watershed (RIGIS, s44llu95) is 44% residential (75% of this value, or 32% of the total land use is medium to high density residential), 19.7% forest and wetland, 16.1% airport, 11.4% commercial-industrial, 5.2% open, 3.3% agricultural, and 2.2% institutional. Figure 2.2 shows the land use for Buckeye Brook Watershed.

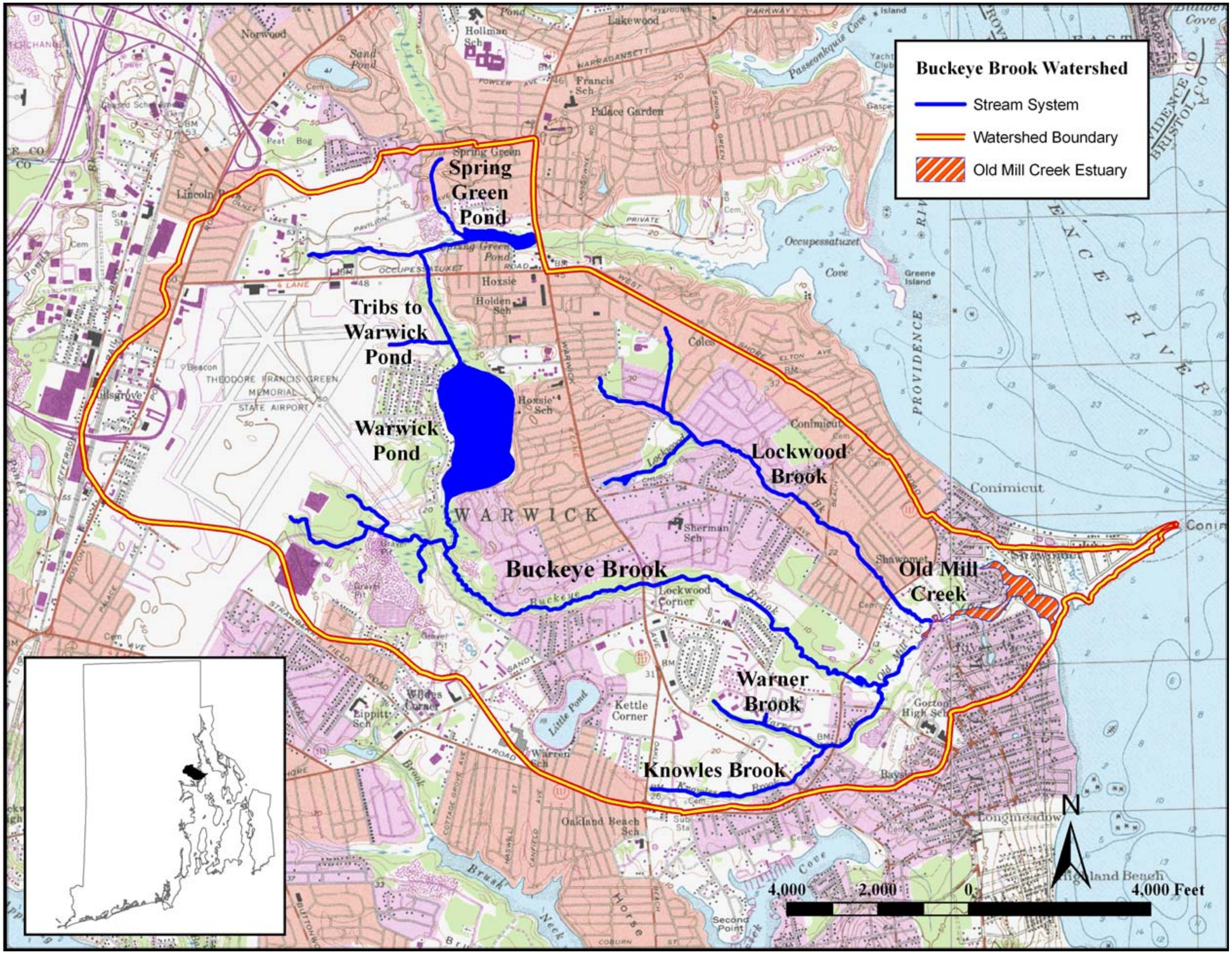

Figure 2.1 Buckeye Brook Watershed Stream Systems.

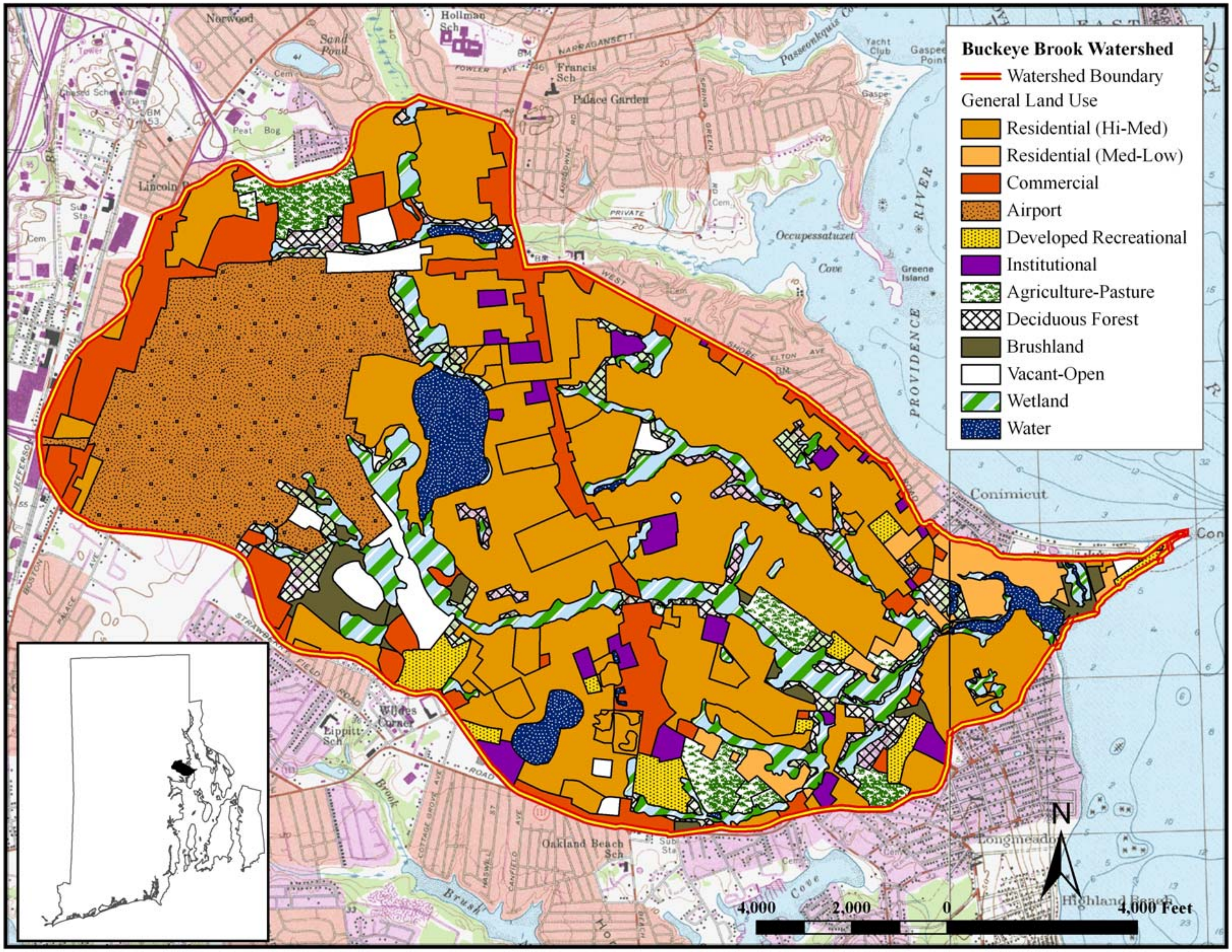

Figure 2.2 Buckeye Brook Watershed Land Use.

2.2 Watershed History

The recorded history of Warwick and the Buckeye Brook watershed area began with the arrival of the Europeans in 1636. The attractions of the region to colonists were: the natural resources afforded by the geographic and topographic diversity that allowed settlers to hunt, fish, and farm in abundance. The lowland and central portions of Warwick, in which the Buckeye Brook Watershed is found, are generally composed of glacial outwash soils. These soils are well sorted, well drained, sandy, and loosely packed. They are especially amenable to farming and building construction.

In 1642, Samuel Gorton and eleven followers established the city of Shawomet, which encompassed an area including parts of modern-day Warwick, West Warwick, and Coventry. They purchased 107 square miles in the area of Shawomet from Miantonomi, the chief Sachem of the Narragansett Indian tribe. Mill Creek was the site of the original settlement, but later they relocated to the south at Warwick Cove.

Another change in the area was the construction of Hillsgrove State Airport (now T.F. Green Airport) in 1931. In the same year, Warwick transformed from a town to a city, complete with a mayor-city council form of government. The post WWII era brought a rash of newcomers and development to the area, filling the area with gas stations, restaurants and the necessary municipal developments to support the expanding population. As transportation in the area gradually improved, many residents began to transform their summer homes along the coast into year-round residences.

In spite of this development, a few areas have managed to remain as open green space. Buckeye Brook, its tributaries and wetlands, situated among the residential developments, industrial parks and the airport, has continued to provide a habitat for a diversity of wildlife.

Buckeye Brook supports the blue back herring, an anadromous fish species that annually makes its way back up the river to spawn in Warwick and Spring Green Ponds. The wetlands around Old Mill Creek support the state’s best remaining example of a salt marsh community. Typical species include the narrow-leaved cattail (*Typha angustifolia*), bulrushes (*Scirpus robustus, S. pungens, and S. validus*), pickerelweed (*Pontedaria cordata*), arrow weed (*Sagittaria latifolia*), spatterdock (*Nuphar variegatum*), salt marsh hemp (Amaranthus cannabinus) and water-parsnip (*Sium suave*). Other aquatic life, wood ducks and black ducks use the area as habitat as well.

3.0 WATER QUALITY MONITORING

Water quality monitoring to assess watershed conditions in Buckeye Brook began in 1992 with establishment of a biological sampling station on the main stem at the Old Warwick

Road crossing with Roger Williams University doing the monitoring through 2000. In 2002, the ESS Group continued the annual survey until 2005. Because the monitoring at this location was strictly biological, only field water quality measurements were collected that included dissolved oxygen, temperature and conductivity. Pathogen sampling was not conducted as part of the biological sampling program. This location was rated as moderately impaired for biodiversity starting in 1998 and continued to maintain that condition in 2003 and 2004 (ESS, 2004, ESS, 2005) and is listed as such on the state's 2008 303(d) list.

In 2004, volunteers working with the University of Rhode Island Watershed Watch started sampling at four locations: Old Mill Creek, Buckeye Brook and its tributaries, Warner and Lockwood Brooks. In addition to fecal coliform, samples were also analyzed for nutrients, pH, chlorides, temperature, and dissolved oxygen. Other efforts to assess the water quality of Buckeye Brook relate to specific land uses – including the state's airport and a closed landfill. More specifically, winter surveys have been conducted on behalf of the Rhode Island Airport Corporation (RIAC) to monitor impacts associated with aircraft de-icing and anti-icing operations at the airport. Other assessment work has been conducted at the Truk-Away Landfill, located to the west of Buckeye Brook, including a site inspection and sampling of several monitoring wells on the landfill property. Table 3.1 provides a partial list of Buckeye Brook monitoring reports.

3.1 Watershed Watch Monitoring

As described above, beginning in 2004, volunteers working with the University of Rhode Island Watershed Watch Program started sampling Buckeye Brook and its tributaries, Warner and Lockwood Brooks. Samples were collected monthly from May through October at four locations within the watershed. Buckeye Brook was sampled at the end of Novelty Road, approximately 0.34 miles upstream of the point the brook passes under West Shore Road (RT 117) and again as it entered Old Mill Creek estuary at Tidewater Drive. Lockwood Brook was sampled at the culvert outlet where it passes under West Shore Road, and prior to the confluence with Buckeye Brook. Warner Brook was sampled on the downstream side of the culvert that passes under Draper Avenue.

The Watershed Watch volunteers took a total of sixty-three samples over the three-year period, with an average of approximately 16 samples per station. Twenty-eight of the samples were taken either during wet weather conditions, or within 48 hours of a wet weather event. The program sampled for fecal coliform each year and for Enterococci starting in 2006. As shown in Table 3.1, the data indicate elevated levels of both fecal coliform and enterococci bacteria at all stations.

3.2 Old Mill Creek Shoreline Survey

On March 10, 2006, RIDEM /OWR conducted a shoreline survey under dry weather conditions in the Old Mill Creek estuary to locate any potential bacterial sources discharging directly into the estuary. A total of seven samples were collected in and around Old Mill Creek estuary. Additionally, four samples were taken at Watershed Watch stations and were considered background, or ambient water samples. These locations were BB06 (Buckeye Brook at Novelty Road), BB08 (Buckeye Brook at Tidewater Drive, LK04 (Lockwood Brook at West Shore Road), and WR02 (Warner Brook at Draper Avenue). The remaining samples were considered as source samples since they originated from outfalls or drainage swales. Fecal coliform was the only constituent of interest since the discharges were into SA class waters. The data table from this survey can be found in Appendix A.

Table 3.1 Monitoring Conducted in Buckeye Brook Watershed

Primary Organization	Sample Location	Period	Analyte
Rhode Island Department of Environmental Management	Buckeye Brook, Lockwood Brook, and Warner Brook	2006	Field measurements
Watershed Watch University of Rhode Island	Buckeye Brook, Lockwood Brook, and Warner Brook	2004-2006	F. Coliform, Enterococci, nutrients, chlorides, pH, temperature, D.O.
Rhode Island Department of Environmental Management	Buckeye Brook at Old Warwick Avenue Bridge crossing	2003-present	Biological Assessment
Rhode Island Department of Environmental Management	Truk-Away Landfill groundwater from monitoring wells	2005	VOCs
U.S. Environmental Protection Agency (USEPA)	Main area of Truk-Away Landfill	1993	Soil and Leachates

Table 3.2 Geomean Values for Pathogens at Watershed Watch Monitoring Sites in Buckeye Brook Watershed

Monitoring Location	2004	2005	2006	2006
	Fecal Coliform (CFU/100ml)			Enterococci[1]
Buckeye Brook -Novelty Road (BB06)	707	133	576	363.7
Buckeye Brook -Old Mill Creek (BB08)	3723	976	1512	135.6
Lockwood Brook - RT117 (LK04)	4690	864	858	822.3
Warner Brook - Draper Avenue (WR02)	2870	534	870	223.6

1. Enterococci Units are MPN/100ml. Enterococcus was added for the 2006 sampling season.

The Watershed Watch stations included the sample at Tidewater Drive, with the highest value of 240 MPN/100ml measured at LK04 where Lockwood Brook crossed under West Shore Drive. The confluence of Lockwood Brook with Buckeye Brook occurs only 200 feet upstream of Tidewater Drive, where Buckeye Brook flows into Old Mill Creek estuary, thus Lockwood Brook pathogen levels may have a direct influence on the values observed at the headwaters of the estuary.

The value for fecal coliform at this point, where Buckeye Brook passes under Tidewater Drive and enters the estuary was 93 MPN/100ml. The next highest value was 75 MPN/100ml and came from an outfall at the end of Mill Cove Road that discharged onto a sandy beach area adjacent to mouth of Old Mill Creek. The remaining outfalls had bacteria counts of 15 MPN/100ml or lower.

3.3 RIDEM Water Quality Survey

The Watershed Watch data from the first two years of monitoring provided an initial overview of the pathogen violations that were occurring in the Buckeye Brook Watershed. Volunteers were able to sample the major tributaries to Buckeye Brook but the locations were of limited value for locating the source or stream reach that contributed to the high fecal coliform levels observed in the samples. In an attempt to pinpoint the sources of the elevated bacteria levels, RIDEM undertook a more comprehensive sampling effort commencing in August 2006.

3.3.1 RIDEM Water Quality Station Selection

There were initially fourteen stations selected within the watershed that covered all tributaries and the mainstem of Buckeye Brook. The scheduled was for ten surveys to be collected bi-weekly, starting in August and ending in November 2006. The mainstem of Buckeye Brook had seven stations, with three stations on Lockwook Brook, two on Warner Brook, and two on Parsonage (Knowles) Brook, a small tributary of Warner Brook.

After the first two sets of survey sample results indicated that a significant pathogen source may be upstream of the Knowles Brook Station at Warwick Avenue (KB01), three additional stations were added to isolate the most upstream sections of the brook. The additional stations were KB00A, KB00A-1, and KB00B, bringing the total stations to seventeen. Figure 3.1 shows the station locations sampled for this study and Appendix A lists the street location and rational for station selection.

3.3.2 RIDEM Buckeye Brook Watershed Pathogen Monitoring Results

Starting in August 2006, RIDEM staff conducted ten pathogen surveys within the Buckeye Brook Watershed. The ten surveys were to be conducted on a weekly or bi-weekly interval, regardless of the weather conditions. The surveys consisted of one grab sample per station plus one duplicate from a selected station, for a total of fifteen samples per survey. Follow-up surveys were scheduled to locate any point source upstream of stations with elevated fecal coliform and/or Enterococci levels. The first survey was on August 11, 2006 with the last scheduled survey on November 3, 2006.

If any source or flowing pipes were found, additional samples were to be taken and analyzed for fecal coliform and Male-specific Bacteriophage. Flows were to be collected from these sources at the time of sampling to assess relative loads. However, loads were not calculated since the TMDL is based on concentrations of pathogens rather than loads.

The surveys were nearly equally divided between wet and dry periods. For a survey to be classified as a wet survey, at least 0.10 inches of precipitation had to have occurred within the twenty-four hour period prior to the start of sampling. Buckeye Brook is highly urbanized and effective runoff (runoff that contributes to stream flow after infiltration and evapotranspiration losses) can be seen in the streams after this amount of precipitation has fallen on the watershed. Twenty-four hours was the cut-off due to the small size of the watershed, and that most flows returned to pre-storm levels within that time.

Six of the ten surveys were conducted under dry weather conditions. The survey on October 20, 2006 was the only one to be conducted during actual wet weather conditions. The other three wet surveys had precipitation ending from 10 to 23 hours prior to the first sample being collected at BB01. Rainfall amounts for the wet surveys were from 0.16 inches in November to 0.48 inches for the August 11^{th} survey.

Tables 3.3 and 3.4 show the statistical summaries for the RIDEM monitoring conducted within the Buckeye Brook Watershed for Fecal Coliform and Enterococci respectively. The tables include the water quality classification for each location, number of samples taken, geometric mean criteria, and 90 percentile criteria. These tables include all RIDEM samples taken at each location, regardless of weather conditions. Figure 3.2 shows the dry weather fecal coliform geomean for each sampling station, with the wet weather geomean values in parenthesis. In-situ field measurements were taken during each sampling event at all stations. These included dissolved oxygen, temperature (°C) and conductivity (µS/cm) using a handheld YSI-85 meter; these data are included in the final data report.

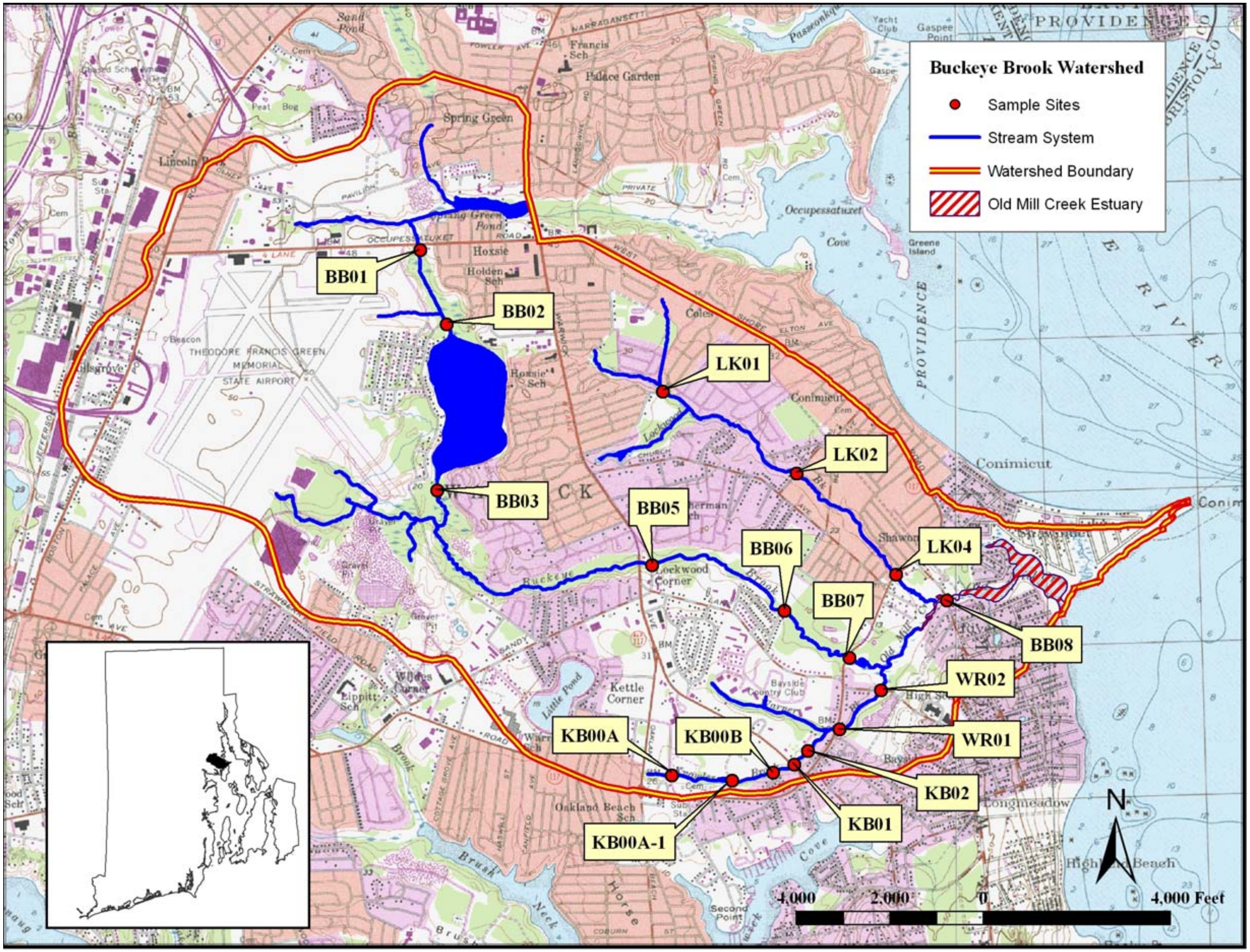

Figure 3.1 Buckeye Brook Watershed Pathogen Sampling Stations.

Table 3.3 Statistical Summary of RIDEM Fecal Coliform Data for Buckeye Brook Watershed

Station	Waterbody	Class	Number* of Samples		Geometric Mean (CFU/100ml)			90th Percentile (CFU/100ml)			Geometric Mean (CFU/100ml)		90th Percentile (CFU/100ml)	
			Dry	Wet	Target Value	Observed Dry	Observed Wet	Target Value	Observed Dry	Observed Wet	Target Value	Observed All Samples	Target Value	Observed All Samples
BB01	Tribs to Warwick Pond	B	5	4	200	164	417	400	372	649	200	249	400	614
BB02			5	4		191	173		236	597		183		392
BB03	Buckeye Brook	B	5	4	200	128	300	400	432	1,350	200	187	400	776
BB05			6	4		304	579		365	1,472		379		1,016
BB06			5	4		389	708		544	1,450		427		1,220
BB07			7	3	14	528	407	49	724	1,044	14	509	49	848
BB08	Old Mill Creek	SA	6	3	14	1,123	1,036	49	1,870	2,260	14	1,405	49	8,520
KB00A	Knowles Brook	B	5	3	200	594	575	400	1,000	5,794	200	587	400	2,940
KB00A-1			4	3		423	225		819	572		323		768
KB00B			5	3		10,631	9,646		33,200	56,600		10,250		44,200
KB01			6	4		7,560	7,758		11,000	48,700		7,638		18,400
KB02			5	4		2,774	5,492		5,020	22,500		3,758		15,000
LK01	Lockwood Brook	B	5	4	200	403	1,490	400	578	6,490	200	720	400	4,140
LK02			5	4		637	1,510		1,564	3,280		935		3,080
LK04			5	4	14	794	1,185	49	1,548	4,470	14	1,004	49	5,340
WR01	Warner Brook	B	5	7	200	571	1,256	400	788	3,260	200	905	400	3,080
WR02			5	4	14	565	935	49	784	2,747	14	790	49	4,904

*Number of samples includes any duplicates that were taken at a particular monitoring location.
Class SA standards were used Stations BB07, LK04, and WR02.

Table 3.4 Statistical Summary of RIDEM Enterococci Data for Buckeye Brook Watershed

Station	Waterbody	Class	Number* of Samples		Geometric Mean (MPN/100ml)			Geometric Mean (MPN/100ml)	
					Target Value	Observed		Target Value	Observed All Samples
			Dry	Wet		Dry	Wet		
BB01	Tribs to Warwick Pond	B	5	4	54	183	221	54	199
BB02			5	4		74	60		67
BB03	Buckeye Brook	B	5	4	54	27	46	54	34
BB05			6	4		135	320		191
BB06			5	4		151	112		198
BB07			7	3	35	116	165	35	129
BB08	Old Mill Creek	SA	6	3	35	539	406	35	293
KB00A	Knowles Brook	B	5	3	54	46	9	54	25
KB00A-1			4	3		6	46		14
KB00B			5	3		126	368		189
KB01			6	4		84	1,629		275
KB02			5	4		184	497		286
LK01	Lockwood Brook	B	5	4	54	53	86	54	65
LK02			5	4		147	95		121
LK04			5	4	35	167	125	35	292
WR01	Warner Brook	B	5	7	54	74	218	54	139
WR02			5	4	35	70	156	35	138

*Number of samples includes any duplicates that were taken at a particular monitoring location.
Class SA primary contact recreation/swimming standards were used for Stations BB07, LK04, and WR02.

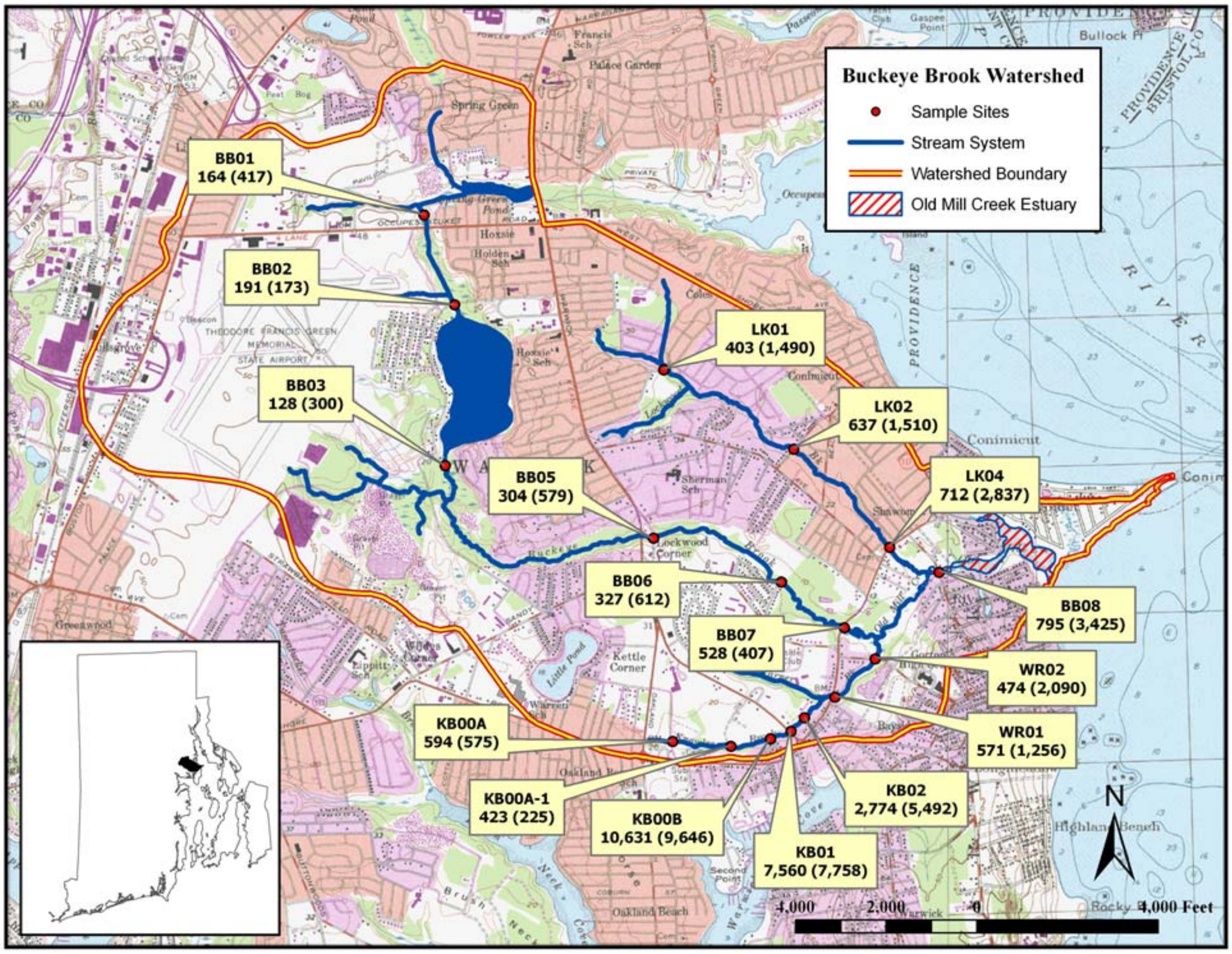

Figure 3.2 Buckeye Brook Watershed Dry and Wet Weather Survey Results: Fecal Coliform Geomeans (wet weather in parenthesis)

4.0 POLLUTION SOURCES

Sources of pathogens in the Buckeye Brook watershed were identified through a review of water quality surveys conducted during dry and wet weather conditions, and through targeted inspections and sampling of storm drain systems and facilities throughout the watershed. TMDL staff reviewed available information from Warwick Department of Public Works, and the Department of Transportation to identify storm drain networks and outfall information. TMDL staff also reviewed information on file with RIDEM’s Office of Compliance and Inspection regarding complaints and notices of violation relating to failed septic systems or otherwise inadequately treated wastewater.

Waterborne pathogens can enter surface waters from a variety of sources including sewage and the feces of warm blooded wildlife. Even small numbers of microorganisms from sewage wastes can cause diseases, such as hepatitis, in people who consume or come in contact with the water. Pathogens can also contaminate shellfish and make them unsuitable for human consumption.

Potential sources of bacterial contamination to surface waters include failed or improperly operated septic systems, sanitary sewer by-passes or leaks, stormwater runoff; illicit connections to stormwater drainage systems, direct surface runoff, pet and wildlife waste. Potential sources are summarized in Table 4.1 and are discussed below.

Table 4.1 Potential Sources of Pollution to Buckeye Brook Watershed

Source	Location
Stormwater Runoff	Contaminated runoff from parking lots, streets and urban areas
Sanitary Waste/ Septic System Failures	Watershed – Wide – Failing or improperly maintained septic systems or cesspools that discharge untreated or partially treated effluent to groundwater or surface waters or into the stormwater drainage systems which discharge into surface waters. Sanitary sewer leaks and bypasses – as well as illicit connections to stormwater systems are other potential sources.
Animal Waste	Watershed -Wide – Pet waste left to decay on streets, sidewalks, or on grass areas may be washed into storm drains by rain or melting snow. Watershed –Wide – Contamination from geese, raccoons, and coyotes. Parsonage (Knowles) Brook- Farm animals

4.1 Stormwater Runoff

Stormwater is an important source of bacteria in urban and suburban areas. Urbanized and suburban land use increases the amount of impervious surface relative to undeveloped areas. The result is increased rates and volumes of runoff. Bacteria from a wide range of sources are washed untreated in runoff discharged into surface waters through stormwater systems, or as overland flow directly into surface waters.

Overall, the highest values for fecal coliform and enterococci were found in the Knowles Brook and Lockwood Brook watersheds, with Warner Brook coming in third as it is influenced by the pathogens coming from Knowles Brook. Buckeye Brook has some problem areas but the more significant pathogen contributions are found in the tributaries to the brook. Table 4.2 lists the larger stormwater outfalls in the watershed considered to be a priority for stormwater treatment. Figure 4.1 identifies the location of outfalls greater than 20 inches in diameter.

In Lockwood Brook watershed, there are four outfalls that are larger than 20 inches, with the largest being a 42-inch pipe located between stations LK02 and LK04. Table 3.3 shows wet weather fecal coliform geomean values that are 2 to 4 times higher than the dry weather geomean values for the entire brook. The enterococci geomean values for

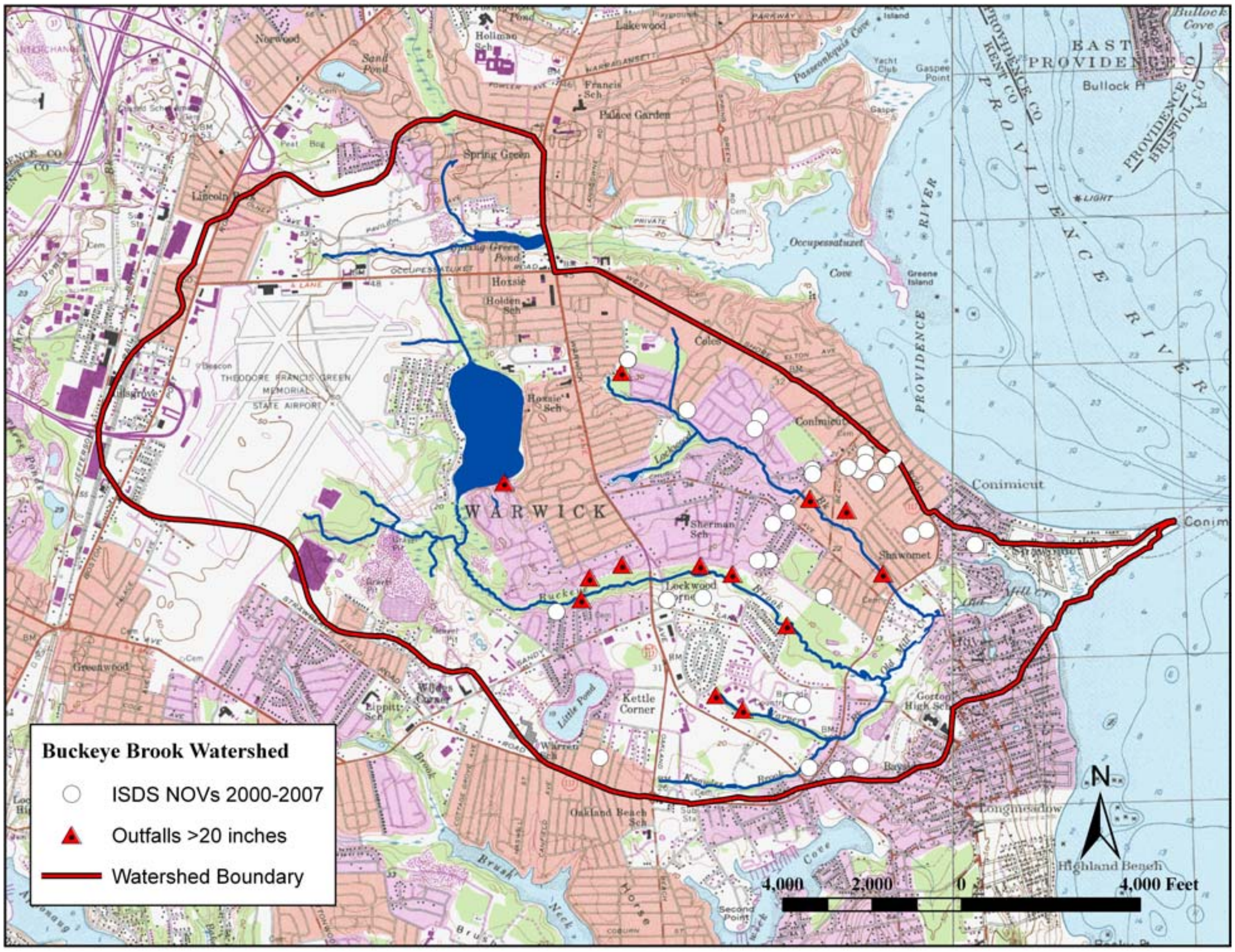

Figure 4.1 Buckeye Watershed ISDS Violations and Large Outfalls.

Lockwook Brook just prior to its entry into Old Mill Creek estuary at Station LK04 are three times higher for wet weather than dry weather.

Knowles Brook watershed doesn't have any large outfalls, however stormwater flows overland directly into the brook's waters from streets and the agricultural area that comprises the Morris Farm. At the Warwick Avenue crossing, stormwater flows untreated into the brook without any attenuation of pollutants from impervious areas. Wet weather geomean values for pathogens in the brook are twice the dry weather values for fecal coliform at station KB02, and as much as 19 times the dry weather geomean for enterococci at KB01. Knowles Brook is a tributary to Warner Brook with the confluence of the two streams located approximately 200 feet upstream from station WR01.

Warner Brook has two 24-inch outfalls located upstream of station WR01 at West Shore Road. Both outfalls are situated between large condominiums and the headwaters for Warner Brook. The wet weather pathogen geomean values for Warner Brook are 2 times higher than the dry weather geomean values for fecal coliform and three times higher for enterococci geomean values. Since

Knowles Brook flows into Warner Brook above WR01, it cannot be ruled out that Knowles Brook may be a significant pathogen source to Warner Brook at WR01. Table 3.3 shows a slight reduction in the fecal coliform geomean between stations WR01 and WR02 for both dry and wet weather surveys, which indicates that the source of the pathogens may be upstream of WR01. This same pattern is evident for the enterococci geomean values as well. However, both stations exceeded the pathogen water quality criteria for both dry and wet weather.

Buckeye Brook has five stormwater outfalls that are located in the lower portion of the watershed between stations BB03 and BB07, south of Warwick Pond. Three pipes are in the stream reach between BB03 and BB05. The largest, a 30–inch pipe, is located at the end of Everill Street, with a 24-inch pipe extending off of Stillwater Drive, east of Crescendo Drive. Another 24-inch outfall is located on the south side of the brook at the northern most end of Crane Street. In Buckeye Brook, this reach (BB03 to BB05) has the largest increase in pathogen geomean values for both fecal coliform and enterococci during wet weather events when compared to the downstream portions of the brook.

The next reach (BB05 to BB06) has one 24-inch outfall off the end of Winchell Road, with two 21-inch pipes draining Waco Court and Novelty Road, respectively. There is a slight increase of fecal coliform geomean concentrations in this reach for dry and wet events, but enterococci geomean concentrations drop over 60% between the two stations for wet weather events.

The reach between BB06 and BB07 does not have any large stormwater outfalls and flows through an area with wetland and forested buffer zones that range from two hundred to six hundred feet wide. There are no clear trends in the wet and dry weather fecal coliform and enterococci data in this reach

Table 4.2 Stormwater Outfalls

Street	Size (inches)	Waterbody	Presumed Ownership
June Ave	42	Lockwood Brook	Warwick
Emerson Ave	24	Lockwood Brook	Warwick
Meadowbrook Ave	24	Lockwood Brook	Warwick
Ridgeway Ave	36	Lockwood Brook	RIDOT/Warwick
Vineyard Rd	24	Warner Brook	RIDOT/Warwick
Warner Brook Dr	24	Warner Brook	Warwick
Everill St	30	Buckeye Brook	Warwick
Crane St	24	Buckeye Brook	Warwick
Stillwater Dr	24	Buckeye Brook	Warwick
Winchell Rd	24	Buckeye Brook	Warwick
Waco Ct	21	Buckeye Brook	Warwick
Novelty Rd	21	Buckeye Brook	Warwick

4.2 Sanitary Waste

Failing private septic systems can be another significant source of pathogen impairment in urban and suburban areas. When properly installed, operated, and maintained, septic systems effectively reduce pathogen concentrations in sewage. However, age, overloading, or poor maintenance can result in failure of septic systems and the release of pathogens and other pollutants (USEPA 2002).

In addition to showing the locations of the large outfalls, Figure 4.1 shows the locations of ISDS violations that occurred within the watershed between 2000 and 2007. The greatest number of violations has been in the Lockwood Brook area with six and four violations occurring in Buckeye Brook and Knowles – Warner Brook areas respectively.

4.3 Animal Waste

Pet waste and wildlife can be significant sources of bacteria in urban and suburban areas.
Pet waste left to decay on streets, sidewalks, or on grass near the street is often washed into storm sewers by rain or melting snow. Dogs in particular are likely a major source of fecal coliform bacteria, given their population density and daily defecation rate.

DNA fingerprinting techniques have clearly shown pet waste to be a major contributor of bacteria in urban and suburban watersheds. A study by Lim and Oliveri (1982) found that dog feces were the single greatest source contributing fecal coliform and fecal strep bacteria in highly urban Baltimore catchments. Trial et al. (1993) reported that cats and dogs were the primary source of fecal coliforms in urban subwatersheds in the Puget Sound Region. Bacterial source tracking studies in a watershed in the Seattle, Washington area found that nearly 20% of the bacteria isolates that could be matched with host animals were matched with dogs (Samadpour, M. and N. Checkowitz, 1998). A study conducted by the Washington State Department of Ecology determined that in an area with a population of approximately 100,000 individuals, dogs were found to generate approximately two and a half tons of feces per day, equating to nearly two million pounds per year.

DEM staff observed significant amounts of pet waste in grassy areas that are frequented by people walking their dogs throughout the watershed. Many of these areas are located directly adjacent to Buckeye Brook and its tributaries. The areas that appeared to have the most waste were near the state road crossings for the tributaries to Buckeye Brook, with the area around LK04 at the top of the list.

Concentrations of geese, gulls, and ducks are of particular concern because they often deposit their waste directly into surface waters. Therefore, they can be major sources of pathogens, particularly near lakes and ponds where large resident populations have become established in the area. Waterfowl have been observed in many of the areas in the lower part of the watershed where high concentrations of pathogens were found. In Warwick Pond, Canadian Geese were often seen at the pond’s exit, either swimming in the water or resting on the shoreline where there was easy access to the water. It should be noted that only the wet weather fecal coliform geomean concentration at BB03, located at the exit of Warwick Pond, exceeded water quality criteria, and this exceedance may or may not be attributed to small number of geese that sometimes congregate near the south end of the pond.

In the upper reaches of Knowles, station KB00A-1 is at the exit of a small unnamed pond that is utilized by Canadian Geese. Small groups of 12 to 15 waterfowl were observed swimming in the pond during several of the RIDEM surveys. This small pond is adjacent to Morris Farm where larger groups of the birds have been observed, and it is possible that the groups of birds seen on the pond may be an overflow from the farm. An absence of a riparian buffer on the south side of the pond provides an easy access for waterfowl to enter and exit the water.

Old Mill Creek estuary is home to several varieties of waterfowl. Cranes, egrets and several species of wild ducks have been observed in the estuary, both up and downstream of station BB08 at Tidewater Drive.

Wildlife and waterfowl may play a role in the elevated bacteria concentrations in other portions of the watershed. Large populations of geese have been observed in open fields adjacent to Knowles Brook, which had significant levels of pathogen contamination throughout the study. Residents in the Morris Farm area, where surface runoff drains directly into Knowles Brook, observed significant numbers of geese resting and feeding on the grounds. In the absence of any point sources, the high levels of fecal coliform bacteria concentrations in this area may be attributed to these waterfowl populations. RIDEM staff also observed several coyotes near Knowles and Warner Brooks, and local residents claimed to have seen two separate packs of the animals on several occasions. Reducing the impact of wildlife on pathogen concentrations in water bodies generally requires either reducing the concentration of wildlife in an area or reducing their proximity to the water body. The primary means for doing this is to eliminate human inducements for congregation. In addition, in some instances population control measures may be appropriate.

Agricultural land use can contribute to bacterial impairment of surface waters. Agricultural land uses in the watershed attract migratory birds as they seek out areas that are open and provide a food source. Agricultural practices with the potential to contribute to pathogen pollution include:

- Field applications of manure and/or manure storage,
- Livestock grazing, and
- Animal feeding operations, barnyards and paddocks.

In agricultural areas, bacteria can reach adjacent streams through a variety of pathways. One typical pathway is via runoff whereby bacteria wash off land surfaces into adjacent streams. Although Morris Farm is primarily in croplands, a number of farm animals are present within the farm area. Studies by the USEPA show that agricultural animals (e.g. poultry, cows, sheep, horses) are potentially significant sources of pathogens to urban communities (USEPA, 2007). RIDEM's TMDL program's experience has been that even a few farm animals, if given access to waterways or to hydrologically connected wetlands, can cause elevated concentrations of bacteria and nutrients.

5.0 TMDL ANALYSIS

5.1 Numeric Water Quality Targets

The numeric water quality targets are set at the applicable water quality criteria or standard for each segment Buckeye Brook, its tributaries, and Old Mill Creek, as described in Section 1.5. In some areas, a waterbody segment with higher allowable limits of fecal coliform or enterococci bacteria discharges to a waterbody with more stringent criteria. In these places, the numeric water quality target must be set to the more strict criteria of the two standards at the point of discharge. The last stream segments of Buckeye, Lockwood, and Warner Brooks fall into this category.

During the field assessment work for this TMDL, RIDEM staff discovered that Buckeye, Lockwood, and Warner Brooks are tidally influenced at their lower reaches. Salinity measurements taken in Warner Brook showed that salt water reached as far upstream as Draper Road (WR02), and that salt water traveled upstream in Buckeye Brook just past West Shore Road (BB07) during high tides. However, only the last reach of Lockwood Brook that is below West Shore Road (LK04) has a tidal influence. These reaches were not identified as such in the state's Water Quality Regulations nor in the TMDL, but as Class B freshwaters. Re-classification of these lower reaches of Buckeye, Lockwood and Warner Brooks to Class SB will be proposed in a future update of the State's Water Quality Regulations.

While these streams are Class B waters, the final stream segments flow into Old Mill Creek, a Class SA waterbody. Therefore, these segments must meet the more stringent criteria for fecal coliform (14 CFU/100ml) and for enterococci (35 MPN/100ml). The station having the largest violation relative to the state's fecal coliform and enterococci standards was used to calculate the percent reduction for the segment containing that station and is shown in bold in Tables 5.1 and 5.2. The required reduction for each segment is the higher of the two reductions ("geometric mean" versus the "90th percentile value").

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

5.2 Water Quality and Resource Impairments

Data collected by RIDEM in the watershed confirm that Buckeye Brook, Lockwood Brook, Knowles Brook, Warner Brook and Old Mill Creek estuary are not meeting either or both parts of the water quality standards for fecal coliform and enterococci bacteria. The impaired use is primary and secondary contact recreation for the Class B waterbodies, and shellfishing and primary contact recreation for the Class SA waterbody.

Table 5.1 Fecal Coliform Expressed as Percent Reductions to Meet Concentration Targets.

Station	Waterbody	Geometric Mean Value (CFU/100ml)	Target Value (CFU/100ml)	90 Percentile Value (CFU/100ml)	90 Percentile Target Value (CFU/100ml)	% Reduction Geomean Value	% Reduction 90 Percentile Value	Final Segment Reduction [b]
BB01	Tribs to Warwick Pond	249	200	614	400	19.7%	**34.9%**	34.9% (38.4%)
BB02		183	200	392	400	NA	NA	
BB03	Buckeye Brook	187	200	776	400	NA	48.5%	97.2% (>100%)
BB05		379	200	1,016	400	47.2%	60.6%	
BB06[a]		427	200	1,220	400	51.9%	67.2%	
BB07		509	14	848	49	**97.2%**	94.2%	
BB08[a]	Old Mill Creek	1,405	14	8,520	49	99.0%	**99.4%**	99.4% (>100%)
KB00A	Knowles Brook	587	200	2,940	400	65.9%	86.4%	99.1% (>100%)
KB00A-1		323	200	768	400	38.1%	47.9%	
KB00B		10,250	200	44,200	400	98.0%	**99.1%**	
KB01		7,638	200	18,400	400	97.4%	97.8%	
KB02		3,758	200	15,000	400	94.7%	97.3%	
LK01	Lockwood Brook	720	200	4,140	400	72.2%	90.3%	99.1% (>100%)
LK02		935	200	3,080	400	78.6%	87.0%	
LK04[a]		1,004	14	5,340	49	98.6%	**99.1%**	
WR01	Warner Brook	905	200	3,080	400	77.9%	87.0%	99.0% (>100%)
WR02[a]		790	14	4,904	49	98.2%	**99.0**%	

a- RIDEM and URI Watershed Watch stations.
b - 10 Percent Reduction with MOS Included in parentheses.

Table 5.2 Enterococci Expressed as Percent Reductions to Meet Concentration Targets.

Station	Water body	Geometric Mean Value (MPN/100ml)	Target Value (MPN/100ml)	% Reduction Geomean Value	Final Segment Reduction [b]
BB01	Tribs to Warwick Pond	199	54	**72.9%**	72.9% (80.2%)
BB02		67	54	19.4%	
BB03	Buckeye Brook	34	54	NA	72.9% (80.2%)
BB05		191	54	71.7%	
BB06[a]		198	54	72.7%	
BB07		129	35	**72.9%**	
BB08[a]	Old Mill Creek	293	35	**88.1%**	88.1% (96.9%)
KB00A	Knowles Brook	25	54	NA	81.1% (89.2%)
KB00A-1		14	54	NA	
KB00B		189	54	71.4%	
KB01		275	54	80.4%	
KB02		286	54	**81.1%**	
LK01	Lockwood Brook	65	54	16.9%	88.0% (96.8%)
LK02		121	54	55.4%	
LK04[a]		292	35	**88.0%**	
WR01	Warner Brook	139	54	61.2%	74.6% (82.1%)
WR02[a]		138	35	**74.6%**	

a- RIDEM and URI Watershed Watch stations.
b - 10 Percent Reduction with MOS Included in parentheses.

5.3 Critical Conditions and Seasonal Variation

The Clean Water Act, Section 303(d)(1)(C) requires that TMDLs "be established at a level necessary to implement the applicable water quality standards with seasonal variations…" The current regulation also states that determination of "TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters" [40 CFR 130.7(c)(1)]. Elevated fecal coliform levels occur throughout the year and under different flow regimes, however violations of the standards occur with more frequency during wet weather events. Elevated bacteria concentrations occur in all seasons, so seasonal variation is not an issue. Critical conditions vary by station therefore the TMDL analysis includes concentration reduction targets for all seasons and all weather conditions.

5.4 Margin of Safety

The TMDL must contain a margin of safety (MOS) to account for uncertainty in the analysis. The MOS may be incorporated into the TMDL in two ways. One can implicitly incorporate the MOS by using conservative assumptions throughout the TMDL development process or one may explicitly allocate a portion of the TMDL as the MOS. This TMDL uses the former approach for bacteria. An explicit margin of safety of 10% was used for this TMDL, however, the examination of Table 5.1 shows that with this 10% MOS applied, Knowles, Lockwood and Warner Brooks will need over 100% reduction in fecal coliform bacteria concentrations to meet water quality criteria and support designated uses. This applies to the seawater portion of the watershed, Old Mill Creek as well. The use of an explicit margin of safety provides a conservative estimate of reductions needed. However, RIDEM believes that pollution reductions between 90 to 100 percent should be adequate to achieve water quality standards.

5.5 Technical Analysis

The technical analyses are based on the data collected by RIDEM staff combined with the URI Watershed Watch data for their stations on Buckeye, Lockwood and Warner Brooks. The pathogen datasets for fecal coliform enterococci bacteria contains varying amounts of dry and wet weather values for each station. The RIDEM sampling plan for Buckeye Brook watershed was designed to sample all sites biweekly, regardless of the weather conditions encountered on the day of sampling. The number of dry versus wet samples were approximately equal for the RIDEM survey, but the Watershed Watch data had a greater percentage of samples collected under dry conditions. Although this resulted in 60% of the fecal coliform data being collected during steady state conditions, the geomean and percentile values of these data were deemed to be representative of the range of conditions encountered in the watershed. Enterococci data were evenly divided between wet and dry conditions, with twelve surveys each.

5.6 Establishing the Allowable Loading (TMDL)

EPA guidelines specify that a TMDL identify the pollutant loading that a waterbody can assimilate per unit time without violating water quality standards, with loads expressed as mass per time, toxicity, or any other appropriate measure (40 CFR§130.2). In this TMDL, the allowable load or loading capacity is expressed as concentrations set equal to the applicable water quality standard. Concentration is considered to apply daily because daily values are used to calculate the geometric means and percent variability. The allowable daily load is the criterion concentration multiplied by the flow in the receiving water. For the purposes of implementation and the reasons expressed below, it is recommended that the concentration and percent reduction bacteria TMDL targets be used.

- Expressing bacteria TMDL reductions in terms of concentration provides a direct link between existing water quality and the numeric water quality criteria.
- Using concentration to set TMDL reductions is more relevant and consistent with water quality standards, which apply for a range of flow and environmental conditions.
- Expressing bacteria TMDL reductions as daily loads can be more confusing to the public and can be more difficult to interpret since they are dependent on flow conditions.

Extensive field surveys, water quality monitoring, and a review of aerial and topographic maps were used to establish the link between pollutant sources and instream concentrations. As a first step in determining percent reductions, RIDEM organized the surface waters in the study area into segments based on waterbody identification numbers.

The reduction goal for each segment was determined by comparing current fecal coliform and enterococci concentrations to the applicable water quality targets (geometric mean and 90th percentile values for fecal coliform and geometric mean for enterococci). The percent reductions required to reach each portion of the target were then calculated. For fecal coliform, the higher percent reduction resulting from evaluation of the data against both the geometric mean and 90th percentile criteria was used to set each segment's necessary reduction. The geometric mean values were calculated using the GEOMEAN function in Microsoft Excel while 90th percentile values were calculated using the PERCENTILE function.

5.6.1 Required Reductions

EPA guidance requires that load allocations be assigned to either point (wasteload) or nonpoint (load) sources. As is the case for most bacteria impairments, insufficient data existed to accurately differentiate between point (stormwater discharges regulated under RIPDES stormwater permitting program) and nonpoint sources of bacteria. Therefore, as recommended by EPA Region 1, all bacteria source reductions for this TMDL are combined into the wasteload allocation. However in implementing this TMDL both point and nonpoint controls will be necessary to meet the plan's water quality targets. To guide TMDL implementation, RIDEM evaluated the Buckeye Brook watershed land use and pollution source data.

The required fecal coliform and enterococci reductions for the Buckeye Brook Watershed are presented in Tables 5.1 and 5.2, respectively. They are calculated from observed concentrations at the instream stations. These values were then compared to the applicable portion of the water quality standard. The station having the largest violation relative to the state's pathogen standard was used to calculate the percent reduction for the segment containing that station and is shown in bold. The required reduction for each segment is the higher of the two reductions (geometric mean versus 90th percentile value).

5.7 Fecal Coliform Reductions

Fecal coliform reductions for 17 Buckeye Brook Watershed stations are listed in Table 5.1 and are calculated from water quality data collected between 2004 and 2006. The geometric mean and percentile values were calculated as described above for each station. These values were then compared to the applicable portion of the water quality standard and a percent reduction was calculated. Final required reductions for each waterbody segment are presented in the last column of Table 5.1 and consist of the greatest reduction required of any station within that waterbody segment.

5.8 Enterococci Reductions

Enterococci reductions for 17 Buckeye Brook Watershed stations are listed in Table 5.2 and are calculated from water quality data collected in 2006. The geometric mean values were calculated as described above for each station. These values were then compared to the applicable portion of the water quality standard and a percent reduction was calculated. Final required reductions for each waterbody segment are presented in the last column of Table 5.2 and consist of the greatest reduction required of any station within that waterbody segment.

5.9 Load and Wasteload Allocations

EPA guidance requires that load allocations be assigned to either point (wasteload) or nonpoint (load) sources. As is the case for most bacteria impairments, insufficient data exist to accurately differentiate between point and nonpoint sources of bacteria. Therefore, as recommended by EPA Region 1, all bacteria source reductions for this TMDL are combined into the wasteload allocation. However, in implementing this TMDL, both point and nonpoint controls will be necessary to meet the TMDL plan's water quality targets. A summary of wasteload allocations, by segment, is presented in Sections 5.9.1 through 5.9.6.

5.9.1 Tribs to Warwick Pond (North of Warwick Pond)

The most prevalent source of bacteria to this segment is stormwater runoff. Other possible sources include illicit discharges to storm drains, and wildlife and waterfowl. With a 10% MOS included, the final segment reduction for fecal coliform is 38%, and 80% for enterococci. As a source, stormwater runoff will receive 100% of the WLA. A WLA of zero (0) is set for illegal connections to storm drains, and leaking sanitary sewer lines.

5.9.2 Buckeye Brook (South of Warwick Pond)

The most prevalent source of fecal coliform bacteria to this segment is stormwater runoff. Other possible sources include illicit discharges to storm drains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl. With a 10% MOS included, the final segment reduction for fecal coliform is 100%, and 80% for enterococci. As a source, stormwater runoff will receive 100% of the WLA. A WLA of zero (0) is set for failing septic systems that flow (via groundwater seeps and/or overland flow) into storm drains, illegal connections to storm drains, and leaking sanitary sewer lines.

5.9.3 Lockwood Brook

The most prevalent source of fecal coliform bacteria to this segment is stormwater runoff. Elevated concentrations of bacteria during dry weather also point to the potential significance of illicit discharges to storm drains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl. With a 10% MOS included, the final segment reduction for fecal coliform is 100%, and 97% for enterococci. As a source, stormwater runoff will receive 100% of the WLA. A WLA of zero (0) is set for failing septic systems that flow (via groundwater seeps and/or overland flow) into storm drains, illegal connections to storm drains, and leaking sanitary sewer lines. Sewer construction has been in progress for the past two years and is nearing completion. Sewer hooks-ups will be mandatory for all residents when the City of Warwick has completed construction.

5.9.4 Knowles Brook

Significantly elevated concentrations of bacteria during dry weather point to the potential for illicit discharges to storm drains, leaking sanitary sewer lines, failing septic systems, and/or wildlife and waterfowl as significant sources. Data indicate that stormwater is another prevalent source of bacteria. This portion of the watershed has a significant amount of open areas that include a school, as well as a commercial vegetable farm. A significant number of Canadian geese use this area as a feeding ground during the fall migrations. Geese have been prone to depositing vast amounts of fecal material wherever they roost and where stormwater runoff can wash these feces into the adjacent stream systems. With a 10% MOS included, the final segment reduction for fecal coliform is 100%, and 89% for enterococci. As a source, stormwater runoff will receive 100% of the WLA. A WLA of zero (0) is set for failing septic systems that flow (via groundwater seeps and/or overland flow) into storm drains, illegal connections to storm drains, and leaking sanitary sewer lines.

5.9.5 Warner Brook

The most prevalent source of fecal coliform bacteria to this segment is stormwater runoff. Other possible sources include illicit discharges to storm drains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl. With a 10% MOS included, the final segment reduction for fecal coliform is 100%, and 82% for enterococci. As a source, stormwater runoff will receive 100% of the WLA. A WLA of zero (0) is set for failing septic systems that flow (via groundwater seeps and/or overland flow) into storm drains, illegal connections to storm drains, and leaking sanitary sewer lines.

5.9.6 Old Mill Creek Estuary

The most prevalent sources of fecal coliform bacteria to this segment are from the tributaries to Buckeye Brook and stormwater runoff. The possible sources include illicit discharges to storm drains, leaking sanitary sewer lines, failing septic systems, and wildlife and waterfowl. Lockwood Brook and Knowles Brook (and thus, Warner Brook) have had significant levels of fecal coliform bacteria in the past and, in the instance of Lockwood Brook, its mouth is less than 250 feet from the sampling site for Old Mill Creek. Additionally, numerous waterfowl can be seen in this part of the watershed at any time of the year. With a 10% MOS included, the final segment reduction for fecal coliform is 100%, and 97% for enterococci. As a source, stormwater runoff will receive 100% of the WLA. A WLA of zero (0) is set for failing septic systems that flow (via groundwater seeps and/or overland flow) into storm drains, illegal connections to storm drains, and leaking sanitary sewer lines.

5.10 Strengths and Weaknesses in the Technical Approach

Strengths

- The TMDL implementation is based on extensive data and knowledge of the area
- The phased implementation approach allows an emphasis on mitigation strategies rather than on modeling and more complex monitoring to keep the focus on source reduction

Weaknesses

- Although several surveys were classified as wet, only one survey occurred under wet weather conditions where rainfall was present during sample collection.

6.0 IMPLEMENTATION

This section describes the actions necessary to implement the TMDL to attain and maintain fecal coliform and enterococci water quality criteria in the Buckeye Brook Watershed. The plan describes implementation responsibilities assigned to cooperating agencies and other responsible parties. The goal of the Implementation Plan is to ensure that the Buckeye Brook Watershed meets water quality criteria for fecal coliform and enterococci bacteria at all times and throughout the watershed. Compliance with the TMDL will be accomplished by ensuring that all point source discharges (stormwater) and nonpoint sources meet the wasteload allocations set forth in section 5.0 of this report.

Eliminating pathogen impairments in the Buckeye Brook Watershed requires a reduction in both dry and wet weather inputs. All stream segments in the watershed violate water quality standards for fecal coliform and enterococci bacteria. These elevated bacteria concentrations originate from within the watershed and are caused by both stormwater and non-point sources. Recommended implementation activities for Buckeye Brook should focus on stormwater and wastewater management. At most sampling locations in Buckeye Brook, bacteria concentrations rise dramatically during wet weather. Achieving water quality standards requires that both the volume of stormwater and the bacteria concentrations in that stormwater be reduced.

Wastewater management activities include continuing the extension of sewer lines, encouraging homes presently on individual systems to tie-in to the existing sewer systems where available, periodic checking of existing sewer infrastructure to ensure there are no chronic leaks, and adopting wastewater management ordinances in areas without sewers to ensure that septic systems are properly maintained and operated.

6.1 Stormwater Management

To realize water quality improvements in the watershed, pathogen concentrations in storm water must be reduced. The large amount of impervious areas within the watershed directly affects the volume of runoff entering streams during and immediately after rain events. Peak runoff rates and runoff volumes generated by a storm increase because developed lands have lost much or all of their natural capacity to delay, store, and infiltrate water. As a result, pathogens from streets, lawns, wildlife, and domestic pets quickly wash off during storm events and discharge into the nearby streams.

While the City of Warwick and RIDOT must implement the Phase II minimum measures town-wide, they should prioritize implementation of Phase II minimum measures by targeting construction of stormwater BMPs for priority outfalls. Addressing priority outfalls would of course first entail confirming ownership of the outfall and secondly, the identification of the catchments associated with each of these outfalls and any interconnections with the drainage systems of other MS4s. This mapping was required by the General Permit and must be specifically made available to RIDEM as part of the required SWMPP amendments. Illicit discharge detection and elimination, required by the General Permit, should focus on the outfalls that discharge into the streams.

Municipalities must conduct BMP feasibility studies to identify locations and technologies for installing infiltration basins or equivalent BMPs in these priority catchments, and evaluate alternatives to end-of-pipe technologies. Water quality improvements identified through ongoing water quality monitoring may result in modifications to the schedule and/or the need for additional BMPs.

6.1.1 Municipal and State Stormwater Systems- Phase II -Six Minimum Measures

The large area of impervious surfaces and the significant rise of bacteria concentrations in wet weather suggest that stormwater is the major cause of bacteria impairment in the watershed. Significant stormwater is generated in the mostly urban watershed. The City of Warwick and the RI Dept. of Transportation operate Municipal Separate Storm Sewer Systems (MS4s) that discharge to the surface waters of Buckeye Brook and its tributaries. These entities have applied for and obtained coverage under the RIPDES General Permit and have developed and submitted the required Storm Water Management Program Plans (SWMPPs). The plans contain implementation schedules that include interim milestones, frequency of activities and reporting of results. The SWMPPs describe BMPs for the six minimum measures and include measurable goals and schedules for each measure:

- A public education and outreach program to inform the public about the impacts of stormwater on surface water bodies,
- A public involvement/participation program,
- An illicit discharge detection and elimination program,
- A construction site storm water runoff control program for sites disturbing 1 or more acres,

- A post construction storm water runoff control program for new development and redevelopment sites disturbing 1 or more acres, and
- A municipal pollution prevention/good housekeeping operation and maintenance program.

Post-construction storm water management in areas undergoing new development or redevelopment is necessary because runoff from these areas has been shown to significantly effect receiving waterbodies. To meet the requirements of the Phase II minimum control measure relating to Post Construction Runoff Control, the operator of a regulated small MS4 will need to at a minimum:

- Develop and implement strategies that include a combination of structural and/or nonstructural BMPs;
- Develop an ordinance or other regulatory mechanism requiring the implementation of post-construction runoff controls to the extent allowable under State or local law;
- Ensure adequate long-term operation and maintenance of controls;
- Determine appropriate best management practices (BMPs) and measurable goals for this minimum control measure.

6.1.2 Required Amendments to Phase II Stormwater Management Program Plans

Part IV.D of the General Permit states that the operator must address the TMDL provisions in the SWMPP if a TMDL has been approved for any waterbody into which storm water discharges from the MS4 contribute directly or indirectly the pollutants(s) of concern (Part II.C3). Accordingly, upon approval of this TMDL, the RI Department of Transportation and the City of Warwick will be required to submit SWMPP amendments addressing the TMDL provisions within one hundred and eighty (180) days of the date of written notice from the RIPDES Program (Rule 31 (f)(8)(iii), as described in greater detail below. RIDEM acknowledges the receipt on September 3, 2008 of the City of Warwick's amended SWMPP and annual reports. The City should review their revised SWMPP against the Buckeye Brook Bacteria TMDL requirements and revise as necessary.

More specifically, the SWMPPs must be revised to describe the six minimum measures and other additional controls that are or will be implemented to address the pathogen-related impairments including any specific provisions described herein. The operators must provide measurable goals for the development and/or implementation of the six minimum measures and additional structural and non-structural BMPs that will be necessary to address provisions for the control of storm water identified in this TMDL including an implementation schedule, which includes all major milestone deadlines including the start and finish calendar dates, the estimated costs and proposed or actual funding sources, and the anticipated improvement(s) to water quality. These requirements apply to any operators of MS4s contributing to specifically identified outfalls, regardless of outfall ownerships. If no structural BMPs are recommended, the operator must evaluate whether the six minimum measures alone (including any revisions to ordinances) are sufficient to meet the TMDL's specified pollutant reduction targets. The revised SWMPP must specifically address the following:

1) Determine the land areas contributing to the discharges identified in TMDL using sub-watershed boundaries as determined from USGS topographic maps or other appropriate means;
2) Address all contributing areas and the impacts identified by the Department;
3) Assess the six minimum control measure BMPs and additional controls currently being implemented or that will be implemented in the SWMPP and describe the rationale for the selection of controls including the location of the discharge(s), receiving waters, water quality classification and other relevant information;
4) Identify and provide tabular description of the discharges identified in the TMDL including:

a) The location of discharge (latitude/longitude and street or other landmark);
b) Size and type of conveyance (e.g. 15” diameter concrete pipe);
c) Any existing discharge data (flow data and water quality monitoring data);
d) Impairment of concern and any suspected sources(s);
e) Interconnections with other MS4s within the system;
f) TMDL provisions specific to the discharge;
g) Any BMP(s) that have or will be implemented to address TMDL provisions and bacteria-related impairments;
h) Schedule for construction of structural BMPs including those for which a Scope of Work (SOW) is to be prepared, as described below.

6.1.2.1 Post Construction Provisions

Among the six minimum measures described earlier is the requirement for operators to establish post construction storm water runoff control programs for new land development and redevelopment sites disturbing one or more acres.

Post-construction stormwater management in areas undergoing new development or redevelopment is necessary because runoff from these areas can significantly affect receiving waterbodies. To meet the requirements of the Phase II minimum control measure relating to Post Construction Runoff Control, the operator of a regulated small MS4 will need to at a minimum:

- Develop and implement strategies, which include a combination of structural and/or nonstructural BMPs.
- Develop an ordinance or other regulatory mechanism requiring the implementation of post-construction runoff controls to the extent allowable under State or local law.
- Ensure adequate long-term operation and maintenance of controls.
- Develop and implement strategies to reduce runoff volumes.
- Determine appropriate best management practices (BMPs) and measurable goals for this minimum control measure.

Examples of acceptable reduction measures include reducing impervious surfaces, sloping impervious surfaces to drain towards vegetated areas, using porous pavement, and installing infiltration catch basins where feasible. Other reduction measures to consider are the establishment of buffer zones, vegetated drainage ways, cluster zoning or low impact development, transfer of development rights, and overlay districts for sensitive areas.

It is imperative that land development and re-development projects utilize best management practices if Buckeye Brook watershed is to be successfully restored. To ensure consistency with the goals and recommendations of the TMDL, the revised SWMPP must also address revisions to the local ordinances to ensure that:

- New land development projects employ stormwater controls to prevent any net increase in bacteria pollution to the waterbodies in the watershed.
- Redevelopment projects employ stormwater controls to reduce bacteria pollution to the waterbodies in the watershed to the maximum extent feasible

6.1.2.2 Site Specific Structural BMP Requirements

This TMDL has determined that structural BMPs are necessary, therefore all operators of MS4s identified herein must also prepare and submit a Scope of Work describing the process and rationale that will be used to select BMPs and measurable goals to ensure that the TMDL provisions will be met. The Scope of Work must also be accompanied with a schedule prioritizing outfalls for the construction of structural stormwater BMPs. A targeted approach to construction of stormwater retrofit best management practices (BMPs) at state and locally owned stormwater outfalls is recommended. As stated previously, these requirements apply to any operators of MS4s contributing to specifically identified outfalls, regardless of outfall ownerships. Priority outfalls have been identified in Table 4.2. Operators of MS4s must work to identify other outfalls that contribute the greatest pollutant loads and prioritize these for BMP construction, as detailed in the following sections.

For those operators for which specific outfalls or discharges are identified in the TMDL, the scope of work must:

1) Describe the tasks necessary to design and construct BMPs that reduce loads of bacteria and stormwater volumes to *the maximum extent feasible* including:

a) The delineation of the drainage or catchment area,
b) Determination of interconnections within the system and the approximate percentage of contributing area served by each operator’s drainage system, as well as a description of efforts to cooperate with owners of the interconnected system, and
c) Completion of catchment area feasibility analyses to determine drainage flow patterns (surface runoff and pipe connectivity), groundwater recharge potentials(s), upland and end-of-pipe locations suitable for siting BMPs throughout the catchment area, appropriate structural BMPs that address the pollutants(s) of concern, any environmental (severe slopes, soils, infiltration rates, depth to groundwater, wetlands or other sensitive resources, bedrock) and other siting (e.g. utilities, water supply wells, etc.) constraints, permitting requirements or restrictions, potential costs, preliminary and final engineering requirements.

2) Establish a schedule to identify and assess all remaining discharges not identified in the TMDL (owned by the operator) contributing to the impaired waters addressed by the TMDL, to delineate the drainage or catchment areas to these discharges, and as needed to address water quality

impairments, to design and construct structural BMPS. To determine the prioritization for BMP construction, the assessment of identified discharges shall determine the relative contribution of bacteria taking into consideration pollutant loads (i.e. concentrations and flows) as indicated by drainage area, pipe size, land use, known hot spots and/or sampling data.

A wide range of BMPs are available to control both the quality and quantity of urban storm water runoff entering receiving waters. BMPs should be incorporated into a comprehensive storm water management program. Without proper selection, design, construction, and maintenance, BMPs will not be effective in managing storm water runoff. Site suitability and other factors are crucial in effective BMP selection. The University of New Hampshire Storm Water Center and the USEPA both have excellent websites regarding structural BMPs

http://www.unh.edu/erg/cstev/ and http://www.epa.gov/nrmrl/pubs/600r04184/600r04184.pdf

6.1.2.3 Illicit Discharge Detection and Elimination

During all surveys in the Buckeye Brook Watershed, the pathogen concentrations were consistently highest in both Knowles and Lockwood Brooks. Priority must be given to investigating the pathogen sources to these two waterbodies when conducting the Illicit Discharge Detection and Elimination (IDDE) Surveys required by the General Permit.

As part of the IDDE requirements, the General Permit requires that all stormwater outfalls be identified and mapped, and that interconnections be identified and drainage system connectivity mapped. Consistent with these requirements, the TMDL requires that the City of Warwick and Rhode Island Department of Transportation confirm ownership of outfalls identified as priorities in the TMDL – as well as to identify and map other outfalls discharging to Buckeye Brook or its tributaries and prioritize for pollution abatement, as appropriate.

In addition, the General Permit requires that the both the City of Warwick and RIDOT perform catch basin and manhole inspections, perform two dry weather screenings and summarize the results.

Lastly, the City of Warwick and RIDOT must provide an implementation plan with prioritization based on the results of the dry weather screening and IDDE investigations including work to investigate sources of elevated bacteria levels in Knowles and Lockwood Brooks. Work completed in fulfillment of the Phase II General Permit should be summarized and reported separately for the Buckeye Brook watershed so as to allow analyses of the results in the context of the TMDL findings and required actions.

6.1.2.4 Public Education/Public Involvement

The public education program should focus on both water quality and water quantity concerns within the watershed. Public education material should target the particular audience being addressed. For example, the residential community should be educated about the water quality impacts from residential use and activities and the measures they can take to minimize and prevent these impacts. Examples include disposing of pet waste properly, discouraging large waterfowl populations by eliminating human feeding of waterfowl and utilizing plantings and/or fencing adjacent to large tracts of open land near waterbodies where waterfowl land and congregate, and prohibiting illegal tie-ins to storm drains from failing septic systems or washing machines.

Public involvement programs should actively involve the community in addressing these concerns. Involvement activities may include posting signs informing the public not to feed waterfowl, stenciling storm drains with *Do Not Dump* labels, and designating and maintaining areas with pet waste bags and containers.

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

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

RIDOT, in conjunction with RIDEM, has signed an agreement with the University of Rhode Island Cooperative Extension (URI) for a Public Education and Outreach Program. This program will provide participating MS4s the opportunity to use prepared education and outreach programs for their individual use, which could be easily tailored to the TMDL public education recommendations. To date, each of the MS4 designated in the TMDL studies are participating in the Program, except Coventry. More information may be found on the URI NEMO website

http://www.uri.edu/ce/wq/RESOURCES/STORMWATER/index.htm

6.1.2.5 Good Housekeeping/Pollution Prevention

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

As part of their Good Housekeeping/Pollution Prevention requirements, the City of Warwick and RIDOT must investigate the feasibility of increased street sweeping and/or stormwater system maintenance to address pathogen loads to the stream systems. At least one street sweeping and storm drain cleaning should be conducted in the spring when the last reasonable chance of snowfall has past.

6.2 Stormwater from Industrial Activities

6.2.1 Industrial Activities covered by the Statewide Multi-Sector General Permit

The TMDL has shown that stormwater is a major source contributing to the pathogen impairments to the watershed. Stormwater discharges from industrial activities may be discharged to these waters directly or via the MS4s and may contain pathogens that contribute to these impairments. Stormwater discharges from facilities that discharge “stormwater associated with industrial activity” are regulated under the statewide general RIPDES permit prescribed in Chapter 46-12, 42-17.1 and 42-35 of the General Laws of the State of Rhode Island.

In accordance with Part I.B.3.j of the RIPDES Multi-Sector General Permit, prior to authorization to discharge stormwater associated with industrial activity, the applicant is required to demonstrate that the stormwater discharge is consistent with the requirements of the TMDL. With completion of this TMDL, consistent with Part I.C. of the general permit, facilities currently authorized to discharge under the permit must either demonstrate that the existing Storm Water Pollution Prevention Plan (SWPPP) is consistent with the TMDL or amend their plan demonstrating consistency with the TMDL. More specifically, the TMDL requires that facilities currently authorized or seeking authorization to discharge to the ponds must demonstrate that their SWPPP reduces bacteria to the maximum extent feasible. Permittees will have 90 days from written notification by RIDEM to submit this documentation including revised SWMPPs to RIDEM.

The owner/operators of facilities currently authorized to discharge to the streams within the watershed are listed below:

- Jay Packing Group (Buckeye Brook)

The SWPPP must identify the potential sources of pollution, including specifically the TMDL pollutant of concern (bacteria), which may reasonably be expected to affect the quality of storm water discharges from the facility; and describe and ensure implementation of practices, which the permittee will use to reduce bacteria in storm water discharges from the facility. The SWPPP must address all areas of the facility and describe existing and/or proposed BMPs that will be used and, at a minimum, must include the following:

- Frequent sweeping of roads, parking lots and other impervious areas
- Effective management (storage and disposal) of solid waste and trash

- Regular inspection and cleaning of catch basins and other stormwater BMPs
- Other pollution prevention and stormwater BMPs as appropriate

Where structural BMPs are necessary, as stated in Part IV.F.7 of the permit, selection of BMPs should take into consideration:
1) The quantity and nature of the pollutants, and their potential to impact the water quality of receiving waters;
2) Opportunities to combine the dual purposes of water quality protection and local flood control benefits (including physical impacts of high flows on streams - e.g., bank erosion, impairment of aquatic habitat, etc.); and
3) Opportunities to offset the impact of impervious areas of the facility on ground water recharge and base flows in local streams.

For existing facilities, the SWPPP must include a schedule specifying when each control will be implemented. Facilities that are not currently authorized will be required to demonstrate compliance with these requirements prior to authorization.

6.2.2 Industrial Activities covered by Individual Permits

The state airport, T.F. Green Airport operated by the RI Airport Corporation is the only industrial facility covered by an individual stormwater permit which discharges to any of the waters covered by this TMDL.

The Rhode Island Airport Corporation (RIAC) has applied for and obtained a permit to discharge stormwater to a tributary to Warwick Pond and Buckeye Brook. The permit requires the implementation of the permittee’s existing Storm Water Pollution Prevention Plan (SWPPP) as of the effective date of the permit. The permit establishes a schedule that requires the permittee to amend the SWPPP to include additional BMPs as specified in the permit. The goal of the SWPPP is to help identify the source of pollutants in the discharge of storm water and to ensure practices are being implemented to minimize pollutants associated with industrial activities from entering any storm water discharge. This Plan emphasizes the use of Best Management Practices (BMPs) to provide the flexibility to address different sources of pollutants.

The SWPPP includes required elements and BMPs to mitigate the impacts of the following: aircraft, vehicle, and equipment maintenance, aircraft and pavement deicing/anti-icing fueling and washing, aircraft lavatory service, illicit discharge detection and elimination, pesticide management, building and grounds maintenance, chemical and fuel handling and storage, materials handling, stormwater pollution prevention education, outdoor area and floor wash-down, and water quality monitoring.

The list of BMPs presented in the SWPPP for each of the major airport activities is comprehensive. For instance, the following existing BMPs are listed for aircraft, vehicle, and equipment washing:

- "dry" washing;
- secondary containment for containers of washing and steam cleaning additives;
- covering catch basins with mats during washing;
- keep wash areas clean and free of waste;
- proper signage to prohibit the discharge of waste oils into the drains;
- aircraft vehicles and equipment should be washed indoors at a designated area and wash water should be collected;
- in the event that an indoor wash facility is not available, outdoor rinsing may be performed away from any storm water drains, with rinse water directed to a grassed area;
- consider offsite commercial washing and steam cleaning;
- use designated indoor wash areas and bermed or covered outdoor areas where feasible;
- filter and recycle wash water where practical; and
- conduct berm repair.

Implementation of these and other BMPs outlined in the SWPPP are expected to address the discharge of pathogens associated with major airport activities.

The Director may notify the permittee at any time that the Storm Water Pollution Prevention Plan does not meet one or more of the minimum requirements of the permit. After such notification from the Director, the permittee shall make changes to the Plan and shall submit to the Director a written certification that the requested changes have been made. Unless otherwise provided by the Director, the permittee shall have thirty (30) days after such notification to make the necessary changes.

6.3 Sanitary Waste

Inadequately treated wastewater from substandard and failed septic systems can add bacteria and nutrients to Buckeye Brook and ultimately Narragansett Bay, contributing to water quality impairments. It is important that these sources be mitigated through planned sewer extensions and tie-ins. While it is RIDEM's understanding that the entire Buckeye Brook watershed is slated to be sewered, it is the homeowner's responsibility to ensure that septic systems are properly maintained until such time as connections to the sewer system can be made.

Within the last year, the city has completed the installation of sewers throughout most of the watershed, but residential connections to the sewers were not scheduled to begin in Buckeye Brook watershed until Greenwich Bay watershed has completed their sewer connections. However, the Warwick Sewer Authority decided to authorize sewer hook-ups for the newly sewered areas within the watershed in March 2007, and to date, approximately thirty homes have applied for connection or have been connected.

In Greenwich Bay watershed, consultants for the Warwick Sewer Authority used parameters such as soil type, proximity to wetlands, and housing density to identify priority areas for mandatory connection. While mandatory connections have not been started in the watershed, it is recommended that Warwick use the same parameters as in Greenwich Bay in identifying priority areas of Buckeye Brook watershed where mandatory tie-in should occur. Particular attention should be given to the areas around Lockwood and Warner Brooks. As noted above, the Warwick Sewer Authority has authorized and encouraged sewer hook-up for all residential areas of Buckeye Brook watershed as soon as construction was completed. It is recommended that this be continued even though Greenwich Bay watershed sewer tie-in are projected to take until 2011 to complete.

6.4 Waterfowl Control

Large, open areas are invitations for migrating waterfowl to rest and feed. Within the watershed, large groups of Canadian Geese had been observed in the athletic fields used by Bishop Hendricken High School. The open fields of Morris Farm are also areas where these birds have been observed in large groups. During field surveys, RIDEM staff found significant amounts of goose feces in the City of Warwick athletic sports complex north of Buckeye Brook off of Bend Street.

It is recommended that the City of Warwick work with private property owners experiencing problems with nuisance populations of Canadian Geese, and with the Division of Fish and Wildlife to develop a comprehensive and publicly acceptable strategy to manage Canadian Geese. A selection of methods to control nuisance populations of Canadian Geese is summarized below.

There are many ways to discourage waterfowl and especially geese from settling adjacent to a waterbody. No single technique is universally effective and feasible in a suburban or urban setting. Persistent application of a combination of methods is usually necessary and yields the best results. Some methods for controlling goose populations include the following: discontinuing feeding, modifying habitat, installing fencing, using visual scaring devices, applying repellents, using dogs to chase geese, controlling goose nesting and capturing and removing geese. Although the preceding methods pertain to the control of goose populations, many of the methods may also work for other waterfowl and gulls.

Although many people enjoy feeding waterfowl, feeding waterfowl is illegal in the State of Rhode Island and may cause large numbers of geese to congregate in unnatural concentrations. Well-fed domestic waterfowl often act as decoys, attracting wild birds to the site. Geese that depend on supplemental feeding are also less likely to migrate when winter arrives. Feeding usually occurs in the most accessible areas such as lawns, streets, walkways, and parking areas. Some success in reducing goose feeding may be achieved through simple public education such as “ Do not feed the geese” signs (the Division of Fish & Wildlife will provide examples on request). Further reduction of feeding may require the adoption and enforcement of local ordinances such as fines or community service (cleaning up droppings for example) for violations.

Various materials may be used to create a visual image that geese will avoid, especially if they are not already established on a site. Geese are normally reluctant to linger beneath an object hovering overhead. However, visual scaring device are not likely to be effective on suburban lawns where trees or other overhead objects exist and where geese have been feeding for years. One very effective visual deterrent for geese is Mylar tape that reflects sunlight to produce a flashing effect. Another visual scaring technique is the placement of flagging of helium-filled, bird-scaring balloons on poles at the shoreline. Owl decoys may also be effective. If geese become acclimated to any of these devices, frequent relocation may be necessary. The use of remote control boats can also be used to repel geese, and may be practical if local hobbyists are willing to participate.

The U.S. Environmental Protection Agency has approved the product, ReJeXiT ®, as a goose repellent for lawns. The active ingredient in ReJeXiT ® is methyl anthranilate (MA), which is a human-safe food flavoring derived from grapes. Geese will avoid feeding on treated lawns because they dislike the taste. However geese may still walk across treated areas. The material is available at some garden supply shops and costs about $125 per acre per application. Several applications per year are usually necessary.

Dogs trained to chase but not harm geese have been used effectively to disperse geese from parks, golf courses, and athletic fields. Border Collies or other breeds with herding instincts work best. The dogs must be closely supervised during this activity. Initially, chasing must be done several times a day for several weeks, after which less frequent but regular patrols will be needed. Dogs generally should not be used when geese are nesting or unable to fly, such as during the summer molt or when goslings are present.

Without efforts to reduce nuisance waterfowl populations, these non-lethal methods of control may just shift the populations and their associated negative water quality impacts to other waterbodies.

The control of goose nesting and the capture and removal of geese are two other methods that could be used to reduce excessive goose populations on lakes and ponds. Both activities require federal permits. The Division of Fish & Wildlife of RIDEM should be contacted if this method is being considered. Other methods to be considered may include where applicable, the extension of the hunting season and/or increased limits for specific waterbodies where waterfowl have been identified as a significant source of pollution in a TMDL.

6.5 Agricultural Source Control

Knowles Brook borders the southern edge of Morris Farm. This reach consistently had a significant rise (two orders of magnitude) in pathogen concentrations during the entire survey period. Although the farm is primarily in crop cultivation, there are some farm animals present that may contribute to the pathogen contamination observed in this area of the brook.

Some prevention measures that should be implemented include a widening of the riparian buffer strip along this reach of the brook, which is very narrow, allowing for direct runoff from storm events to flow into the stream system between the two stations. The ground in this area slopes toward the brook, providing an easy path for untreated runoff to discharge to the brook. Proper containment and management of farm animal waste should be a priority to prevent this from occurring.

7.0 PUBLIC PARTICIPATION

RIDEM presented the draft TMDL plan to the general public and stakeholders, including public officials and other agencies, in a public meeting on October 2, 2008. Letters were sent to key stakeholders in advance of the meeting. In addition, the meeting was publicized through public notices that were posted at the Warwick City Hall and the Warwick Public Library. The draft TMDL was made available to the public on RIDEM's website approximately two weeks prior to the public meeting. Hard copies of the draft are available upon request. The public comment period ended on November 3, 2008, thirty-two days after the final meeting, and resulted in several comments from attendees that can be found in Appendix C, along with the responses from RIDEM

8.0 FUTURE MONITORING

This is a phased implementation TMDL. Results of water quality monitoring will allow RIDEM to track compliance with the water quality objectives as remedial actions are accomplished. URI Watershed Watch (URIWW) volunteers have historically conducted monitoring of the watershed. URIWW monitored four of the seventeen water quality stations within the watershed during the 2004-2006 period. RIDEM encourages URIWW volunteers to continue monitoring these stations and to add one additional station for Knowles Brook.

RIDEM will also seek to have the performance of BMPs monitored as they are installed throughout the Buckeye Brook watershed in order to assess the effectiveness of these controls. Lastly, RIDEM will conduct follow-up monitoring to assess the success of implementation activities at key locations in the watershed, as part of the state's rotating basin baseline water quality monitoring program.

9.0 REFERENCES

Lim, S. and V. Olivieri. 1982. Sources of Microorganisms in Urban Runoff. Johns Hopkins School of Public Health and Hygiene. Jones Falls Urban Runoff Project. Baltimore, MD 140 pp.

Samadpour, M. and N. Checkowitz, 1998. Little Soos Creek microbial source tracking. RESOURCE, Spring,1998. University of Washington Urban Water Resources Center.

RIDEM. 2006. *Final Data Report for Buckeye Brook Watershed in Warwick, RI, October, 2006,* Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.

RIDEM. *State of Rhode Island 2006 303(d) List: List of Impaired Waters, November, 2006,* Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.

RIDEM. *State of Rhode Island Water Quality Regulations*: *July 2006* Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.

RIGIS. *RIGIS Metadata for 1995 Rhode Island Landuse*. 1999. Rhode Island Geographic Information System. <http://www.edc.uri.edu/rigisspf/Metadata/ Landuse/s44llu95.html>

Trial, W. et al. 1993. Bacterial Source Tracking: Studies in an Urban Seattle Watershed. Puget Sound Notes. 30:1-3.

US EPA *Guidance for Water Quality-Based Decisions: The TMDL Process*. EPA 440/4-91-001. Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C. 20460.

US EPA *Protocol for Developing Pathogen TMDLs*. EPA 841-R-00-002. Office of Water, Washington, D.C. 20460.

US EPA *Report of the Experts Scientific Workshop on Critical Research Needs for the Development of New or Revised Recreational Water Quality Criteria.* EPA 823-R-07-006. Office of Water , Office of Research and Development, Warrenton, VA, 20187.

APPENDIX A

Water Quality Stations

Table A.1 Buckeye Brook Watershed Pathogen Sampling Stations

Station	Name	Description	Type	Purpose
BB01	Buckeye Brook @ Airport Road N41°43.977' W71°24.999'	In-Stream: Upstream of culvert under Airport Road	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Background sample of stream and isolates the headwaters of Buckeye Bk
BB02	Buckeye Brook @ Lakeshore Drive N41°43.711' W71°24.867'	In-Stream, Downstream of culverts under Lakeshore Dr.	Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets airport and residential area between below Airport Road
BB03	Outlet of Warwick Pond N41°43.151' W71°24.911'	In-stream: Exit of Warwick Pond	Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets Warwick Pond
BB05	Buckeye Brook @ Old Warwick Ave. N41°42.855' W71°23.904'	In-stream: Upstream side of bridge crossing	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets residential area between Warwick Pd and Old Warwick Ave
BB06*	Buckeye Brook @ end of Novelty Road N41°43.687' W71°23.281'	In-stream, location of Watershed Watch site	Flow, Fecal coliform, Enterococci, DO, Temp, Conductivity	Brackets residential area between Old Warwick Ave and end of Novelty Rd
BB07	Buckeye Brook @ West Shore Road N41°42.527' W71°22.975'	In-stream, prior to bridge crossing of West Shore Rd	Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets residential area between end of Novelty Rd and West Shore Rd
BB08*	Buckeye Brook @ Tidewater Drive N41°42.732' W71°22.513'	In-stream, Downstream side of Tidewater Dr bridge	Fecal Coliform, Enterococci, DO, Temp, Conductivity	Entry point of Buckeye Bk into Old Mill Creek
KB00A	Pond exit behind Bishop Hendricken High School N41°42.124' W71°23.803'	In-stream, Downstream side of culvert at pond exit	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Isolates pond from Knowles Brook
KB00A-1	Behind Elks Club on West Shore Road N41°42.098' W71°23.517'	In-stream, Downstream side of culvert at pond exit	Fecal Coliform, Enterococci, DO, Temp, Conductivity	Isolates upper reach and second pond from Knowles Brook
KB00B	End of Churubusco Avenue N41°42.119' W71°23.323'	In-Stream, End of road	Fecal Coliform, Enterococci, DO, Temp, Conductivity	Isolates reach between second pond and station at Churubusco Ave
KB01	Knowles Brook @ Warwick Ave N41°42.154' W71°23.220'	In-stream, Upstream side of Warwick Ave crossing	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Isolates reach between Churubusco Ave and Warwick Ave
KB02	Knowles Brook @ Edythe St. N41°42.197' W71°23.173'	In-stream, Upstream side of road culvert	Flow, Fecal coliform, Enterococci, DO, Temp, Conductivity	Brackets area behind commercial strip mall- Last site before confluence with Warner Bk
LK01	Lockwood Brook @ Vernon Road N41°43.465' W71°23.820'	In-stream, Downstream of road culvert	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Isolates headwaters of Lockwood Bk
LK02	Lockwood Brook @ Overbrook Avenue N41°43.181' W71°23.226'	In-stream, Upstream side of culvert	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets residential area between Vernon Rd and Overbrook Ave
LK04*	Lockwood Brook @ West Shore Road N41°42.816' W71°22.751'	In-stream, Downstream side of culvert	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets residential area between Overbrook Ave and West Shore Rd- Last site before Buckeye Bk
WR01	Warner Brook @ West Shore Road N41°42.274' W71°23.032'	In-stream, Downstream of West Shore Rd culvert	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Isolates headwaters of Warner Bk and downstream of Knowles Bk confluence
WR02*	Warner Brook @ Draper Road N41°42.421' W71°22.830'	In-stream, Downstream of Draper Rd culvert	Flow, Fecal Coliform, Enterococci, DO, Temp, Conductivity	Brackets residential area between West Shore Dr. and Draper Rd. Last site before Buckeye Bk

Note: BB07, BB08, and WR02 are influenced by inflows from high tides. These stations were sampled at low tide with outgoing flows.
* - Stations also monitored by University of Rhode Island's Watershed Watch Volunteer Monitoring Program. Underlined stations were added after results from second survey were received.

APPENDIX B

Shoreline Survey Data

Table B.1 Old Mill Creek Shoreline Survey Results for March 10, 2006

Source	Latitude		Longitude		Description/	Actual /	Direct /	Results	Velocity	Source Dims (ft)		Flow	Load
	deg	min	deg	min	Location	Potential	Indirect	(MPN/100ml)	(ft/sec)*	Width	Depth	Ft^3/sec	MPN/day
231	41	42.95	71	22.25	Outfall, End of Mill Cove Rd	A	D	9	trickle	3	0.16	-	-
235	41	42.84	71	21.87	Channel draining wetland/ salt marsh	A	D	<3	0.73	3	0.08	0.175	-
239	41	42.94	71	22.47	Stream draining wetlands	A	D	15	0.19	4	0.25	0.036	1.32E+07
243	41	42.69	71	22.04	12" Reinforced Concrete Pipe (RCP)	A	D	75	0.25	1	0.33	0.083	1.52E+08
247	41	42.77	71	22.08	Crack in retaining wall	A	D	<3	trickle	0.5	0.13	-	-
251	41	42.71	71	22.32	Small stream draining wetland	A	D	15	trickle	3	0.33	-	-
208	41	42.73	71	22.52	Buckeye Brook at Tidewater Dr.(BB08)	A	D	93	-	-	-	-	-
212	41	42.82	71	22.75	Lockwood Brook at West Shore Rd. (LK04)	A	D	240	-	-	-	-	-
216	41	42.42	71	22.82	Warner Brook at Draper Rd. (WR02)	A	D	9	-	-	-	-	-
220	41	42.69	71	23.28	Buckeye Brook at Novelty Rd. (BB06)	A	D	23	-	-	-	-	-

*Trickle assumed to be 0.01 ft/sec **E+07 =107 = 10,000,000

APPENDIX C

Response to Comments

Response to Comments

The following comments were received by RIDEM during the public comment period for the draft Buckeye Brook Watershed Pathogen TMDL document. The complete text of all comments received is on file in the Office of Water Resources at RIDEM.

RHODE ISLAND DEPARTMENT OF TRANSPORTATION

Allison LeBlanc, Environmental Scientist for RIDOT, attended the public meeting on the draft Buckeye Brook Watershed Pathogen TMDL that was held on October 2, 2008.

Ms. LeBlanc had a comment about the indicator bacteria used by RIDEM in Section 1.3, Pollutants of Concern. Fecal Coliform is the indicator pathogen used in the shellfishing program, while Enterococci is used for primary contact recreation/ swimming criteria. She had an inquiry about who sets these indicator bacteria.

RIDEM Response:
Through promulgation of the Water Quality Standards, RIDEM is the agency that sets the criteria for the threshold and type of indicator bacteria used in the state's water quality protection program. This information was added to the TMDL under Section 1.3.

BUCKEYE BROOK COALITION

Mr. Paul Earnshaw, Vice-President of the Buckeye Brook Coalition, attended the public meeting on the draft Buckeye Brook Watershed Pathogen TMDL that was held on October 2, 2008. Mr. Earnshaw was concerned about Section 1.5.1 of the TMDL as noted below.

Under Section 1.5.1 Designated Uses, it states that "…in no case shall waste assimilation of waste transport be considered a designated use." Yet, DEM has located several sites in the upper reaches of the brook and wetlands flowing into Warwick Pond, which have been using the brook to do just that. T.F. Greene Airport is a state airport, which has stormwater outfalls directly, and indirectly discharging into the Buckeye Brook watershed. These outfalls carry into the brook and the pond all of the chemicals and pollutants associated with the airport's daily operations. Yet it appears that this has not been considered an area of major concern in the TMDL, although the lack of biodiversity in this area has been noted. It is our opinion that the airport, the nearby uncapped landfill, the Truk Away site, and the industrial operation of the Lessona Corporation are the sources of this degradation of the biodiversity in the watershed and should be included in the TMDL.
Mr. Earnshaw also brought up the issue of Bayside Country Club Apartments located in the Warner Brook watershed not being connected to the sewer.

RIDEM Response:
The commenter correctly cites Rhode Island's Water Quality Regulations in stating that neither waste assimilation nor waste transport shall be considered a designated use. That does not mean, however, that the regulations do not allow for the consideration of a waterbody's ability to assimilate pollutants while still meeting water quality standards. In fact, various provisions of

the regulations provide for the consideration of this assimilative capacity while still meeting water quality standards – including both the numeric criteria and the designated uses. By contrast, if waste assimilation were considered a designated use, it would not be protective of other designated uses – such as protection of aquatic life. The RIDEM staff have conducted field investigations in the areas north of Warwick Pond that were accessible to the public. These included Spring Green Pond and the tributaries to Warwick Pond. Locations of the water quality sampling stations were selected to isolate those reaches of the watershed that received discharges from the airport. During normal operations, the Airport generates various pollutants. During wet weather, these pollutants combine with stormwater runoff, which is ultimately discharged into a wetland and the tributary to Warwick Pond as well as Buckeye Brook. The Airport has been issued a Rhode Island Pollutant Discharge Elimination System (RIPDES) permit for these discharges. The permit requires the airport to submit quarterly reports on the outfall sampling and results, and to sample for pathogens at all outfalls, which has been on going since January 2007. A review of these data reports show that there have been no exceedances of the pathogen criteria reported by T.F. Green Airport, to date. The TMDL calls for continued implementation of the BMPs outlined in the Airport's Stormwater Pollution Prevention Plan (SWPPP) as a means to address the discharge of pathogens associated with major airport activities. RIDEM continues to evaluate the water quality impacts associated with these and other pollution sources to Buckeye Brook as part of its ongoing biodiversity assessment.

The Bayside Country Club Apartments are currently being investigated for septic violations by RIDEM's Office of Compliance and Inspection, however, the final disposition of the issue is still to be determined, and cannot be commented on at this time.

Ms. Michelle Komar also attended the public meeting on the draft Buckeye Brook Watershed Pathogen TMDL that was held on October 2, 2008. The following are comments submitted by her.

Spring Green Pond and Tributaries
What water quality studies or data does RIDEM possess or have knowledge being performed by others? I do not believe that the pond or tributaries are included in the URI Watershed Watch Volunteer Water Quality Monitoring Program. Has RIDEM TMDL Program asked the Rhode Island Airport Corporation (RIAC) and/or RIDEM Fish and Wildlife (Phil Edwards) if they have any water quality data or conducted any environmental studies pertaining to the pond and/or its tributaries?

RIDEM Response:
Fish and Wildlife Department of RIDEM has conducted fish counts for Spring Green Pond in 2003 and 2006. Pathogen data was not collected, however, only field water quality measurements for temperature, dissolved oxygen, conductivity and pH data were collected. To our knowledge, neither Watershed Watch nor RIAC has conducted water quality studies in the pond area or tributaries.

Tidal Influence
Based on past observation, Buckeye Brook is tidally influenced to near West Shore Road and portion of Lockwood Brook also is tidally influenced. The TMDL – Pathogens report may

suggest these and Warner Brook are at least in portion, tidally influenced. TMDL-Pathogens report only mentions Old Mill Creek as estuarine. Does this affect the TMDL –Pathogens?

RIDEM Response:
We became aware that Buckeye, Lockwood, and Warner Brooks are tidally influenced at their lower reaches as part of the assessment work completed for this TMDL. Salinity measurements taken in Warner Brook during the study show that salt water reached as far upstream as Draper Road. The salt water travels upstream in Buckeye Brook just past West Shore Road during high tides. However, only the last reach of Lockwood Brook that is below West Shore Road has a tidal influence. These reaches are not identified as such in the state's Water Quality Regulations nor in the TMDL, but as Class B freshwaters. Re-classification of these lower reaches of Buckeye, Lockwood and Warner Brooks to Class SB will be proposed in a future update of the State's Water Quality Regulations. The TMDL has been modified changing the target values for fecal coliform and enterococci at the furthest downstream stations on Buckeye, Lockwood and Warner Brooks to Class SA standards to be protective of the downstream Class SA waters, Old Mill Creek. At the same time, these more stringent criteria for these stations also provide adequate protection of the tidal reaches of the tributary streams.

Watershed History
"Buckeye Brook supports the blue back herring, an anadromous fish species that annually makes its way back up the river to spawn in Warwick Pond." Do anadromous fish species spawn elsewhere in the watershed?
Also, "freshwater tidal marsh community" is not common terminology to what may be intended to describe as brackish marsh. Suggest that wetland biologists at RIDEM Freshwater Wetlands Program be contacted to suggest better terminology to fit the audiences of the TMDL – Pathogens report
There is no mention of the relatively recent changes in vegetation composition of Buckeye Brook wetland system relative to invasive species, in particular, on the downstream side of the West Shore Road crossing, in area of the most up gradient extent of tidal influence. Suggest that this should be monitored by RIDEM.

RIDEM Response:
As noted above, Fish and Wildlife has conducted fish counts in Spring Green Pond and observed the blue back herring during the spawning season. Warwick and Spring Green Ponds are the only waterbodies where these species have been observed during the spawning season. The freshwater tidal marsh community has been changed in the TMDL to salt marsh community. As to the changes in the vegetation, your point is noted, however, it does not pertain to this TMDL addressing pathogens and therefore no revisions to the document were made.

Water Quality Monitoring and Table 3.1
"This location was rated as moderately impaired for biodiversity in 2003 and 2004 (ESS, 2004, ESS, 2005), which is the reason for the biodiversity impairment listing on the state's 303(d) list." Was biodiversity impairment listing prior to 2003, which was based upon Rogers William University assessment?

RIDEM Response:
Buckeye Brook was first listed as impaired for biodiversity in 1998 based upon the data collected by Roger Williams University. The dates in the TMDL referred to the dates of the ESS Group's reports that noted the biodiversity impairment. The TMDL has been corrected to reflect this fact.

There is other groundwater and soil data available in the watershed and recommend that the RIDEM TMDL Program contact RIDEM Office of Waste Management and include in TMDL – Pathogens report. (At the request of Warwick City Councilwoman, Jeff Crawford and Chris Walusiak have given presentation of certain sites at public meeting in Warwick.)

RIDEM Response:
The data collected by Waste Management was reviewed during the course of this TMDL. As noted above, the information collected did not pertain to a pathogen TMDL. This data may be more applicable to the biodiversity TMDL that is currently in progress.

Pollution Sources
"…TMDL staff also reviewed information on file with RIDEM's Office of Compliance and Inspection regarding complaints and notices of violation relating to failed septic systems or otherwise inadequately treated wastewater." Did TMDL staff contact the Warwick Sewer Authority (WSA) for information? It is my understanding that the WSA maintains record of frequently pumped out septic systems and cesspools, which may be an indication of failing systems. WSA may be collecting other useful data.

Animal Waste
Watershed -Wide – Pet waste left to decay on streets, sidewalks, or on grass areas adjacent to streams may be washed into storm drains by rain or melting snow. Implies that necessary to be adjacent to stream to be problematic—needs revision.
Contamination from geese, raccoons, and coyotes. The City of Warwick has established program for public to report coyote sightings. If this collected information would be helpful to RIDEM, please contact City of Warwick.
Parsonage (Knowles) Brook- Farm animals. Are fertilizers being used comprised of animal wastes which also are problematic sources of pathogens?

RIDEM Response:
RIDEM staff did not contact the Warwick Sewer Authority concerning failed septic systems as the Office of Compliance and Inspection maintains a record of failed septic systems. This database was checked and RIDEM feels that that is sufficient for this TMDL. The WSA was contacted as to the status of the on-going sewer project within the city concerning whether the construction was complete and if homeowners were connecting to the sewer. WSA confirmed that the current phase of construction was complete and that some homeowners had applied for permits to connect to the sewer.
Changes were also made to reflect that animal waste does not necessarily have to be adjacent to streams. Additionally, the number of coyote sightings within the watershed is not critical to this TMDL.

RIDEM's Agriculture Department verified that animal wastes were not being used as fertilizer on the Morris Farm. The staff did verify that large numbers of geese have been observed at the farm throughout the year.

Stormwater Runoff

Any data from RIAC and/or RIDEM which supports that stormwater discharges from the airport are laden with pathogens? If yes, add outfalls in TMDL –Pathogens

RIDEM Response:

As noted above, a review of quarterly data reports submitted by RIAC show that there have been no exceedances of the pathogen criteria reported by T.F. Green Airport, to date.

Sanitary Waste

Ms. Komar requested that RIDEM verify with the Warwick Sewer Authority that potential pollution sources may be from leaky sanitary sewer systems and/or bypasses, and to verify the accuracy of the scheduling by the WSA of sewer construction in the watershed and the distinction between the mandatory sewer connection program and mandatory sewer tie-ins.

RIDEM Response:

Construction of new sewers within the watershed has recently been completed. Because of this, it is unlikely that there are any leaks or illegal connections to the sewer system, nor is it likely that infiltration of stormwater has occurred at any point within the system. Paragraphs three and four of Section 4.2 have been deleted to reflect this.

The WSA does have plans to construct sewers throughout the watershed, however, this construction is to be done in phases and a final construction date has not been set.

There is a mandatory connection program in place, and the priority is now in the Greenwich Bay Watershed, however, there is nothing in place to force homeowners to tie into the sewers once construction is completed. A request was made to the Warwick City Council that the WSA be allowed to charge a homeowner a Connect Capable Fee until such time that the home is connected to the sewer line, however, the council rejected the request. Without some enforcement path, the WSA cannot force mandatory tie-ins for homeowners.

Public Education/Public Involvement

The Buckeye Brook Coalition (BBC) has been actively involved in working with RIDEM during TMDL preparation; BBC and other local environmental groups have expressed and would like to establish working relationship with the City of Warwick Dept. of Public Works, since these groups are stakeholders in the community and contribute volunteer efforts in collecting water quality data through URI Watershed Water Volunteer Water Quality Monitoring Program. (A few years ago, the BBC asked the City of Warwick to fund the 4 existing URI Watershed Watch monitoring sites located with the Buckeye Brook watershed.) If not mandated by RIDEM, unfortunately, public involvement may be fulfilled by RIDEM required newspaper legal notice for the updated SWMPP and not more. What are RIDEM intentions for public involvement of stakeholders?

Suggest that RIDEM host City (Dept of Public Works and Warwick Sewer Authority), RIDOT and stakeholders meeting on regular basis (at least yearly) to present progress in implementation of TMDL-Pathogens, effectiveness of implementation strategies (in particular, based on water quality monitoring data), changes within the watershed which may affect the TMDL-Pathogens or have anticipated affect on future water quality data.

RIDEM Response:
Our public involvement in the watershed issues is through the development of the TMDL. Throughout the development, we did have contact with the Buckeye Brook Coalition through Steve Insana. The City of Warwick was also contacted through the city planners and the Department of Public Works. More formal public involvement was through the public meeting held on October 2, 2008 on the draft TMDL and continues through this response to comments. Due to staffing, RIDEM is not able to organize more meetings either with the public or watershed coalitions. However, RIDEM would be a willing participant if someone does schedule a meeting.

Future Monitoring
Ms. Komar had an issue with the following excerpt from the TMDL:
"This is a phased implementation TMDL. Results of water quality monitoring will allow RIDEM to track compliance with the water quality objectives as remedial actions are accomplished. URI Watershed Watch (URIWW) volunteers have historically conducted monitoring of the watershed. URIWW monitored four of the seventeen water quality stations within the watershed during the 2004-2006 period. RIDEM encourages URIWW to continue monitoring these stations and to add one additional station for Knowles Brook."
What water quality monitoring is RIDEM going to conduct? Is RIDEM funding the recommended additional URI Watershed Watch station for Knowles Brook? (If not, funding will need to be secured either from the City of Warwick, which currently funds the 4 existing stations, or other funding source.)

RIDEM Response:
RIDEM conducts baseline monitoring of the state's waters through the rotating basin monitoring approach. It is RIDEM's intent to monitor the Buckeye Brook watershed as part of this effort, with the first round of sampling slated to be conducted in FY 2010. As stated above, in the interim RIDEM encourages URIWW to continue monitoring their established stations and to add one additional station for Knowles Brook. It is uncertain at this point whether RIDEM can support any additional Watershed Watch monitoring stations.