FINAL DATA REPORT FOR THE AQUATIC LIFE USE STRESSOR STUDY FOR: BUCKEYE BROOK WATERSHED AND TRIBUTARIES TO WARWICK POND

FEBRUARY 2016

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

OFFICE OF WATER RESOURCES
235 PROMENADE STREET
PROVIDENCE, RHODE ISLAND 02908

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS AND TERMS

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.

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

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

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 (NPS). 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

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) requires States to assess water quality conditions of the state's waters and develop biennial reports describing the water quality conditions, identify and list impaired waters (those waters that do not meet water quality standards with existing required technology-based pollution controls alone) in the state's 303(d) list, and develop Total Maximum Daily Loads (TMDL's) for each listed waterbody and each cause of impairment. Buckeye Brook was first placed on the state's 303d List in 1998 as impaired for Fish and Wildlife Habitat (Aquatic Life Use). The purpose of this study was to: further characterize the biological condition impairment of Buckeye Brook (through macroinvertebrate and periphyton sampling); document water quality conditions; identify potential contributing pollution sources or stressors; and support development of a TMDL to address the fish and wildlife habitat impairment.

1.2 Study Area

The focus of the Aquatic Life Use Stressor Study was the portion of the watershed that includes the mainstem stream system for Buckeye Brook as well as the tributaries to Warwick Pond located in the northern part of the watershed. Prior to the 2014 303(d) listing, the Tributaries to Warwick Pond were included as part of the Buckeye Brook waterbody assessment unit ID. The new listings show a separate waterbody ID for the stream system north of Warwick Pond. As a result of RIDEM creating this separate waterbody ID for the upstream tributaries, the watershed for Buckeye Brook is redefined as the drainage area that extends from the exit of Warwick Pond to where the brook crosses under Tidewater Drive as it empties into Old Mill Creek. The field work for the data report covered approximately 55 percent of the full watershed for the areas surrounding T.F. Green Airport and Warwick Pond. Figure 1.1 shows the two areas of the watershed where the field work for this TMDL was conducted and Table 1.1 shows the waterbody IDs with their current water quality classifications in the 2014 303(d) listing.

1.3 Water Quality Impairments

Buckeye Brook was first placed on the state's 303d List in 1998 as impaired for Fish and Wildlife Habitat (Aquatic Life Use) based upon macroinvertebrate sampling conducted by RIDEM's contractor, Roger Williams University. Subsequent sampling conducted by ESS, Inc. as part of RIDEM's Wadeable Stream Biomonitoring and Habitat Assessment Program, confirmed Buckeye Brook's impairment (ESS, 2002). Samples were collected annually at a station located at Old Warwick Avenue in Warwick, Rhode Island 2002-2005.

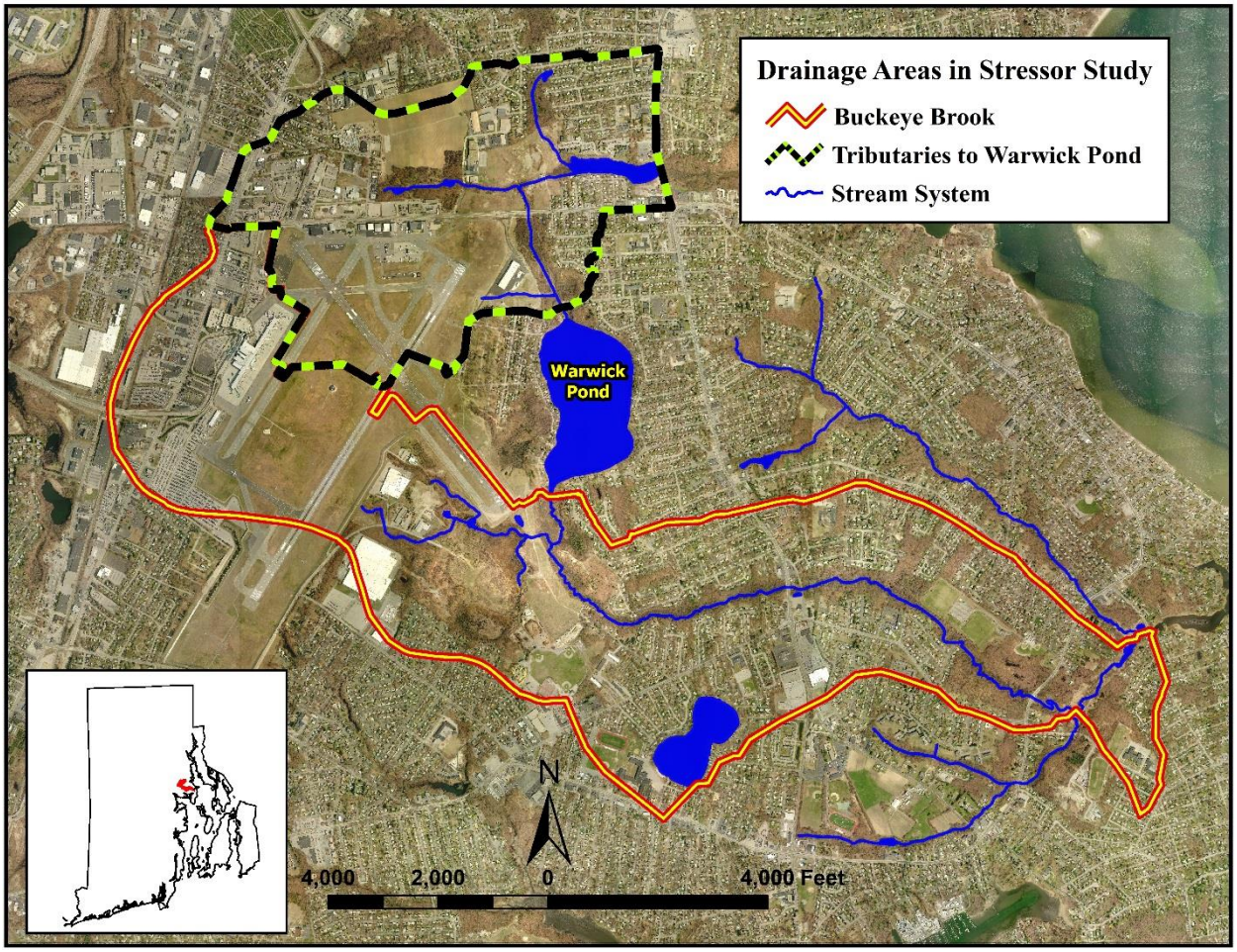

Figure 1.1 Watershed Drainage Areas

Buckeye Brook pathogen impairments were added to the state's 303d List in 2006. RIDEM completed a water quality investigation and TMDL addressing these pathogen impairments, which was approved by US EPA in December 2008. Also in 2008, DEM commenced the Aquatic Life Use Stressor Study of Buckeye Brook and Tributary to Warwick Pond. Results of this study led to the additional listing of metals and dissolved oxygen impairments on the 2014 303(d) List. Table 1.1 describes all water quality impairments for Buckeye Brook and Tributary to Warwick Pond identified on the 2014 303(d) List.

Table 1.1 2014 303(d) List -Water Quality Impairments

Waterbody ID Number	Waterbody Description	Water Quality Classification	Water Quality Impairment
R10007024R-01	Buckeye Brook, Warwick, RI	B	Benthic-Macroinvertebrate Bioassessments, Cadmium, Copper, Iron, Dissolved Oxygen, Pathogens (TMDL completed)
R10007024R-05	Tributaries to Warwick Pond	B	Benthic-Macroinvertebrate Bioassessments, Cadmium, Iron, Pathogens (TMDL completed)

1.4 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 regulations, which are specifically applicable to the impairments that caused Buckeye Brook and its tributaries to be listed on the State's 2012-303(d) list, are listed below.

1.4.1 Waterbody Class and Designated Use

Section 8.B of the Water Quality Regulations (RIDEM, 2006, Amended 2010) 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.

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

> *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.*

1.4.2 Numeric Water Quality Criteria

The water quality standards for toxics, including dissolved metals, set forth in Appendix B of the State of Rhode Island Department of Environmental Management Water Quality Regulations (DEM December 2009) state that "to protect aquatic life, the one-hour average concentration of a pollutant should not exceed the acute criteria more than once every three years on the average. The four-day average concentration of a pollutant should not exceed the chronic criteria more than once every three years on the average. These aquatic life criteria shall be achieved in all waters, except mixing zones, regardless of the waters' classification.

Hardness is a measure of the concentration of cations in solution (Minton 2002), with hardness usually measured as calcium carbonate ($CaCO_3$) equivalents in mg/l. An increase in hardness decreases the toxicity of metals, because calcium and magnesium cations compete with the metal ions for complexing sites, allowing fewer metal complexes to form and therefore resulting in a lower level of toxicity (Minton 2002).

The chronic and acute freshwater criteria of metals apply to the dissolved form and are calculated using water hardness (in mg/l as CaCO3) based on equations in Table 2-Appendix B of Rhode Island's Water Quality Regulations shown below in Table 1.2. The criterion for iron is not dependent upon the hardness of the water sample but is a single chronic value of 1000 µg/L for all conditions. Arsenic (As) is another metal that is independent of hardness. The acute freshwater aquatic life criterion is 340 µg/L and the chronic criterion is 150 µg/L.

Table 1.2 Applicable Freshwater Criteria Equations

Parameter	**ACUTE (µg/L)** $CF \times e^{(m_a[\ln Hardness] + b_a)}$			**CHRONIC (µg/L)** $CF \times e^{(m_c[\ln Hardness] + b_c)}$		
	CF =	m_a	b_a	CF =	m_c	b_c
Cadmium (Cd)	@	1.0166	-3.924	@	0.7409	-4.719
Copper (Cu)	0.96	0.9422	-1.700	0.96	0.8545	-1.702
Lead (Pb)	#	1.273	-1.46	#	1.273	-4.705
Zinc (Zn)	0.978	0.8473	0.884	0.986	0.8473	0.884

@ = Cadmium Conversion Factors: Acute CF= 1.136672 – [(ln H) x 0.041838]; Chronic CF= 1.101672 – [(ln H) x 0.041838]

= Lead Conversion Factors: Acute and Chronic CF= 1.46203 – [(ln H) x 0.145712]

One exceedance of the chronic criteria is acceptable given that the State's WQRs stipulate "the four-day average concentration of a pollutant should not exceed the chronic criteria more than once every three years on the average". However, more than one exceedance would constitute a violation of chronic criteria and would necessitate calculating a required reduction.

Similarly, one exceedance of the acute criteria is acceptable given that the State's WQRs stipulate "the one-hour average concentration of a pollutant should not exceed the acute criteria more than once every three years on the average". However, more than one exceedance would constitute a violation of acute criteria and would necessitate calculating a required reduction.

In some instances, a single exceedance of the criteria may be viewed as non-compliance with the standards if there is strong evidence that the criteria could be exceeded again within a three-year period. More specifically, one exceedance may be considered a violation of criteria where RIDEM has knowledge of an actual or potential upstream pollution source or where the exceedance occurred during a wet weather event, and it is considered likely that the condition would reoccur and the criteria would be exceeded again within a three year period.

The observed hardness values for the stream stations over the dry weather surveys varied more during the first survey than they did for the second. For the first survey, "main stem" stream stations ranged from 47 mg/L to 66 mg/L; whereas the landfill stream station had the highest value of 91 mg/L. The second dry weather survey had observed values for all stations that ranged from 40 mg/L to 45 mg/L. Wet weather values ranged from an observed low of 15 mg/L during Runs 2 and 3 of Wet Weather 1 at the airport outfall OF08 to a high of 98 mg/L observed during the Pre-storm run at the landfill stream station. The resulting range of numeric water quality concentration criteria for dissolved cadmium (Cd) and copper (Cu) are shown in Table 1.3, and the data tables and criteria evaluations are located in Appendix A.

Table 1.3 Range of Water Quality Criteria Utilized for the Buckeye Brook TMDL

Hardness as $CaCO_3$ (mg/L)	Cadmium (µg/L)		Copper (µg/L)	
	Acute Criteria	Chronic Criteria	Acute Criteria	Chronic Criteria
15.00	0.31	0.07	2.25	1.78
30.00	0.62	0.11	4.32	3.20
60.00	1.23	0.18	8.31	5.79
90.00	1.82	0.24	12.2	8.19
120.0	2.40	0.29	15.9	10.5
150.0	2.99	0.34	19.7	12.7

The criterion for iron is not dependent upon the hardness of the water sample but is a single chronic value of 1000 µg/L for all conditions. The target criteria concentrations for copper and cadmium were calculated using the observed hardness values of the field samples. RIDEM evaluated hardness value distributions during both dry and wet weather conditions, as follows:

Dry weather acute and chronic criteria were calculated for all sampling stations using the dissolved metals data and the associated hardness values for each survey date to determine the applicable criteria. The resultant criteria were compared against the observed dissolved metal collected at each sample location for each survey date to determine if an exceedance occurred.

The criteria for the wet weather surveys were calculated as follows:

1. Acute criteria: For both wet weather surveys, the observed hardness values associated with each station and for each sampling run, including the pre-storm sample, were used to determine the criteria using the equations in Table 1.2. The resulting criteria were then compared against the observed dissolved metal at each station to determine the required reduction.
2. Chronic criteria:

    a. Wet Weather 1 averaged the hardness values for all runs from each station and this average value was then used to calculate the chronic criteria for that event. The calculated criteria were compared against each observed value for that station to determine the required reduction.

b. Wet Weather 2 was conducted over an 8 day period from February 1st to February 8th, 2011. The temporal spacing of the samples did not allow for the averaging of four samples for each station to calculate the criteria. Instead, the hardness values were averaged for the Pre-storm and Run 1 samples, the Run 1 and Run 2 samples, and the Run 2 and Run 3 samples. This resulted in three hardness values for each station for the storm and these values were used to determine the criteria for each pair of samples collected. Similarly, the observed dissolved metals values were averaged together, Pre-storm + Run 1, Run 1+Run 2, and Run 2+ Run 3. The calculated criteria were compared to the averaged observed metals values to determine the required reduction.

2.0 DESCRIPTION OF THE STUDY AREA

2.1 Watershed Stream Systems

There are two primary stream systems in this study: Tributaries to Warwick Pond and Buckeye Brook, a third order stream system that originates at the outlet of Warwick Pond in Warwick, Rhode Island. Buckeye Brook flows in a southeast direction from the southernmost point of Warwick Pond into Old Mill Creek, which is south of Conimicut Point, and ultimately Narragansett Bay. Buckeye Brook Watershed has three tributaries, Lockwood, Warner and Knowles (Parsonage) Brooks, with the exception of Warner Brook, none were included in the biodiversity field study. A station on Warner Brook was established to document water quality conditions in a highly urbanized sub-watershed not influenced by either TF Green Airport or the landfill.

The Tributaries to Warwick Pond are made up of a small stream system north of the airport that empties into Spring Green Pond and the outlet of the pond joins another first order stream that drains an agricultural area located north of Airport Road. Table 1.1 listed the applicable waterbodies in this study and Figure 1.1 showed the hydrologic boundaries of the stream systems.

The two watersheds are highly urbanized and encompass the majority of the area that is the site of Rhode Island's primary airport, T.F. Green. The tributaries north of Warwick Pond have a drainage area of 1.14 mi^2 and the Buckeye Brook watershed drainage area is 2.55 mi^2.

The highly urbanized study area watershed is 3.69 mi^2 and is the site of Rhode Island's primary airport, T.F. Green. The current land use (RIGIS2011) is 78.2% urban, 16.1% mixed forest, 3.4% wetland and water, and 2.3% agricultural. The percentage of impervious area within the watersheds totals 42.1%. Figure 2.1 shows a map of the land use for the Tributaries to Warwick Pond and for Buckeye Brook. Table 2.1 shows the drainage areas and percentages for the specific land use categories for both watersheds.

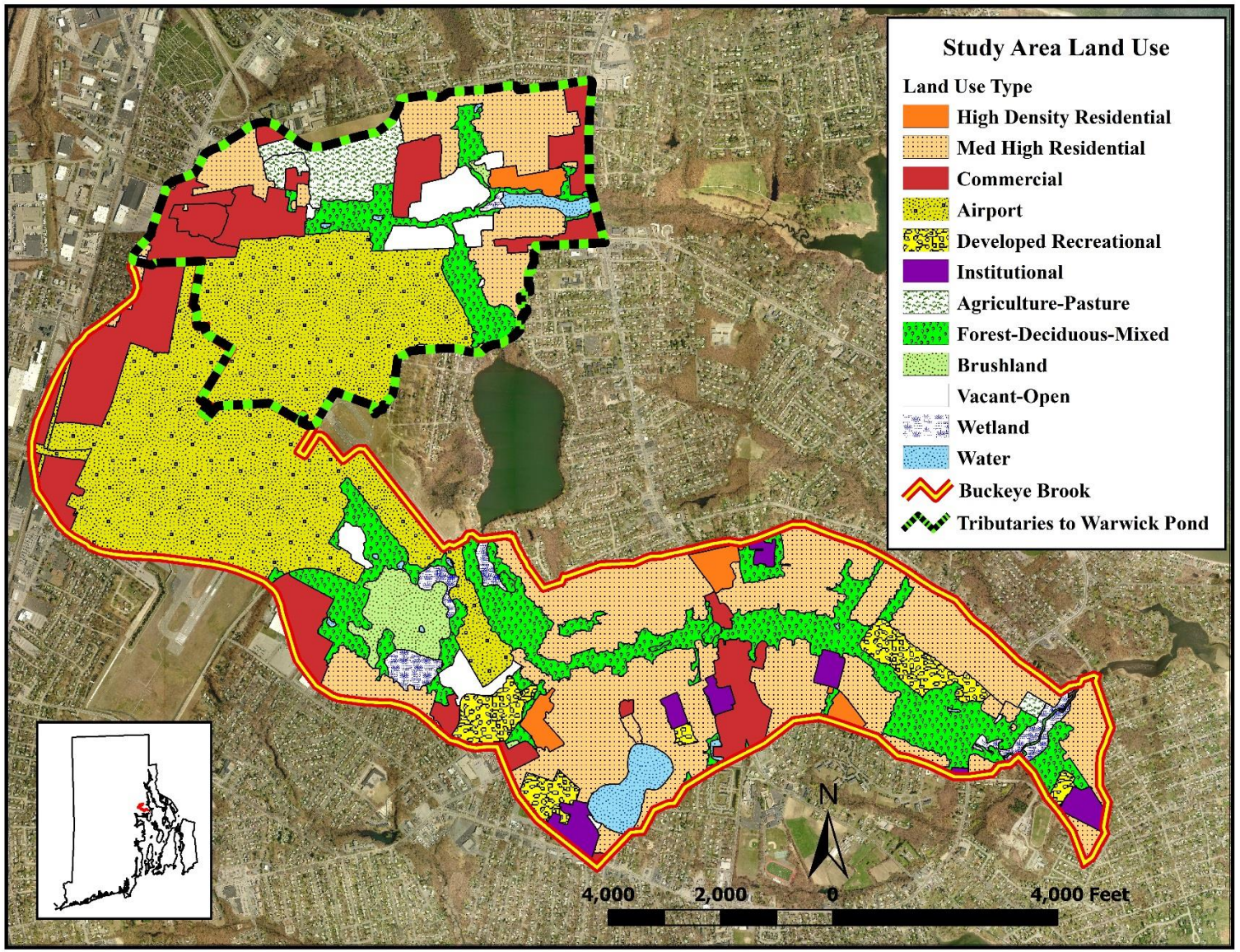

Figure 2.1 Land Use for Aquatic Life Stressor Study

Table 2.1 Study Site Land Use, Drainage Area (Acres) and Impervious Cover Percentages

Land Use Type	Tributaries to Warwick Pond			Buckeye Brook				
	BB00	BB02	Sub-Total	BB04	BB05	BB06	BB07-08	Sub-Total
Residential	27.6	122.5	150.1	54.26	146.52	228.25	105.77	534.8
Commercial	28.5	32.1	60.5	80.8	10.0	63.3	10.2	164.3
Industrial	44.5	19.4	63.9	34.1				34.1
Airport/Transportation	23.6	252.0	275.6	422.0	4.7	0.3		427.0
Developed Recreational	0.4		0.4	24.7		40.1	10.6	75.4
Pasture and Cropland	51.3	0.1	51.4					
Mixed Forest	22.7	49.2	71.9	103.1	35.0	60.7	64.8	263.7
Brushland		1.6	1.6	43.4				43.4
Vacant/Urban Open	1.2	39.9	41.1	18.3		0.5	3.2	22.0
Wetland		1.6	1.6	22.5			13.6	36.1
Water	0.6	9.2	9.8	1.4		29.3	0.2	30.9
Impervious Cover Percentages for Study Areas								
Total Station Drainage Area	200.4	527.5	727.9	804.7	196.2	422.4	208.4	1631.7
Impervious Cover	100.6	227.0	327.6	351.7	86.3	172.9	55.6	666.5
Percentage Impervious Cover	50.2%	43.0%	45.0%	43.7%	44.0%	40.9%	26.7%	40.8%

2.2 Water Quality History

RIDEM‘s Baseline Monitoring Program has a biological sampling station on the main stem of Buckeye Brook at the Old Warwick Road crossing. The ESS Group had conducted several biological surveys at this site starting in 2003 (ESS, 2004, ESS, 2005), with the last one occurring in 2008. Because the monitoring at this locale is strictly biological, only field water quality measurements are collected that included dissolved oxygen, temperature and specific conductivity. Chemistry and pathogen sampling was not conducted for these surveys. This location has been rated as moderately impaired for fish and wildlife habitat.

University of Rhode Island’s Watershed Watch has performed volunteer monitoring on the brook and its tributaries from 2008 through 2012, collecting grab samples twice a month from April through October. Two main stem stations were monitored by the volunteers in Warwick, RI. One was located at the end of Novelty Road, and the other was at the entrance to Old Mill Creek at Tidewater Drive. Constituents sampled included enterococci, chloride, pH, dissolved nitrogen-nitrate, dissolved nitrogen-ammonia, dissolved ortho-phosphate, total nitrogen, and total phosphorus.

Watershed Watch added a winter sampling event in 2012 – 2013. Dissolved oxygen and temperature was measured at six locations within the watershed. The sampling period was once a month from July 2012 to January 2013, with four chlorophyll *a* samples collected from August

to November. Four stations were on the mainstem of Buckeye Brook and two were on Spring Green Pond and Warwick Pond. The four main stem stations for Buckeye Brook were located at Lakeshore Drive, Warwick Avenue, Novelty Road, and Tidewater Drive. A second winter sampling effort is scheduled to commence in November 2013 at the same six stations. The constituents being sampled include propylene glycol, total dissolved solids, dissolved oxygen and temperature.

The watershed is dominated by the presence of Rhode Island's major airport, T. F. Green. During the winter months, aircraft de-icing and anti-icing operations are conducted, with the excess glycol runoff flowing into Buckeye Brook at two primary locations. One site discharges to the brook entering Warwick Pond, and the other site, which is the largest contributor, discharges to Buckeye Brook downstream of the outflow from Warwick Pond. The presence of compounds used in anti-icing and de-icing operations (propylene glycol) was detected in the brook downstream of Warwick Pond during winter surveys conducted on behalf of the Rhode Island Airport Corporation (RIAC) in the winter of 2000-2001.

A new RIPDES Stormwater permit went into effect for T.F. Green Airport on September 1, 2012 that requires RIAC to develop and implement BMPs to promote source reduction and pollution prevention that will be protective of water quality standards and criteria in receiving waters to include dissolved oxygen, aquatic toxicity, foaming, nuisance odors and nuisance bacteria growth. A long term deicing management system will be constructed and sized to collect greater than 99% of all flows above the glycol diversion concentrations of 2,950 mg/L for the terminal area and 1,000 mg/L for the cargo area. Glycol will be collected in two enclosed storage tanks and will be treated on-site and later discharged to the Warwick Sewer Authority sanitary sewer system. Glycol impacted snow will be collected and snow-melt will be diverted to storage at concentrations above 2,950 mg/L for the terminal area and 1,000 mg/L at the cargo pad. These snow piles will be melted with a snow melter and discharged to the collection system, and on-site monitoring of the major outfalls that discharge to Buckeye Brook will be monitored quarterly. Major components of the improved Deicer Management System in include the following:

- Terminal pump station
- Terminal online monitoring system
- Force main from terminal pump station to storage tanks
- Cargo pump station
- Cargo online monitoring system
- Force main from cargo pump station to storage tanks
- Portable snow melter
- Two above ground storage tanks
- Biological treatment system
- Force main from treatment to san

The permit also requires the airport to conduct instream water quality monitoring at four locations on the main stem of Buckeye Brook in order to evaluate storm water impacts to the

brook. The monitoring is to be conducted during a frozen precipitation event (i.e. snow, sleet, freezing rain) during the deicing season (October 1 – March 31) at the T.F. Green Airport while aircraft deicing is occurring and must be coordinated with storm water outfall sampling. The permit is posted on the RIDEM website at;
http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/pdfs/tfgreenfinal.pdf

Additionally, the Truk-Away Landfill, located to the west of Buckeye Brook, had a site inspection performed in 1993 by CDM Federal Programs Corporation (CDM, 1993), and several monitoring wells on the landfill property were sampled by Lincoln Environmental for RIDEM in December 2004 (Lincoln Environmental, 2005). Table 2.2 lists the work that was done in the Buckeye Brook watershed in the past.

Table 2.2 Historic Monitoring Conducted in Buckeye Brook Watershed

Primary Organization	Sample Location	Period	Analyte
U.S. Environmental Protection Agency (USEPA)	Main area of Truk-Away Landfill	1993	Soil and Leachates
RI Department of Environmental Management (RIDEM)	Buckeye Brook at Old Warwick Ave Bridge crossing	2002-2005	Biological Assessment
RI Department of Environmental Management (RIDEM)	Truk-Away Landfill groundwater from monitoring wells	2005	VOCs
RI Department of Environmental Management (RIDEM)	Buckeye Brook, Lockwood Brook, and Warner Brook, Knowles Brook, Old Mill Creek, Tributaries to Warwick Pond	2006	Field measurements (Dissolved Oxygen, Temperature, Specific Conductivity), Fecal Coliform, Enterococci
Watershed Watch, URI	Buckeye Brook, Lockwood Brook, and Warner Brook	2004 - 2012	Fecal Coliform, Enterococci, Dissolved Nitrates, Dissolved Ammonia, Dissolved Ortho-phosphate, Total Nitrogen, Total Phosphorus, pH, Chlorides

3.0 RIDEM AQUATIC LIFE USE STRESSOR STUDY

The state's 2012 Integrated Water Quality Monitoring and Assessment Report 305(b) and 303(d) list identified Buckeye Brook (at that time, inclusive of northern tributaries to Warwick Pond) as non-supporting for fish and wildlife habitat. The cause of the impairment is attributed to the poor comparability of bioassessment metrics evaluating these brooks' benthic-macroinvertebrate community and habitat to a reference site. The Rhode Island Department of Environmental Management conducted a sampling project to characterize the geographic extent and severity of the Buckeye Brook Aquatic Life Use (AQLU) impairment and to identify potential causes and/or pollution sources contributing to the impairment. Water quality and/or benthic biological samples were collected from nine sites in the Buckeye Brook watershed over the course of four surveys from July 2008 through February 2009 that consisted of two dry weather and two wet weather surveys, one of which was during a winter icing event.

3.1 Methodology

3.1.1 Stations

Eight stations were selected in the two watersheds for the surveys. Three stations were located on airport property, two on tributaries to Warwick Pond and three on the Buckeye Brook stream system. A ninth station for Adamsville Brook in Adamsville, RI was used as a biological reference site by the ESS Group, Inc. Table 3.1 lists the stations as well as their location, description, type of sampling conducted, and the reasoning or purpose of the selection. Figure 3.1 shows the location of the sampling stations within the watershed, and Figure 3.2 is a more detailed view of the stations sampled within T.F. Green Airport property.

3.1.2 Parameters

Samples were collected four times for water quality (WQ), with biological and toxicity sampling conducted during the second dry weather survey. The water quality samples were analyzed for dissolved trace metals that included Arsenic (As), Copper (Cu), Cadmium (Cd), Manganese (Mn), Lead (Pb) and Zinc (Zn) as well as Total Iron (Fe). Other constituents included Hardness as $CaCO_3$, five-day Biological Oxygen Demand (BOD_5), Chloride (Cl), Ammonia-Nitrogen (NH_3-N), Nitrate+Nitrite-Nitrogen (NO_2+NO_3-N), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), Total Suspended Solids (TSS), Total Organic Carbon (TOC), pH, and Propylene Glycol. All water quality and toxicity samples were collected by RIDEM staff.

The water quality analyses, with some exceptions were conducted at the RI State Health Laboratories in Providence, RI. ESS Laboratories in Cranston, RI conducted the NH3-N, TKN, TOC and Propylene Glycol analysis. Field measurements consisting of dissolved oxygen (D.O.), temperature in degrees centigrade (° C), and specific conductance in microsiemens per centimeter (µS/cm) were measured by RIDEM staff the field using an YSI-85 meter. Field data was collected during all sampling events. All constituents listed were analyzed for all surveys with the exception of TOC, which was only analyzed for the second dry weather survey when

biological sampling was conducted, and Propylene Glycol, which was analyzed for the wet surveys only. The toxicity samples collected by RIDEM staff were delivered to the EPA Region 1 Laboratory at Chelmsford, MA where the toxicity testing was conducted by the laboratory staff. A Two Species – 7 Day Chronic Toxicity Test was done for *Ceriodaphnia dubia* (daphnid) and the *Pimephales promelas* (fathead minnow). Toxicity sampling was conducted during the first dry weather and winter wet weather surveys. Toxicity sampling runs were conducted every other day to collect water to replenish the specimen tank. The Quality Assurance Project Plan (QAPP) is available on the RIDEM website at; http://www.dem.ri.gov/pubs/qapp/buckbio.pdf

Table 3.1 Biodiversity Sampling Station Locations and Description

Station ID	Location	Description	Type	Purpose
BB00	Unidentified tribs to Warwick Pond above Airport Road	In-stream: Upstream of Airport Road culvert	Water Quality, Biological, CPOM, FPOM, TOC	Background sample of stream away from airport and landfill influence
BB02	Tribs to Warwick Pond @ Lakeshore Drive	In-Stream, Downstream of culverts under Lakeshore Dr.	Water Quality, Toxicity, Biological, CPOM, FPOM, TOC	Brackets airport Outfalls 002 and 003 with background site BB00
BB03	Buckeye Brook @ Lakeshore Drive	In-stream, Exit of Warwick Pond	Water Quality, Toxicity	Separates Warwick Pond from confluence of airport Outfalls 008 and 009 with Buckeye Bk
BB04	Buckeye Brook @ Rufus Road	In-stream: Downstream of confluence of Buckeye Brook and airport outfall flows	Water Quality, Toxicity, Biological, CPOM, FPOM, TOC	Samples the brook after the confluence of all airport outfalls and the landfill
BB05A	Buckeye Brook downstream of Old Warwick Avenue	In-stream and approximately 1000 ft downstream of the ESS Biological Monitoring Site	Water Quality, Toxicity, Biological, CPOM, FPOM, TOC	To compare the 2008-09 monitoring results to the ESS biomonitoring at BB05 located at Old Warwick Avenue
OF08	Stream from the airport Outfall 008	In-stream, prior to confluence with landfill stream	Water Quality, Habitat Assessment, Toxicity	Isolates Outfall 008 flows from landfill influence
TA01	Stream from Truk-Away Landfill	In-stream, prior to confluence with stream from Outfall 008	Water Quality, Habitat Assessment, Toxicity	Isolates landfill stream from outfall stream coming from airport
AP01	Combined flow of streams OF08 and TA01	In-stream, prior to discharge into Buckeye Brook upstream of airport service road.	Biological, CPOM, FPOM, TOC	Evaluates biological community in stream downstream of landfill and airport
Adamsville Brook	@ USGS Gage off of Route 81, Little Compton, RI	In-stream sampling	Macroinvertebrate	Biological Reference Site

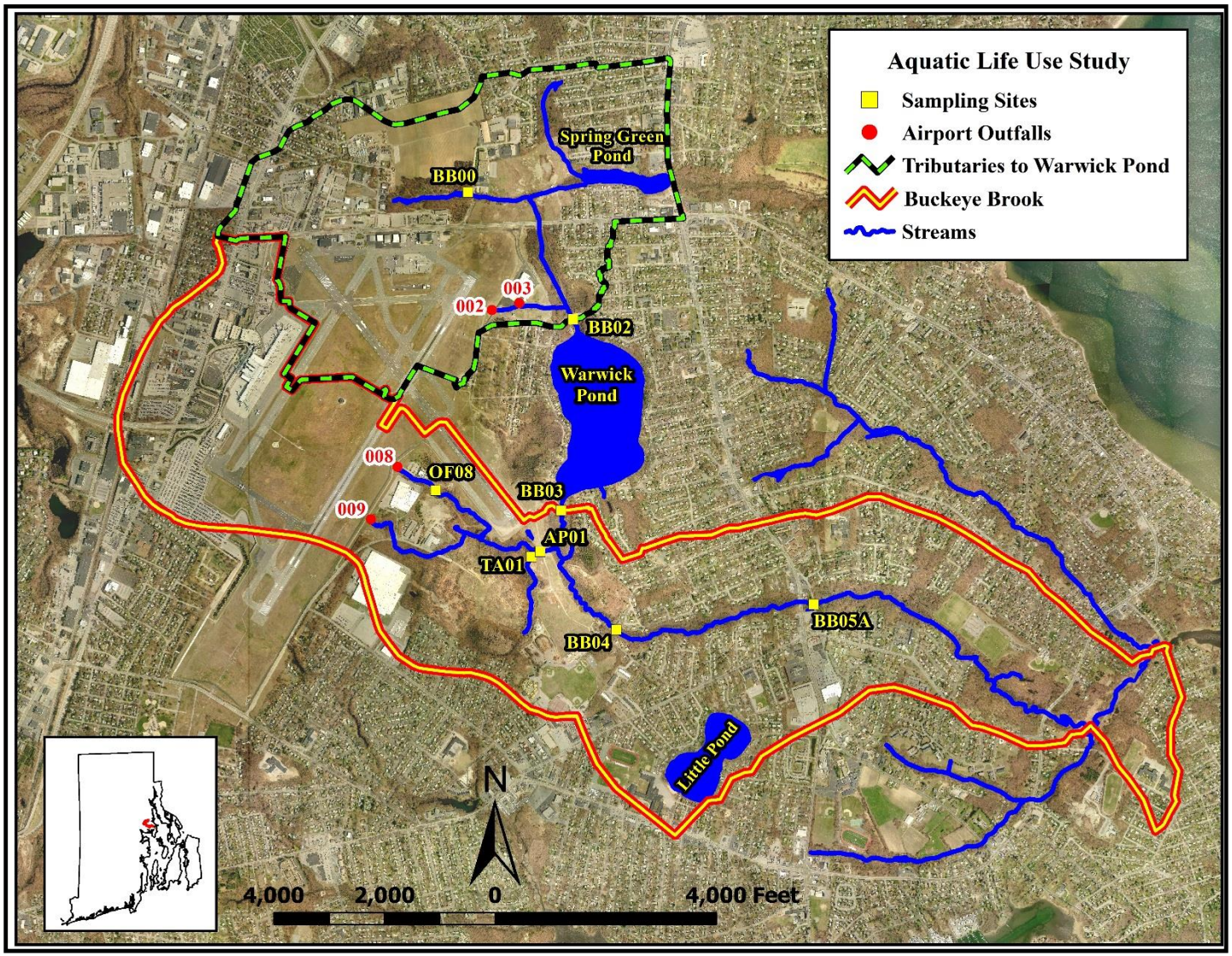

Figure 3.1 Sampling Sites for Aquatic Life Use Stressor Study

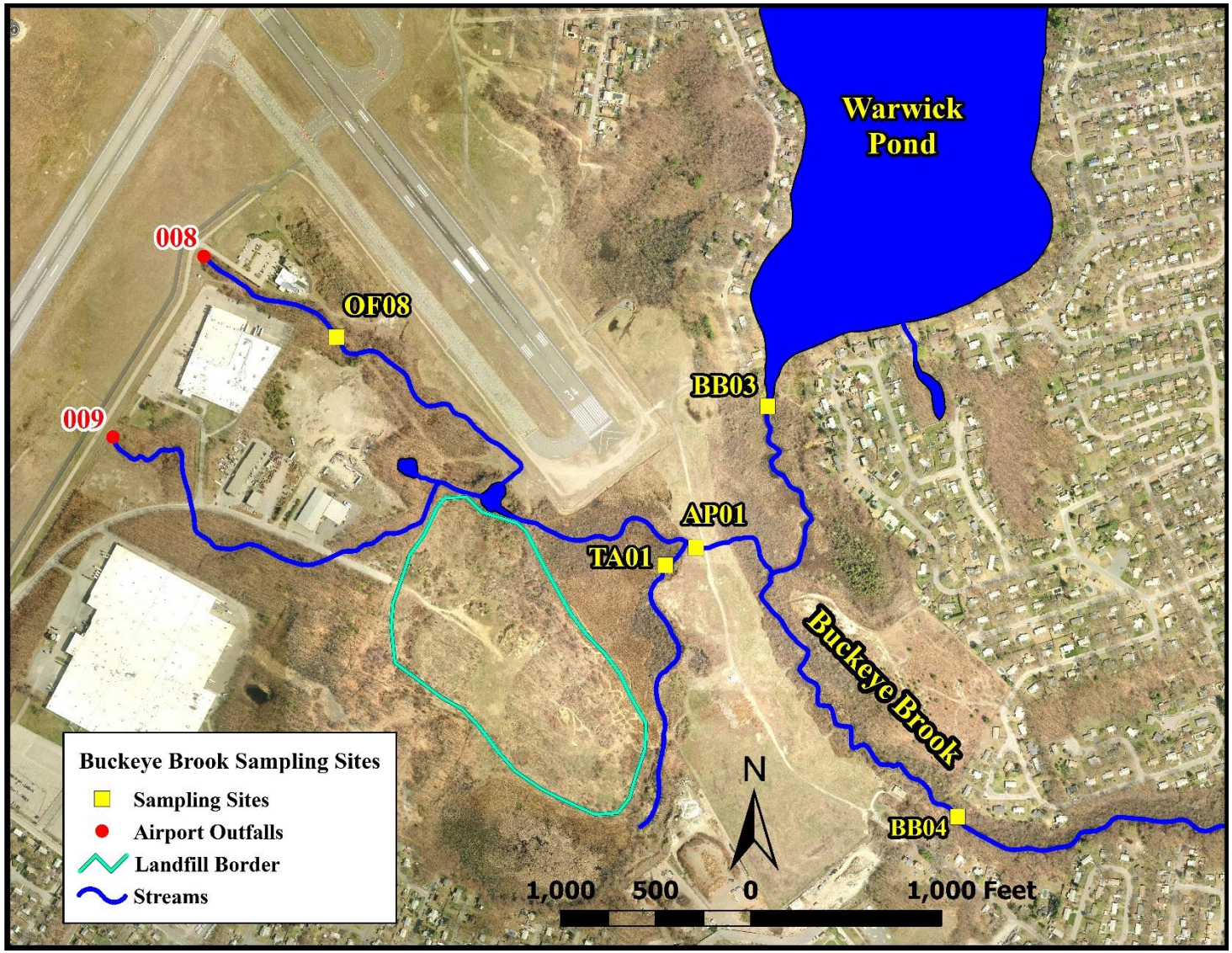

Figure 3.2 Sampling Sites within T.F. Green Airport Boundaries

Biological sampling was done by ESS Group, Inc. and accompanied by RIDEM staff at selected stations. The biological survey included a combination of any or all of the following: Macroinvertebrate sampling, Periphyton sampling, Stream Habitat Assessments, CPOM (coarse particulate organic matter >1mm), and FPOM (fine particulate organic matter, less than 1mm and more than .05 mm).

3.2 Dry Weather Surveys

The first dry weather survey was on July 16, 2008 where single grab samples were collected at eight stations for water quality analysis. Station AP01 was not sampled for the first dry weather survey since it was located downstream of Stations OF08 and TA01, and represented the total of these latter two stations. This survey was the first toxicity sampling event for the watershed and water samples were collected and transported to EPA Region 1 Laboratory at Chelmsford, MA for toxicity tests. The first set of toxicity samples were collected along with the water chemistry samples on July 16th, and additional toxicity water samples only were collected on July 18th and July 20th that were used to replenish the water for the 2-species toxicity test. Table 3.2 shows the dates of the biodiversity dry weather surveys and the type of sampling that took place during those events.

ESS Group, Inc. accompanied RIDEM personnel for the second dry weather survey on September 10, 2008 and collected biodiversity samples for selected stations as noted in Table 3.2. During the second dry survey, grab samples were collected for water quality chemical analysis from all stations except BB03. This station was not a viable candidate for biodiversity sampling and following the recommendation by ESS Group, it was decided to skip this station for the second dry survey.

Table 3.2 Dry Weather Biodiversity Sampling Dates and Sample Type

Station	BB00	BB02	BB03	BB04	BB05A	OF08	TA01	AP01
DW01 July 16-20, 2008	Chem	Chem, Tox	Chem, Tox	Chem, Tox	Chem, Tox	Chem, Tox	Chem, Tox	NS
DW02 September 10, 2008	Chem, Bio	Chem, Bio	NS	Chem, Bio	Chem, Bio	Bio	Bio	Chem, Bio

Notes: Chem – Water Quality Chemistry samples; Tox – Toxicity samples; Bio – Biodiversity samples; NS – Not Sampled

Section 3.1.2 identified the specific testing and analysis that was conducted for all sample types during all the surveys for Buckeye Brook as well as the laboratories that did the analysis.

3.3 Wet Weather Surveys

Two wet weather studies were conducted, the first from December 9-11, 2008 and a second from February 1-8, 2011. The first wet survey in December 2008 was during a rainfall event with an average high temperature of 53°F and a total precipitation of 2.27 inches recorded at T.F. Green Airport. The survey consisted of three runs, a pre-storm on December 9th to check baseline conditions in the brook, and two more survey runs on consecutive days. A fourth run was planned on December 12th, however, between the end of the December 11th run until the planned start of the last run, 3.56 inches of rainfall was recorded at T.F. Green Airport, and it was decided to terminate the survey at three sampling runs. During this event, the samples were analyzed for water chemistry only. A total of eight stations were sampled during the first wet weather event. AP01 was not sampled as it was downstream of TA01 and OF08, and represented the total of the two upstream stations. Table 3.3 shows the dates of the wet weather surveys and the type of sampling conducted.

The second wet weather survey was a winter survey in February 1-8, 2011. The purpose of this survey was to collect water quality and toxicity samples during a winter storm when de-icing and anti-icing solutions were being applied to departing aircraft at T.F. Green Airport. The winter survey proved to be a difficult storm to capture due to the constraints imposed by the EPA laboratory for sample drop-off times and dates when the lab would be available to provide the toxicity analysis. Additionally, the unpredictability of the weather patterns to provide a discrete storm that provided a worst-case scenario to collect runoff from deicing operations was also a challenge. For these reasons, the second wet weather survey was not completed until February of 2011. During this survey, approximately 6 inches of snowfall was recorded at the airport and the average temperature ranged from 20° to 38°F. The survey consisted of four runs, a prestorm on February 1st, Run 1 at the start of the storm (2/3/11), Run 2 (2/6/11) and a final Run 3 (2/8/11).

Table 3.3 Wet Weather Biodiversity Sampling Stations Dates and Sample Type

Station	BB00	BB02	BB03	BB04	BB05A	OF08	TA01	AP01
WW01 December 9-11, 2008	**Chem**	**Chem**	**Chem**	**Chem**	**Chem**	**Chem**	**Chem**	**NS**
WW02 February 1-8, 2011	**Chem, Tox**	**Chem, Tox**	**Chem, Tox**	**Chem, Tox**	**Chem**	**Chem, Tox**	**Chem, Tox**	**NS**

Notes: Chem – Water Quality Chemistry samples; Tox – Toxicity samples; NS – Not Sampled

Two stations sampled during the first toxicity survey were swapped for the winter survey at the suggestion of the EPA laboratory staff. Station BB05A was not sampled for toxicity and Station BB00 was added. As show in Figure 3.1, BB05A was located downstream of Station BB04, and any suspected pollutants being discharged from the airport stations would be in the sample collected at BB04. Station BB00 also provided another station that would not have been directly

influenced by airport de-icing operations or by runoff from the landfill. Its location north of Warwick Pond in a wetland area served as neutral background sampling location for the toxicity analysis being conducted by the EPA laboratory in Chelmsford, MA.

3.4 Rhode Island Airport Corporation (RIAC)

RIAC had an annual monitoring requirement (RIPDES Permit RI0021598) to capture a wet weather storm during a frozen precipitation event (i.e. snow, sleet, freezing rain) during the annual deicing season (October 1 – March 31) at the T.F. Green Airport while aircraft deicing was occurring. Locations to be sampled included the stormwater outfalls that discharged to the Buckeye Brook stream system both above and below Warwick Pond. These included airport outfalls 002, 003 and 008 (RIDEM Station OF08). Receiving water sample sites included the northern Tributaries to Warwick Pond at the pond's inlet (BB02), the exit of Warwick Pond (BB03), Buckeye Brook at West Shore Road (BB07) and Buckeye Brook at Tidewater Drive (BB08). Flows from airport outfalls 002 and 003 entered the tributary stream approximately 200 feet above Warwick Pond inlet, while the flow from airport outfall 008 (OF08) entered Buckeye Brook approximately 0.25 miles downstream of the exit of Warwick Pond (BB03). The next two sampling stations are located 1.8 miles (BB07) and 2.4 miles (BB08) downstream from the confluence of Buckeye Brook and OF08.

Constituents sampled at the airport outfalls by RIAC that were common to the biodiversity study included Arsenic, Copper, Iron, Manganese, Zinc, BOD_5, TOC, TSS, and propylene glycol. The receiving waters were sampled for BOD_5, TSS, chloride, and propylene glycol. The sampling frequency for the airport outfalls (002, 003, and 008) was every hour for the first 12 hours of the storm, while the RIAC Buckeye Brook sites were sampled every four hours for a period of 48 hours. The RIAC sampling for the airport and stream stations commenced on February 1st at 1000 and continued until 1054 on February 3, 2011. Although the data from the 2011 RIAC sampling event is not used in the analysis for the TMDL, it is presented alongside the RIDEM data as a comparison.

3.5 Quality Assurance

All water samples for laboratory analysis were collected in pre-cleaned containers supplied by the RI Department of Health Laboratory in Providence, RI and preserved as specified in the sampling plan (RIDEM 2008), and transported to the laboratory on the day of collection. Toxicity sample containers were supplied by the EPA Lab in Chelmsford, MA and the water collected transported to the laboratory by the RIDEM sampling crew on the day of collection.

Field sampling and measurement protocols followed those specified in the QAPP sampling plan (RIDEM, 2008) for *in-situ* temperature, dissolved oxygen, and specific conductance. All meters were calibrated and post-calibrated per manufacturer's instructions.

Replicate samples were collected to assess total field and laboratory variation. Replicate and blank samples were introduced in the field and submitted with the routine batches of samples to the laboratory. Field duplicates and trip blanks were labeled as "Dup1DW01 or TB DW01". This was done to insure that the laboratories did not know what station was selected for the duplicate sample. Field notes were used to confirm the location where the duplicate sample was taken. Table 3.4 summarizes the parameters, methods, accuracy, precision, bias, and reporting limits for sample measurements.

3.5.1 Evaluation of Data Quality

Data collected during this study were evaluated to determine whether data quality assurance/quality control (QA/QC) objectives for the project were met. Data were evaluated according to the measurement performance criteria described in Section 18 and 19 of the approved QA plan.

Analytical Laboratory Precision

Analytical laboratory precision was determined by calculating the relative percent difference (RPD) between the initial laboratory result and the laboratory duplicate. The criterion used to assess measurement performance for precision for each parameter is given in Table 3.4 and Laboratory precision results are provided in Tables 3.5 and 3.6.

With the exception of samples described below, all samples were delivered to the Rhode Island Department of Health Laboratory (RIDOH) located in Providence, RI. Ammonia, Total Kjeldahl Nitrogen, Total Organic Carbon, and Propylene Glycol samples were taken for analysis to the ESS Laboratory, located in Cranston, RI. Water collected for toxicity testing was delivered to the EPA Region 1 Laboratory in Chelmsford, MA.

The temperature of the coolers delivered to the RIDOH for all surveys ranged from 3.5 to 4.6 degrees Celsius. The sampling plan required a cooler temperature not to exceed 4 degrees Celsius, however since the maximum temperature of the coolers only exceeded this by a maximum of 0.6 degrees it was considered acceptable. Holding times for all parameters were met during all surveys.

Field Accuracy

Field accuracy was determined by calculating the relative percent difference (RPD) between the original field sample and the field duplicate. The criterion used to assess measurement performance for field accuracy for each parameter is given in Table 3.4. The QAPP specified that field duplicates were to be analyzed for 10% of samples (or at least once per batch). Table 3.7 shows the parameters and whether the field accuracy results for the duplicate stations were acceptable or not acceptable. Those parameters that did not meet the performance criteria were not used for analysis.

Table 3.4 Accuracy, Precision, Bias, and Reporting Limits for Sample Measurements.

Analysis	Method	Accuracy	Precision	Bias Contamination	Achievable Limits
Field					
Water Temperature	YSI-85	± 0.2°C	N/A	N/A	N/A
Dissolved Oxygen	YSI-85	N/A	N/A	5	1 mg/L
Specific Conductivity	YSI-85	N/A	N/A	5	1 µmhos/cm
Laboratory					
Ammonia Nitrogen (NH_3-N)*	EPA 350.1	< 30% RPD	< 20% RPD	< 0.10 mg/L	0.10 mg/L
Nitrate Nitrogen (NO_3-NO_2-N)*	EPA 353.2	< 30% RPD	< 20% RPD	< 0.05 mg/L	0.05 mg/L
Total Kjeldahl Nitrogen (TKN)*	EPA 351.2	< 30% RPD	< 20% RPD	< 0.20 mg/L	0.20 mg/L
Total Phosphorus (TP)	SM4500-P-E	< 30% RPD	< 20% RPD	< 0.02 mg/L	0.02 mg/L
Chloride (Cl)	EPA 300	< 30% RPD	< 20% RPD	< 0.20 mg/L	0.20 mg/L
Hardness (as $CaCO_3$)	SM3500-D	< 30% RPD	< 20% RPD	< 1.0 mg/L	1.0 mg/L
Total Organic Carbon (TOC)*	EPA 9060 Mod	< 30% RPD	< 20% RPD	< 30 mg/Kg	30 mg/Kg
5-Day Biological Oxygen Demand (BOD_5)	SM5210B	< 30% RPD	< 20% RPD	< 1.0 mg/L	1.0 mg/L
pH	EPA 150.1	< 30% RPD	< 20% RPD	<0.10 pH Unit	0.10 pH Unit
Total Suspended Solids (TSS)	SM2540D	< 30% RPD	< 20% RPD	< 0.10 mg/L	1.0 mg/L
Propylene Glycol	Modified ASTM E202	< 30% RPD	< 30% RPD	<10 mg/L	20 mg/L
Dissolved Zinc (Zn)	EPA 200.8	<30% RPD	< 20% RPD	<20.0 µg/L	**
Dissolved Metals (As, Cd, Cu, Mn, Pb)	EPA 200.8	< 30% RPD	< 20% RPD	< 1.0 µg/L	**
Total Iron (Fe)	EPA 200.8	< 30% RPD	< 20% RPD	< 10.0 µg/L	**

* Analysis by ESS Laboratory; ** Reporting Limits (µg/L) are: As (0.15), Cd (0.06), Cu (0.30), Fe (10), Mn (1.8), Pb (0.07), Zn (6.46)

Table 3.5 Laboratory precision results for Ammonia-Nitrogen.

Station	Date	Original Result (mg/l)	Lab Dup (mg/l)	Mean	Difference	RPD (%)	Acceptable Y or N
Trip Blank	7/16/08	ND	ND	ND	0	0	Y
DW2 Dup	9/10/09	0.20	0.19	0.195	0.01	5	Y
BB03	12/9/08	0.29	0.27	0.28	0.02	7	Y
BB00	12/10/08	0.15	0.18	0.165	0.03	18	Y
*	12/11/08						
BB00	2/1/11	0.28	0.30	0.29	0.02	7	Y
TA01	2/3/11	1.14	1.22	1.18	0.08	7	Y
Trip Blank	2/8/11	ND	ND	ND	0	0	Y

*If cells are blank then no duplicate was analyzed for that parameter for that date.

Table 3.6 Laboratory precision results for Total Kjeldahl Nitrogen.

Station	Date	Original Result (mg/l)	Lab Dup (mg/l)	Mean	Difference	RPD (%)	Acceptable Y or N
OF08	7/16/08	ND	ND	ND	0	0	Y
*	9/10/09						
*	12/9/08						
*	12/10/08						
*	12/11/08						
*	2/1/11						
*	2/3/11						
TA01	2/6/11	2.33	2.30	2.315	0.03	1	Y
*	2/8/11						

*If cells are blank then no duplicate was analyzed for that parameter for that date

Those parameters that did not meet the performance criteria were not used for analysis. Exceptions to the performance criteria were:

- The Wet Weather Survey 1 sample for BOD_5 and the field duplicate at BB02 had a calculated relative percent difference of 40%. These data were qualified as (J) since the relative percent differences exceeded the DQO of 30%, however the data was considered to be usable for analysis purposes.

- The Wet Weather Survey 2 sample for Dissolved Cadmium and the field duplicate at BB04 had a calculated relative percent difference of 40%. These data were qualified as (J) since the relative percent differences exceeded the DQO of 30%, however the data was considered to be usable for analysis purposes.

Table 3.7 Dry Weather 1 Field Accuracy Results (July 16, 2008)

Constituent	BB05A 9/10/2008	BB02 12/9/2008	BB03 2/6/2011	BB04 2/8/2011
Ammonia Nitrogen (mg/L)	Y	Y	Y	Y
BOD_5 (mg/L)	Y	**J**	**N**	Y
Chloride (mg/L)	Y	Y	Y	Y
Hardness (mg/L)	Y	Y	Y	Y
Nitrate Nitrogen (mg/L)	Y	Y	Y	Y
pH	Y	Y	Y	Y
TKN (mg/L)	Y	NC	Y	Y
Total Phosphorus (mg/L)	Y	NC	NC	Y
TSS (mg/L)	**N**	NC	**N**	**N**
Arsenic (As) (µg/L)	**N**	Y	Y	Y
Cadmium (Cd) (µg/L)	NC	Y	NC	**J**
Copper (Cu) (µg/L)	Y	Y	Y	Y
Iron (Fe) (µg/L)	Y	Y	Y	Y
Lead (Pb) (µg/L)	NC	**N**	Y	NC
Manganese (Mn) (µg/L)	Y	Y	Y	Y
Zinc (Zn) (µg/L)	Y	**N**	Y	NC

J= RPD exceeded DQO however data was considered to be usable,
NC= Not Calculated due to one or both samples below detection limits.

Analytical Bias

Analytical bias was evaluated using method blanks, laboratory check standards (LCS), and matrix spikes. Table 3.8 shows the limits for the data quality checks for ESS Laboratories in Cranston, RI. Each of these control samples were run once per batch. Method blanks for all nutrient and propylene glycol analysis were below quantitation limits and Table 3.9 contain the matrix spike results for the biodiversity survey data analyzed by ESS Laboratories

Table 3.8 Measurements of Analytical Bias and Data Quality Objectives

Parameter	LCS DQO	Method Blank DQO	Matrix Spike DQO
Ammonia Nitrogen	± 10%	< QL	± 25%
Total Kjeldahl Nitrogen	± 20%	< QL	± 25%
Total Organic Carbon	± 10%	< QL	± 25%
Propylene Glycol	± 40%	< QL	± 25%

Method blanks for all nutrient and propylene glycol analysis done at ESS Laboratories were below quantitation limits. Method blanks for all metals analyzed at the RIDOH were below reporting limits (RL). A review of LCS and QCS, method blank, and matrix spike results, analytical bias was considered acceptable for all parameters for the biodiversity study for Buckeye Brook.

Table 3.9 Matrix Spike Data Quality Objective Results.

Date	Parameter	% Recovery	Acceptable Limits	Qualifier
7/16/08	Ammonia Nitrogen	93	75-125	J- acceptable
	Total Kjeldahl Nitrogen	108	75-125	J- acceptable
9/10/08	Ammonia Nitrogen	78	75-125	J- acceptable
	Total Organic Carbon	107	80-120	J- acceptable
12/9/08	Ammonia Nitrogen	94	75-125	J- acceptable
12/10-11/08	Ammonia Nitrogen	90	75-125	J- acceptable
2/1/11	Ammonia Nitrogen	94	75-125	J- acceptable
2/3/11	Ammonia Nitrogen	104	75-125	J- acceptable
2/6/11	Total Kjeldahl Nitrogen	103	75-125	J- acceptable
	Ammonia Nitrogen	104	75-125	J- acceptable
2/8/11	Ammonia Nitrogen	91	75-125	J- acceptable

Field Bias

Field-blank samples were submitted to determine bias from contamination in the field. Field-blank contamination was suspected when measured values exceeded the corresponding reporting limits. During Dry Survey 1, several field blanks had reported values that were above detection. The constituents include, hardness (RL=1.0 mg/L, Reported Value 36 mg/L), Dissolved Cadmium (RL=0.06 µg/L, Reported Value 0.13 µg/L), Dissolved Copper (RL=0.30 µg/L, Reported Value 19.9 µg/L), Dissolved Lead (RL=0.07 µg/L, Reported Value 0.49 µg/L), Dissolved Manganese (RL=0.43 µg/L, Reported Value 0.96 µg/L), and Dissolved Zinc (RL=6.46 µg/L, Reported Value 15.2 µg/L). Sampling protocols were reviewed with all crews and the field blank measurement values for the remaining surveys were below reporting limits.

Data Completeness

Data are considered to be complete if the data collected are considered to be usable. For all parameters, the QAPP sets a goal of 100%. For the most part, this was accomplished and nearly all of the data collected were considered usable for TMDL assessment analysis. The samples listed below were not acceptable and will not be utilized in any analysis as these results significantly failed to meet field accuracy data quality objectives and could not be qualified:

- Dissolved Arsenic sample collected at BB05A on 9/10/2008
- Following samples collected at BB02 on 12/9/2008
- Dissolved Lead and Dissolved Zinc
- TSS sample collected at BB03 on 2/6/2011, and
- TSS sample collected at BB04 on 2/8/2011.

3.6 Results of Water Chemistry Study

This section presents the results of both the dry and wet weather surveys, including water chemistry analytical results and field measurements of dissolved oxygen, temperature, and specific conductance. Table 3.17 shows the field data collected from both the dry and wet

weather surveys. Table 3.18 shows the water chemistry results for all dry weather surveys. Tables 3.19 and 3.20 show the water chemistry results for Wet Weather Survey One and Two, respectively. The tables are located at the end of this section.

3.6.1 Dry Weather

Dissolved Oxygen

The waters of Buckeye Brook Watershed are considered Class B, warm water fish habitat waterbodies. The Rhode Island Water Quality Regulations (December 2010) state that these waterbodies must maintain an instantaneous minimum dissolved oxygen concentration of at least 5.0 mg/l, except as naturally occurs. During both dry weather surveys, the dissolved oxygen levels at four of the nine water quality stations violated the 5 mg/L minimum concentration portion of the criteria. Station BB00 is not affected by the airport discharges but had values below criteria for three of the four field measurements. This station is in the middle of an urban wetland area and the low stream flow may account for the low D.O. values, as stagnant water can produce low D.O readings.

Dissolved oxygen measurements were also collected at the two stations monitoring discharge from the landfill and the airport. At the landfill station (TA01), dissolved oxygen values were only measured during the first dry weather survey with all values below criteria, averaging 3.00mg/L. Observed stream velocities at TA01 were very low during the survey, (estimated <0.10 ft^3/sec) which may contribute to the low D.O. values. The dissolved oxygen levels at Outfall OF08 which drains the airport tarmac were well above the criteria averaging 9.01mg/L for dry weather.

There was a significant decrease in the dissolved oxygen levels observed between Stations BB03 (exit of Warwick Pond) and BB04 (Rufus Road). The dissolved oxygen level at BB04 was an average of 4.01 mg/L lower than the level at BB03 for the two dry weather surveys. During the pathogen field surveys in 2006, the average dissolved oxygen deficit between the two stations from August to October was 2.73 mg/L. After Station TA01, with an average of 3.0 mg/L, Station BB04 had the next lowest overall dissolved oxygen level averaging 3.86 mg/L for the dry weather surveys. Figure 3.3 shows the mean dissolved oxygen values for the dry weather surveys.

Five-day Biological Oxygen Demand (BOD_5)

The mean BOD_5 ranged from 1 to 4 mg/L at the stream stations, and was 4 mg/L at both OF08 and TA01 for the first dry survey. The lowest BOD_5 observed was at Station BB02 with an observed value of 1.0mg/L for both dry surveys.

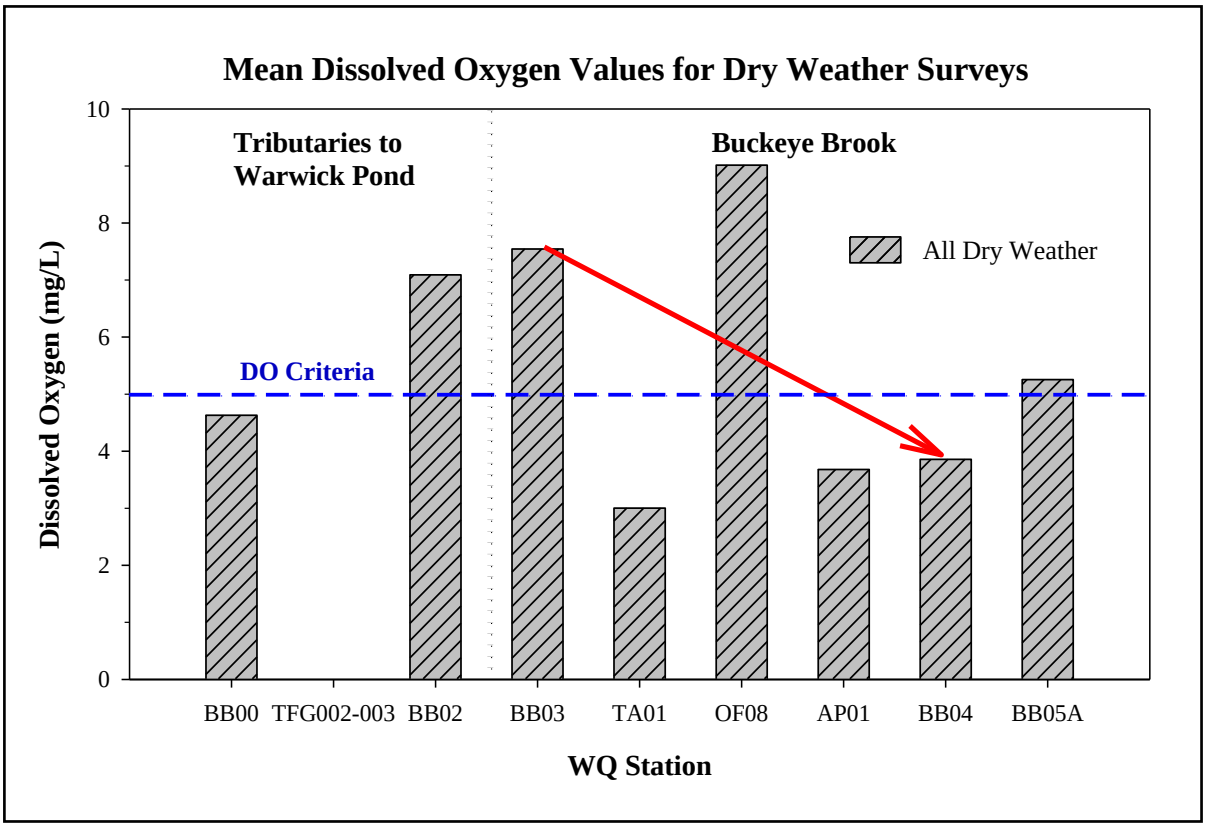

Figure 3.3 Mean Dry Weather Dissolved Oxygen Values for Watershed Survey Sites

Hardness as $CaCO_3$

Hardness, which is used to calculate dissolved metals criteria, averaged between 44 and 55 mg/L. The Buckeye Brook stream station with the highest observed hardness value was Station BB04, which was downstream from the confluence of the airport and landfill discharges, which had the highest hardness for all stations at 91 mg/L.

pH

The pH values for the stations were in the normal range for stream systems in the state, with averages between 7.1 and 7.4 for all stations except BB03. The observed pH at this station was at the upper limit of the criterion, with a value of 9.2 during the first dry survey.

Total Suspended Solids (TSS)

TSS was very low for both dry weather surveys, ranging between a low of 1 mg/L to a high of 7 mg/L at the stream station. As expected, the highest TSS observed was at Station TA01, with a value of 39 mg/L for dry weather survey one.

Chlorides

Chlorides were also measured at all stations. The stream stations averaged from 47 mg/L at BB03 to 84 mg/L at Station BB00. Warner Brook average was 80 mg/L and also had the highest dry weather single value of 107 mg/L during the first dry survey. The observed chloride at the landfill (TA01) and airport stations (OF08) were 46 and 79 mg/L respectively.

Nutrients

Figures 3.4 and 3.5 show the dry weather concentrations for Total Kjeldahl Nitrogen (TKN) and Ammonia (NH_3-N). While there appears to be no significant dry weather sources of nitrogen or phosphorus in the main stem portion of Buckeye Brook, the landfill TKN and NH_3-N samples were above 2.5 mg/L for the first dry survey, and the combined flow from the landfill and airport outfall had the highest TKN and NH_3-N values for dry survey two. TKN ranged from 0.23 mg/L at BB05 to 0.88 mg/L at BB04. The highest TKN levels were at the Truk-Away station with 2.79 mg/L at TA01 for the first dry survey. Ammonia (NH_3-N) levels ranged from 0.13 mg/L at BB03 to a maximum of 0.85 mg/L observed at BB04 during the first dry survey. Of all the stations, TA01 had the highest level at 2.72 mg/L for the first dry weather survey. The airport outfall (OF08) had TKN and NH_3-N values of 0.10 mg/L and 0.13 mg/L respectively for the first dry survey. The second survey only took samples from the AP01, which was the combined flow from the airport and the landfill. TKN and NH_3-N levels at AP01 for the second dry survey were 2.07mg/L and 1.79 mg/L respectively for dry survey two. The TKN and NH_3-N values for the landfill station were significantly higher than any stream station on Buckeye Brook as well as the outfall from T.F. Green. While not the highest observed nitrate values, OF08 at 0.67 mg/L during the first survey would appear to be contributing to increases in nitrate levels from less than 0.05 mg/L at BB03 to 0.24 mg/L at BB04. With the exception of Truk-Away sampling station (TA01), Total Phosphorus (TP) levels were uniformly low during dry weather, with concentrations ranging from below the reporting limit of 0.02 mg/L to a high value of 0.19 mg/L at the landfill station, TA01. There were no exceedances of ammonia criteria, the only nutrient for which RI's Water Quality Standards establish a numeric criteria for rivers and streams.

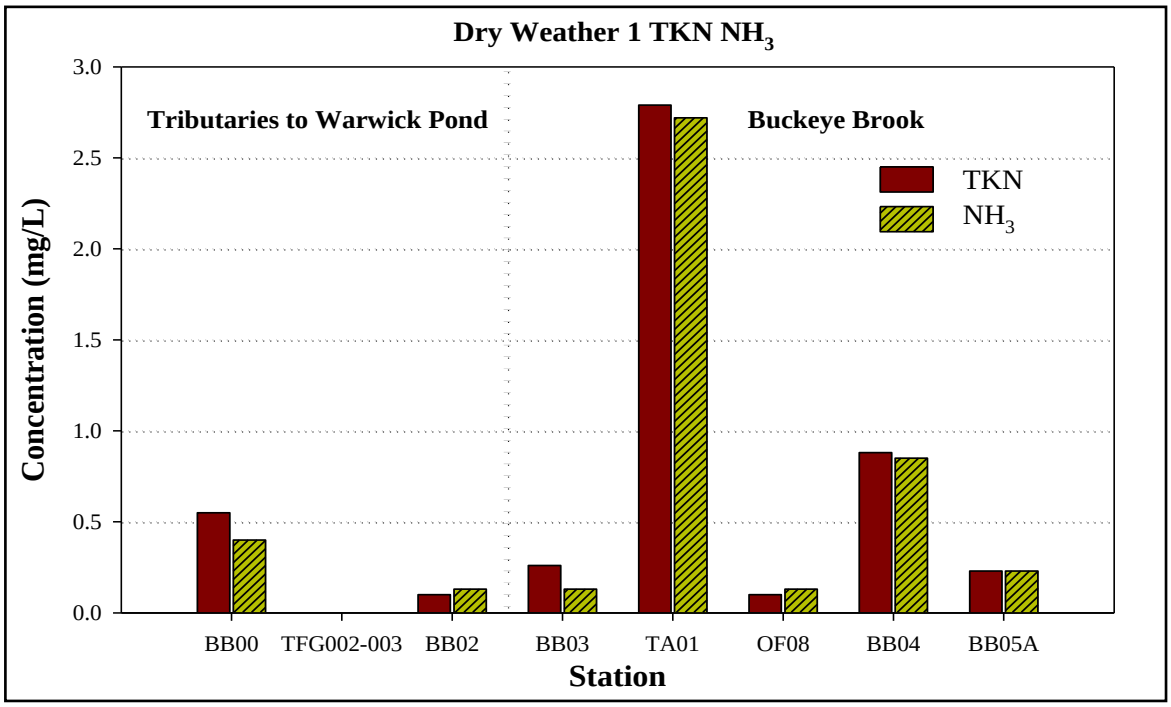

Figure 3.4 Dry Weather 1 TKN and NH_3-N Concentrations

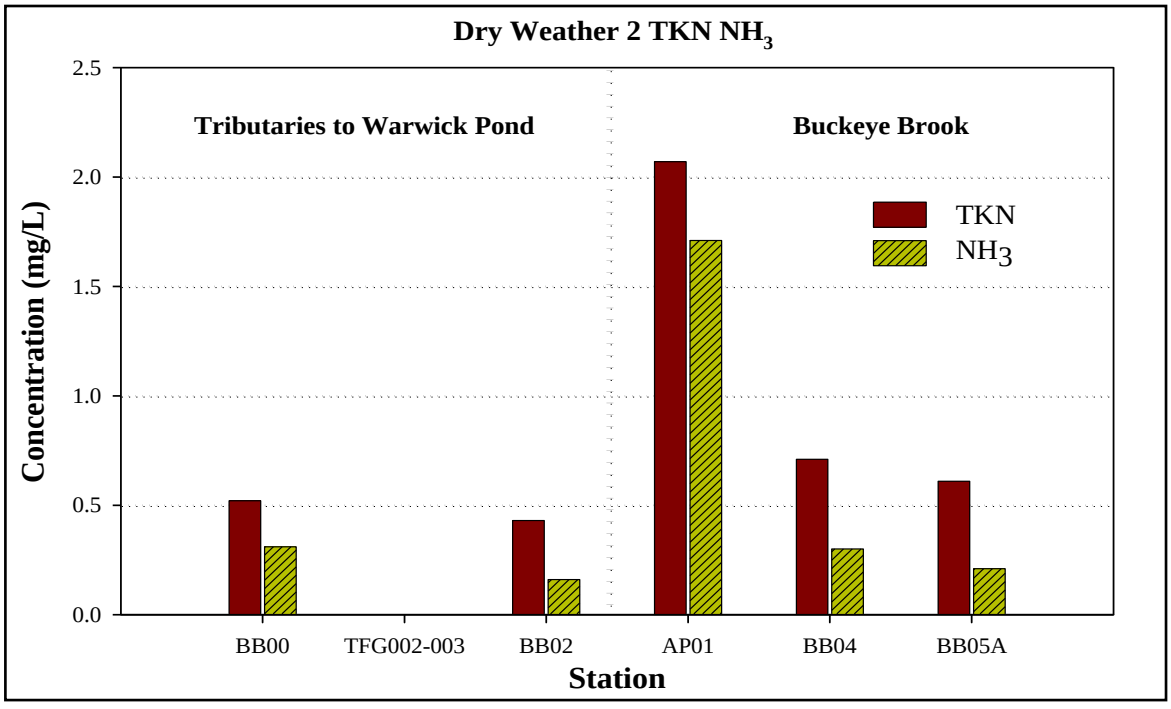

Figure 3.5 Dry Weather 2 TKN and NH_3-N Concentrations

Trace Metals

The chronic and acute freshwater criteria of these metals apply to the dissolved form and are calculated using water hardness (in mg/l as CaCO3) based on equations in Table 2-Appendix B of Rhode Island's Water Quality Regulations. Hardness is a measure of the concentration of cations in solution with hardness usually measured as calcium carbonate ($CaCO_3$) equivalents in mg/l. An increase in hardness decreases the toxicity of metals, because calcium and magnesium cations compete with the metal ions for complexing sites, allowing fewer metal complexes to form and therefore resulting in a lower level of toxicity.

For the dry weather surveys, the actual hardness values for each station were used for each survey date to determine the applicable acute and chronic criteria. The resultant criteria were compared against the observed dissolved metal values collected at each sample location for each survey date.

The trace metals sampled for during the biodiversity field surveys were dissolved Arsenic (As), Cadmium (Cd), Copper (Cu), Lead (Pb), Manganese (Mn), Zinc (Zn) and Total Iron (Fe). There were dry weather exceedances of the fresh water criteria for cadmium and total iron. During the first dry survey, one station on Buckeye Brook (BB00) exceeded the cadmium chronic criteria, as did Truk-Away Landfill (TA01) and the airport station (OF08). The freshwater chronic criterion for iron is 1000µg/L. This limit was exceeded during both dry surveys at Stations BB04 and BB05. The landfill and airport stations, which ultimately discharge into Buckeye Brook above BB04 and BB05, both had high values for the first dry survey, with a total iron value of 11,586µg/L and 2,844 for Truk-Away and the airport station respectively during the first dry survey. Given the relatively low value of the upstream station at BB03, these two stations are the likely source of iron observed at the downstream stations BB04 and BB05A. These stations were not sampled for the second dry survey because it was decided that chemistry samples would be collected only at the stations sampled by the ESS Group. Station AP01 was sampled during the second dry survey, which is downstream of the confluence of the discharges from TA01 and OF08, and had a total iron value of 3,008µg/L.

Elevated levels of other metals were observed, but none in concentrations that exceeded criteria. Manganese also had some high values, ranging from 12µg/L at BB03 to a high of 988µg/L at TA01 for the first dry survey, while the arsenic concentrations were well below the criterion, averaging between 0.29 and 0.72µg/L for all stream stations on Buckeye and Warner Books. The highest arsenic value of 1.87µg/L was for Station TA01 during the first dry survey. Copper, lead and zinc criteria were not exceeded at any station for the dry surveys. Of any stream station, including Warner Brook, the highest mean copper concentration of 3.49µg/L was observed at BB04, which also had the maximum single grab value (5.73µg/L) for dry weather. Copper concentrations from both Truk-Away and the airport station were two to three times lower than values observed in Buckeye Brook.

Total Organic Carbon (TOC)

TOC samples were collected during the second dry survey at the stations visited by the ESS Group during their biology field sampling of Buckeye Brook. TOC is often a source of food for benthic organisms; however, high levels of sediment TOC can result in significant changes in a benthic community structure and the predominance of pollution-tolerant species. The TOC values ranged from a low of 580 mg/L at BB02 to a high of 17,000 mg/L at AP01, which represents the combined flows from airport outfall OF08 and the landfill, TA01. BB00, chosen because it is not influenced by airport run-off, had a TOC level of 1,900 mg/L. BB00 is located in the wetland area that is northwest of the intersection of Commerce Drive and Airport Road.

3.6.2 Wet Weather

Two wet weather surveys were conducted for the biodiversity field program. The first survey, which consisted of three consecutive sampling days, was to capture a storm event that would generate run-off for the watershed but one that did not require the airport to commence de-icing operations. The second wet survey was under icing conditions where the airport had commenced de-icing of aircraft, and also had intermittent rain/sleet as well as snow during the first day of sampling, and totaled four sampling runs for the event. The same constituents that were sampled for the dry surveys were also collected during the wet weather surveys with the exception of TOC, which was dropped. However, propylene glycol was added to the constituent list to determine if significant amounts were being discharged to Buckeye Brook during storm events.

Dissolved Oxygen

The dissolved oxygen levels for both wet weather events were well above instantaneous criteria for all the stream stations. The dissolved oxygen levels fell below criteria during both wet weather events for the landfill station (TA01), with the lowest observed value at 1.38mg/L occurring during the prestorm sampling run for Storm 1, and averaging 3.79mg/L for the event. Again, with the stagnant, low flow discharge from the landfill, this was to be expected. OF08, like the stream stations, was well above criteria, averaging 9.96 mg/L for all wet weather runs.

As with the dry surveys, there was a dissolved oxygen drop observed between Stations BB03 and BB04 for both storm events. The prestorm sample for the first storm event, which had the higher flows of the two wet surveys, had a small deficit of 0.7 mg/L between the stations. However, as the survey continued, the D.O. drop was significant, averaging 4.7 mg/L for the next two runs. The second wet weather also had significant D.O. drops that ranged between 2.8 mg/L for the last run to 4.8 mg/L for Run 2. Figure 3.6 is a plot of the instantaneous dissolved oxygen concentrations for Stations BB03 and BB04 for the first dry weather and both wet weather surveys and shows the drop in D.O. that occurred between the two Buckeye Brook stations.

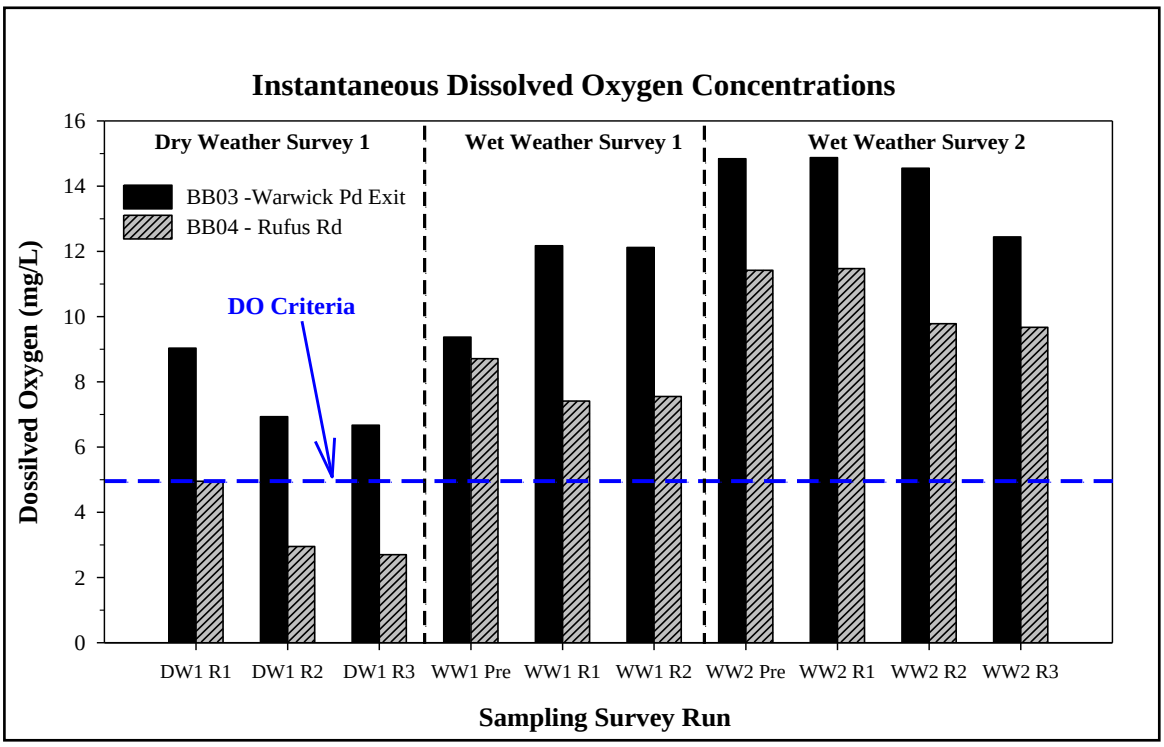

Figure 3.6 Instantaneous Dissolved Oxygen Values for RIDEM Stations BB03 and BB04

Propylene Glycol

Propylene Glycol is one of the main constituents used in de-icing solutions, and concentrated glycol has a potential BOD_5 demand of 200,000 mg/L. Although glycol samples were collected during both wet weather events, active aircraft deicing operations occurred only during the second storm event. Wet weather samples from five stations were analyzed for propylene glycol for each storm. One station, BB05A was dropped for the second storm and BB03 added in its place. BB00 was selected as a background station that would allow a comparison for a station that would not be likely to have any propylene glycol in the samples. BB02 is the inlet of Warwick Pond and receives stormwater discharges from those outfalls draining the aircraft parking area for cargo operations. BB03 and BB04 bracketed the confluence of the flows discharging from the main airport outfall (OF08) with Buckeye Brook. OF08 is the primary outfall for the aircraft parking area of the main airport passenger terminal and the largest contributor of stormwater to the lower segment of Buckeye Brook.

During storm 1, no de-icing activities occurred and no propylene glycol was detected at any of the sampled stations. During Storm 2, in February 2011, de-icing activities did occur and three of the five stations had detectable levels of propylene glycol. The mean values ranged from 22 mg/L at Station BB04 to 79 mg/L at Station OF08. BB02, which receives the discharge from the airport outfalls that are north of Warwick Pond and service the aircraft cargo area, had a mean propylene glycol value of 45 mg/L. The highest single value of 105 mg/L was collected on the last run of the storm event at OF08, more than a week after the winter storm began. The higher

propylene glycol concentrations at OF08 coincide with the higher BOD_5 observed at that station during the second storm.

The Buckeye Brook stations sampled as part of the RIAC monitoring requirements included BB02, BB07 and BB08. Figure 3.7 shows how the concentrations of propylene glycol changes over the 48 hour sampling period for this storm. The time of travel for propylene glycol from OF002 and OF003 appears to be approximately 24 hours after the storm event starts, and 36 hours for the increased glycol concentrations to travel from OF008 to West Shore Road (BB07) and Tidewater Drive (BB08). The maximum observed concentrations of proplyene glycol were 210 mg/L at BB02 and 291 mg/L at BB07 and BB08.

Five-day Biological Oxygen Demand (BOD_5)

The five-day biological oxygen demand (BOD_5) for all stations was slightly higher for the first wet survey, as compared to dry weather, with mean values ranging from 2.0 mg/L at Stations BB00 and BB03 to 6.7 mg/L at BB04, and the landfill (TA01) and airport (OF08) stations at 3.0 and 5.7 mg/L respectively. The BOD_5 concentrations for the second storm during which de-icing activities occurred were two to three times higher than the values observed during storm one. Station BB00 was not influenced by airport de-icing operations had the lowest mean value at 1.7 mg/L. The mean BOD_5 values for the stream stations that receive the discharges from those areas on the airport property where de-icing operations are conducted were significantly greater with BB02 at 11.8 mg/L and BB04 at 12.5 mg/L. The highest BOD_5 storm values were at OF08, which had a mean value of 16.3mg/L for storm two and the highest single grab value at 20.0 mg/L for the prestorm sample. OF08 is the largest airport outfall and had the greatest observed flows during the wet weather events

As stated previously, RIAC was also sampling the airport outfalls and several stations along the mainstem of Buckeye Brook during the February 2011 survey. The stream stations were sampled every four hours for a period of 48 hours after the start of the storm. Figure 3.8 shows the BOD_5 concentrations for the inlet of Warwick Pond (BB02) and the two stream stations on Buckeye Brook (BB07 and BB08). As with propylene glycol, the BOD5 signal appears to lag the start of the storm by 24 to 32 hours at the Buckeye Brook sites, with maximum concentrations ranging from 160mg/L at BB02 to 63mg/L and 73mg/L at BB07 and BB08 respectively.

Hardness as $CaCO_3$

The hardness values observed during both storms were similar to the dry weather values. The stream stations averaged between 36 mg/L at BB02 for the first wet weather event to 53 mg/L at BB03 for the second storm. The highest observed value was the prestorm sample from TA01 at 97 mg/L, while OF08 had the lowest hardness for either storm at 15 mg/L for Run 2 and 3 of Storm 1. The highest single grab sample for the stream stations during either wet weather was during Run 1 of Storm 2 at BB03 with a hardness value 79.2 mg/L.

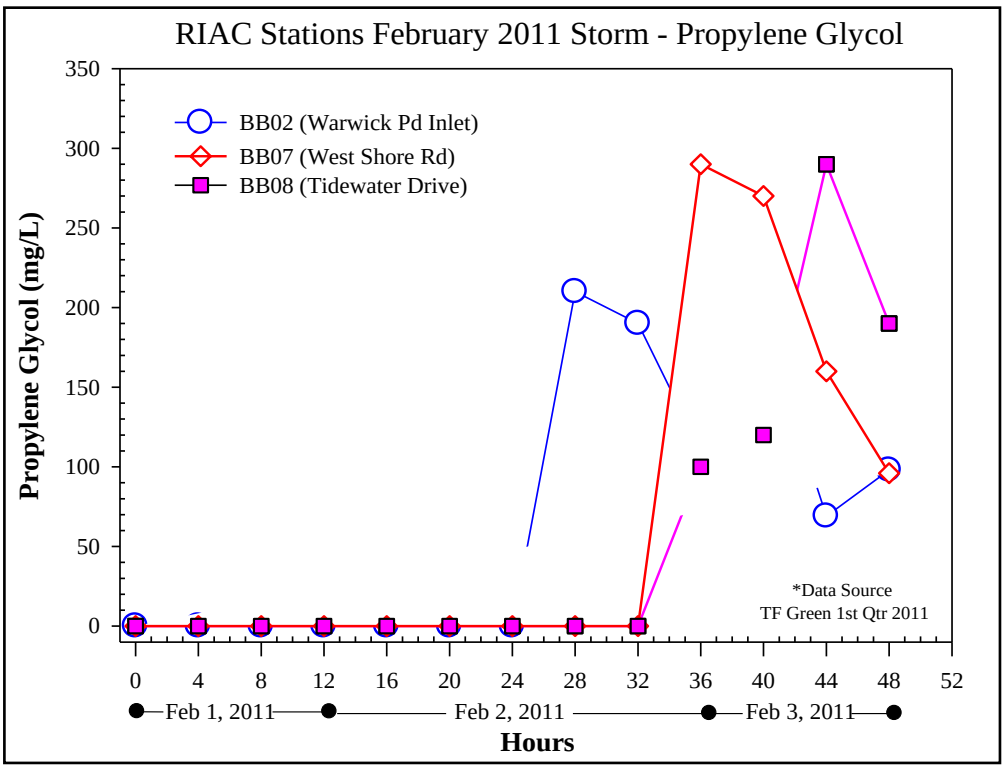

Figure 3.7 Storm 2 Observed Propylene Glycol Concentrations for RIAC Stations

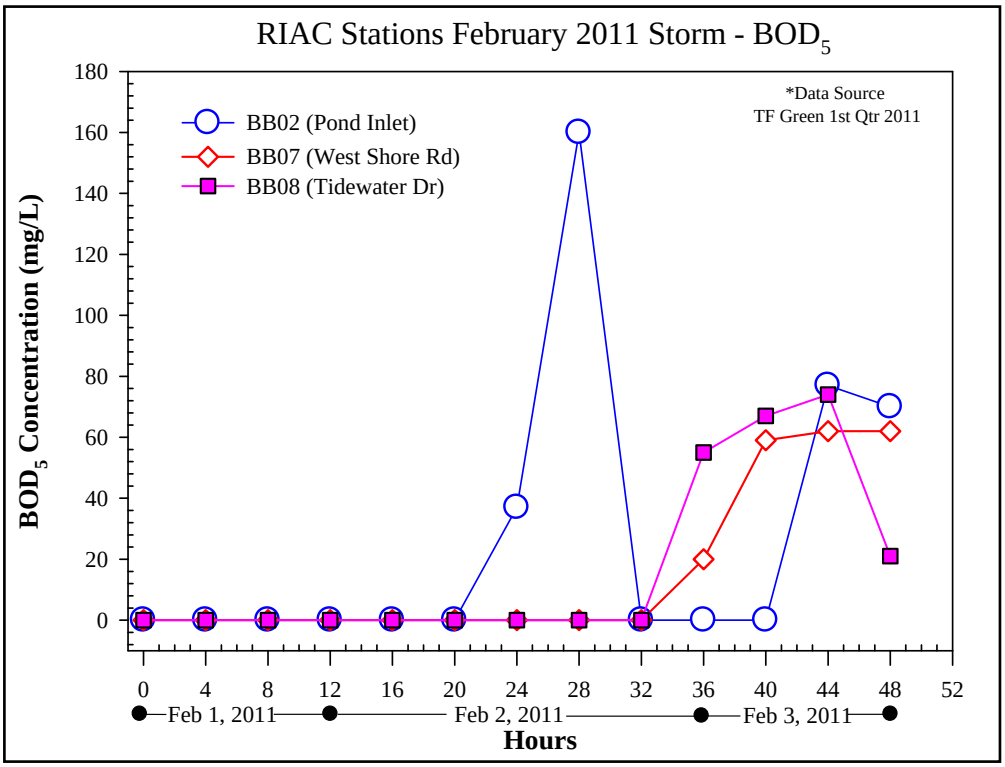

Figure 3.8 Storm 2 Observed BOD_5 Concentrations for RIAC Stations

pH

As with the dry surveys, pH was consistent across all stations, averaging from 6.3 to 7.5 for the two storms. The lowest single grab value, 6.08, occurred at Station BB00 during Storm 2, while the highest pH of 7.8 was observed at Station BB03 during Storm 1.

Total Suspended Solids (TSS)

TSS values were very low for the first storm in December, 2008. Several stations had samples that were below the 0.10 mg/L detection limit for the method. The mean TSS values for the stream stations were between 4.0 to 7.0 mg/L, while the airport and Truk-Away stations recorded mean values of 8.5 and 18 mg/L for Station OF08 and TA01 respectively. The second wet weather event had slightly higher TSS levels for the stream stations, averaging between 1.5 mg/L at BB03 to 13.0 mg/L at BB00. Again, several stream station had values below the detection limit, but the lowest reported value was at BB03 with a value of 1.0 mg/L. BB03also recorded the highest TSS value for any stream station at 31.6 during Run 2 of the second storm. This may be an outlier as a thick layer of ice had formed where the sample had to be collected and the bottom sediments may have been disturbed while breaking the ice layer to collect the sample. The other TSS values at this station were 1.0 and 2.0 mg/L for the first two samples of Storm 2, and the sample collected for Run 3 was below detection. The most consistent site was TA01, which averaged 22.0 mg/L, and also had the highest TSS value at 37.0 mg/L for the prestorm sample.

Chlorides

The chloride values for the first storm, when no de-icing occurred, were very similar to the dry weather values, with the lowest mean value of 34 mg/L at Station BB03, and the high storm mean of 71 mg/L occurring at BB00. The second storm was much different, with mean values nearly six times the averages from Storm 1, though no exceedances of the chloride criteria were observed. Station OF08 had the highest average with a mean value at 224.9 mg/L and the highest observed chloride concentration of 544 mg/L for Run 3. This outfall drains the main terminal aircraft parking area, and the high concentrations may be attributed to the deicing material applied to the tarmac in this location. BB02, which receives stormwater from the integrated cargo tarmac, also had high chloride values, averaging 153 mg/L, which was the highest of the Buckeye Brook stations.

Nutrients

Buckeye Brook stream concentrations for individual nitrogen forms (TKN, NH_3, and NO_3) were lower during the first storm, and depending upon the nitrogen form, were two to three times higher during the second storm event. Comparing the total nitrogen values for the stations (the sum of the TKN and nitrate concentrations), Buckeye Brook averaged from 0.65 to 1.9 mg/L for Storm 1, and from 1.5 to 2.6 mg/L for Storm 2. The mean nitrogen concentrations for the airport and landfill stations were the highest for Storm 1, with an observed mean of 14.6 mg/L at TA01 to 0.47 mg/L at OF08. For both wet weather events, the mean total nitrogen concentrations (sum of TKN and nitrate values) for the two stations above Warwick Pond were almost twice as high as the observed mean at Station BB03 (Warwick Pond exit).

The Total Kjeldahl Nitrogen (TKN-N) values at the Buckeye Brook stations were two to three times higher for Storm 2 while the ammonia levels were similar. Mean TKN concentrations for these stations ranged from below detection (0.20 mg/L) at BB02 for Storm 1 to a high average of 1.75 mg/L at BB04. TA01 mean TKN concentrations were the highest observed for either storm during the first wet event, with an average of 14.6 mg/L for Storm 1 and 2.7 mg/L for the second event. The mean TKN values for the stations above Warwick Pond (BB00 and BB02) were less than half the mean concentrations observed at BB04 and BB05A, both of which are located below the confluence of Buckeye Brook with the landfill discharges from TA01 indicating the possible influence of the landfill runoff on the water quality of the brook. The TKN value at the airport outfall (OF08) was below the detection limit of 0.20 mg/L for Wet Weather 1, and generally lower than other sampling locations for Wet Weather 2.

Ammonia (NH_3-N) mean concentrations were similar for both storm events at the Buckeye Brook stations. Buckeye Brook sites averaged between 0.13 mg/L at BB02 for the first storm to 0.63 mg/L at BB04 for Storm 2. Station TA01 had the highest mean ammonia concentrations for either storm, averaging 2.9 mg/L for Storm 1 and 1.5 mg/L for Storm 2. There were no exceedances of ammonia criteria for either wet weather event.

Nitrate (NO_3-N) concentrations for Buckeye Brook during wet weather were consistent for all the stations, and comparable to observed dry weather values. Wet weather nitrate concentrations on Warner Brook were also comparable to dry weather though more than an order of magnitude higher than the Buckeye Brook stations. The landfill and airport stations were below 0.5 mg/L for both storms, averaging between 0.10 mg/L for TA01 to 0.47 mg/L for OF08.

The Total Phosphorus (TP) values were very low for all stream stations for both wet weather events. The average TP concentration range for both storms was 0.03 to 0.05 mg/L. The highest observed values occurred at the landfill station. TA01 mean TP concentration was 0.45 mg/L for the first storm, and 0.27 mg/L for Storm 2. The airport station (OF08) was slightly elevated during Storm 1 with a mean TP concentration of 0.09 and 0.03 mg/L for Storm 1 and 2, respectively.

Trace Metals

For the wet weather surveys, the acute criteria were calculated using the actual hardness values for each station by survey run. The acute criteria were then compared against the actual observed metals values for each station. For the chronic criteria calculations, the hardness values were averaged for all runs for each station for wet survey 1. For survey two, the prestorm and the first run's hardness values were averaged, as were runs 1 and 2, and runs 2 and 3. The criteria were then calculated using the averaged hardness values. The observed metal values were similarly averaged for Storm 1 and 2. The calculated criteria were then compared against the averaged observed dissolved metal values that were collected at each sample location for each storm. Appendix A contains the tables that show these calculations and comparison to

criteria and Table 3.10 shows trace metals criteria exceedances that occurred during the biodiversity surveys. These are discussed in the section below.

Table 3.10 Dry and Wet Weather Trace Metal Criteria Exceedances

Station	Cadmium				Copper				Lead			
	DW1	DW2	WW1	WW2	DW1	DW2	WW1	WW2	DW1	DW2	WW1	WW2
Tributaries to Warwick Pond (RI0007024R-01)												
BB00	C		C	C								
BB02			C	C				C				
Buckeye Brook (RI0007024R-05)												
BB03	C									C		
BB04	C									C		
BB05A			C					A,C				
TA01	C		C									
OF08	C		C	C			C	A,C				C
AP01												

Station	Zinc				Iron			
	DW1	DW2	WW1	WW2	DW1	DW2	WW1	WW2
Tributaries to Warwick Pond (RI0007024R-01)								
BB00								C
BB02							C	C
Buckeye Brook (RI0007024R-05)								
BB03	A,C							C
BB04					C	C	C	C
BB05A					C	C	C	C
TA01					C		C	C
OF08			A		C		C	C
AP01						C		

A= Acute Criteria Exceeded; C = Chronic Criteria Exceeded; DW1-07/16/08; DW2-09/10/08; WW1-12/09-11/08; WW2-02/02-08/11

Cadmium (Cd)

There were ten exceedances of the dissolved cadmium freshwater chronic criteria for the two wet weather events. Seven occurred at Buckeye Brook stream stations, two at the airport outfall (OF08) and one at Truk-Away landfill (TA01). BB00 exceeded criteria for three of the seven samples collected over the two events, with BB00 cadmium concentration averaging 0.24µg/L for Storm 1, and 0.18µg/L for Storm 2. Station BB02 also had three exceedances of criteria, with dissolved cadmium averages of 0.26 and 0.12µg/L for Storms 1 and 2, respectively. The last stream station, BB05A had one chronic exceedance which for Storm 1, averaging 0.30µg/L. TA01 had one exceedance for cadmium during the first storm with an average concentration of 0.25µg/L, and also had the highest single grab value for either storm with a concentration of 0.58µg/L during the prestorm sample run for Storm 1. OF08, with the largest airport stormwater discharge, had four exceedances total, three during Storm 1 and one in Storm 2. The average cadmium concentrations for OF08 were 0.18 µg/L and 0.12µg/L for Storms 1 and 2,

respectively. Warner Brook did not have any dissolved cadmium exceedances for either wet weather event.

Lead (Pb)

There were two exceedances of the freshwater chronic criteria for dissolved lead during the second wet weather event, both occurring at the airport outfall, OF08. The landfill (TA01) and airport (OF08) stations had the highest mean dissolved lead values for either storm with TA01 averaging 1.38µg/L for Storm 1 and OF08 with a mean concentration of 0.98µg/L for Storm 2. TA01 had the highest single grab value for lead during Storm 1 at 1.70µg/L, while the lead concentration of 2.62µg/L at OF08 was the maximum value for Storm 2. There were no exceedances of lead criteria at any Buckeye Brook stream stations during the wet weather sampling surveys.

Copper (Cu)

Copper was the exception for the wet weather events as there were both acute and chronic violations of the freshwater criteria at the airport and Buckeye Brook sampling sites. The airport site at OF08 had four acute criteria exceedances (two per storm) and one chronic exceedance during Storm 2. OF08 had a mean dissolved copper value of 2.55µg/L for Storm 1 and the higher value of 2.65µg/L for Storm 2. BB05A had one acute and one chronic criteria exceedance during Storm 2, with the highest single grab sample value for any station for the wet weather events occurring Run 1 of the second storm, with an observed copper concentration of 8.48µg/L.

Zinc (Zn)

There were two exceedances of the dissolved zinc acute freshwater criteria during the first wet weather event at the airport station at OF08. The acute criterion was exceeded during the last two sampling runs, with concentrations of 33.5 and 26.2µg/L. The mean wet weather zinc concentrations for all stations sampled were three times higher during Storm 1, with the highest zinc concentration occurring at BB00 with a mean value of 25.9µg/L. There were no wet weather exceedances of zinc criteria for any stream station.

Iron (Fe)

Total iron had numerous exceedances of the criterion during both storm events, with 67% of the samples collected exceeding the 1000µg/L limit. The landfill and airport stations both exceeded the criterion for every sample collected, with TA01 having the highest mean iron concentrations for both storms with levels of 14,272 and 4,752µg/L during Storm 1 and 2 respectively. The Buckeye Brook stations at BB02, BB04 and BB05A also exceeded criterion for all samples collected, with BB04 averaging the highest for the stream stations with total iron concentrations levels of 2,928µg/L during Storm 1 and 2,102µg/L for Storm 2. The influence of the high levels coming from the landfill and airport stations most likely are the reasons for the high iron concentrations observed at Stations BB04 and BB05A. Figure 3.9 shows the mean iron concentrations for the airport (Outfalls OF02, OF03 and OF08 compared with the Wet Weather 2

prestorm values at the stations for the landfill (TA01), northern Tributaries (BB00, BB02) and Buckeye Brook (BB04, BB05A).

Manganese (Mn)

There were not any exceedances of criteria for manganese during the wet weather surveys. The highest mean value for all stations was observed at the airport station TA01, with an overall wet weather mean of 819µg/L. The stream stations north of Warwick Pond had the highest mean wet weather concentration for Buckeye Brook at 744µg/L.

Arsenic (As)

There were no exceedances of the freshwater criteria for arsenic at any station during wet weather events. The mean arsenic values for the wet surveys ranged from 0.22 to 1.36µg/L, with Storm 1 concentrations being slightly higher that the Storm 2 values. Overall, TA01 had the highest mean concentration of all sampling stations at 0.92µg/L for all wet events. Station BB03 had the highest mean wet weather concentration for the stream stations at 0.61µg/L.

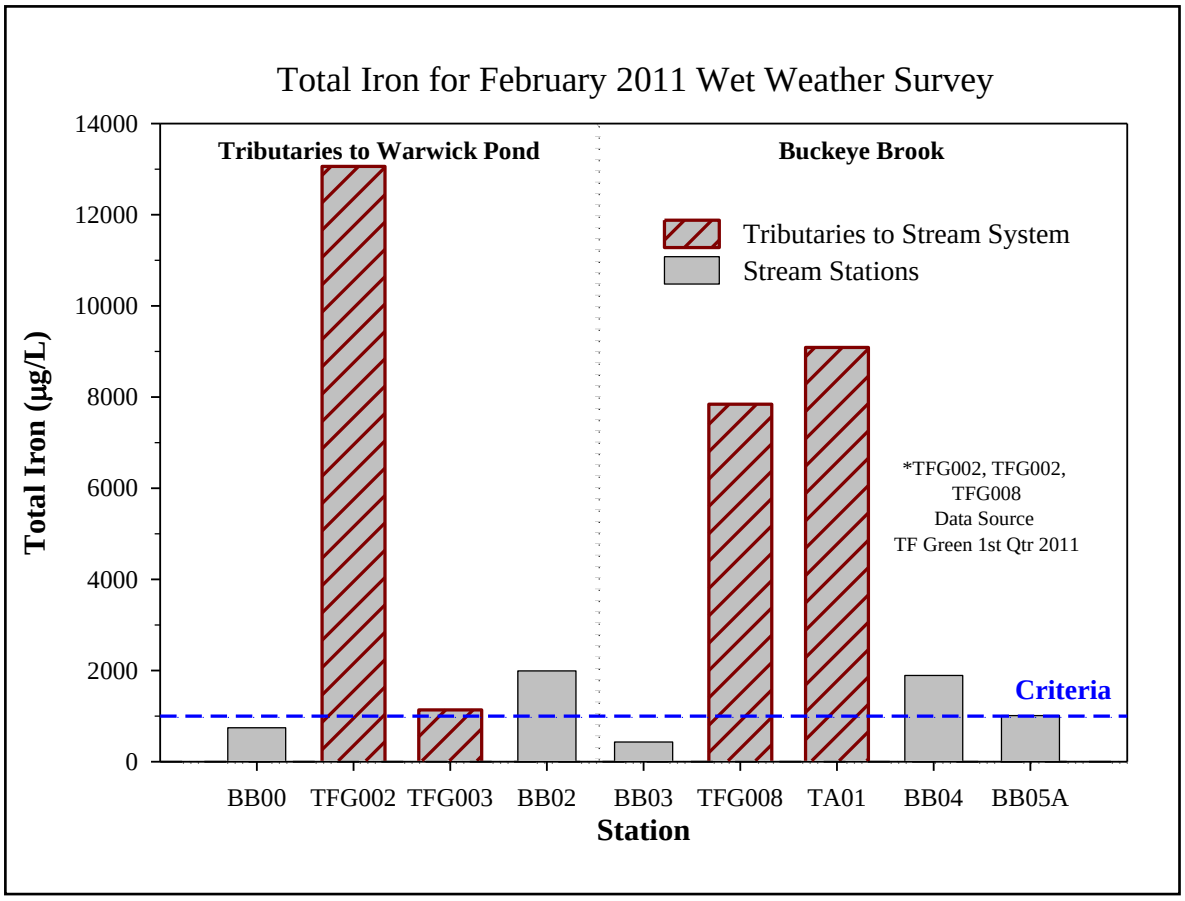

Figure 3.9 Wet Weather 2 Mean Total Iron Concentrations

Table 3.11 Field Data Summaries

Dissolved Oxygen (mg/L)

Survey Type	DW1			DW2	WW1			WW2				Mean
Station	7/16/08	7/18/08	7/21/08	9/10/08	12/9/08	12/10/08	12/11/08	2/1/11	2/3/11	2/6/11	2/8/11	
BB00	4.24	4.58	5.18	4.52	9.75	8.11	9.23	16.85	12.32	11.52	10.38	**8.79**
BB02	7.55	7.33	7.07	6.41	9.45	7.63	9.58	10.93	10.87	11.14	10.24	**8.93**
BB03	9.03	6.93	6.67	NS	9.37	12.17	12.12	14.84	14.87	14.55	12.44	**11.30**
TA01	3.41	2.55	3.05	NS	1.38	4.93	5.05	6.53	4.93	4.84	5.13	**4.18**
OF08	9.29	8.90	8.85	NS	7.20	9.02	10.45	13.00	9.94	12.03	10.91	**9.96**
AP01				3.68								**3.68**
BB04	4.95	2.95	2.70	4.83	8.71	7.41	7.55	11.42	11.47	9.78	9.67	**7.40**
BB05A	5.39	4.82	4.80	6.01	10.24	7.27	8.57	10.12	11.30	9.84	10.91	**8.12**

NS = Not Sampled

Temperature (°C)

Survey Type	DW1			DW2	WW1			WW2				Mean
Station	7/16/08	7/18/08	7/21/08	9/10/08	12/9/08	12/10/08	12/11/08	2/1/11	2/3/11	2/6/11	2/8/11	
BB00	18.6	20.1	22.0	16.0	2.6	11.2	7.1	0.4	1.6	1.9	3.4	**9.5**
BB02	21.3	27.3	27.8	17.6	4.6	11.7	8.0	0.8	3.1	4.0	4.3	**11.9**
BB03	29.2	18.3	20.0	NS	2.8	5.2	5.0	2.1	2.2	2.6	2.6	**9.0**
TA01	17.5	17.9	18.9	NS	0.9	6.9	5.1	0.3	1.0	0.7	0.8	**7.0**
OF08	14.7	14.7	15.0	NS	11.2	13.0	8.0	7.8	7.5	4.7	6.1	**10.3**
AP01				16.7								**16.7**
BB04	26.5	23.2	24.5	21.0	2.7	8.7	6.4	0.9	2.5	2.3	2.9	**11.1**
BB05A	24.5	23.2	24.6	19.8	2.5	9.5	6.5	0.1	0.3	1.5	2.3	**10.4**

Specific Conductance (µS/cm)

Survey Type	DW1			DW2	WW1			WW2				Mean
Station	7/16/08	7/18/08	7/21/08	9/10/08	12/9/08	12/10/08	12/11/08	2/1/11	2/3/11	2/6/11	2/8/11	
BB00	359	395	386	370	399	366	378	444	501	378	390	**397**
BB02	301	270	271	262	286	339	505	370	693	505	882	**426**
BB03	272	304	300	NS	218	218	214	219	210	214	195	**236**
TA01	416	417	415	NS	472	265	284	86	353	448	482	**364**
OF08	322	337	338	NS	268	207	91	333	624	456	1920	**490**
AP01				277								**277**
BB04	346	356	360	245	284	331	491	295	605	491	450	**387**
BB05A	344	343	349	241	279	292	688	308	760	688	498	**435**

Table 3.12 Buckeye Brook Chemistry Data for Dry Weather Surveys

Station	BOD_5 (mg/L)			Chloride (mg/L)			TSS (mg/L)			pH			Hardness (mg/L)			TP (mg/L)		
	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean
BB00	2.00	1.00	**1.5**	92.2	76.20	**84.2**	0.0	1.00	**0.5**	7.66	6.55	**7.1**	50.0	40.0	**45.0**	0.03	0.03	**0.03**
BB02	1.00	1.00	**1.0**	56.1	46.90	**51.5**	1.0	4.00	**2.5**	7.39	6.90	**7.1**	48.0	41.0	**44.5**	0.02	<0.02	**0.02**
BB03	4.00	NS	**4.0**	46.9	NS	**46.9**	3.0	NS	**3.0**	9.22	NS	**9.2**	47.0	NS	**47.0**	0.02	NS	**0.02**
TA01	4.00	NS	**4.0**	46.2	NS	**46.2**	39.0	NS	**39.0**	7.41	NS	**7.4**	91.0	NS	**91.0**	0.19	NS	**0.19**
OF08	4.00	NS	**4.0**	79.0	NS	**79.0**	0.0	NS	**0.0**	7.22	NS	**7.2**	50.0	NS	**50.0**	<0.02	NS	**<0.02**
AP01	NS	1.00	**1.0**	NS	39.70	**39.7**	NS	5.00	**5.0**	NS	7.06	**7.1**	NS	43.0	**43.0**	NS	0.09	**0.09**
BB04	4.00	1.00	**2.5**	62.1	39.20	**50.7**	1.0	4.00	**2.5**	7.33	7.01	**7.2**	66.0	45.0	**55.5**	0.03	0.03	**0.03**
BB05A	3.00	1.00	**2.0**	59.2	38.60	**48.9**	0.0	**R**	**0.0**	7.53	7.13	**7.3**	64.0	44.0	**54.0**	0.03	0.03	**0.03**

Station	TKN (mg/L)			Ammonia-N (mg/L)			Nitrate- N (mg/L)			Arsenic (µg/L)			Cadmium (µg/L)			Copper (µg/L)		
	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean
BB00	0.55	0.52	**0.54**	0.40	0.31	**0.36**	0.78	0.82	**0.80**	0.38	0.29	**0.34**	0.16	0.08	**0.1**	1.82	2.10	**1.96**
BB02	ND	0.43	**0.43**	0.13	0.16	**0.15**	1.90	1.16	**1.53**	0.27	0.42	**0.35**	0.10	0.11	**0.1**	3.53	1.19	**2.36**
BB03	0.26	NS	**0.26**	0.13	NS	**0.13**	<0.05	NS	**<0.05**	0.66	NS	**0.66**	0.28	NS	**0.3**	2.35	NS	**2.35**
TA01	2.79	NS	**2.79**	2.72	NS	**2.72**	<0.05	NS	**<0.05**	1.87	NS	**1.87**	0.30	NS	**0.3**	1.40	NS	**1.40**
OF08	ND	NS	**ND**	0.13	NS	**ND**	0.67	NS	**0.67**	0.39	NS	**0.39**	0.16	NS	**0.2**	0.67	NS	**0.67**
AP01	NS	2.07	**2.07**	NS	1.71	**1.71**	NS	0.41	**0.41**	NS	0.97	**0.97**	NS	<0.06	**<0.06**	NS	1.08	**1.08**
BB04	0.88	0.71	**0.80**	0.85	0.30	**0.58**	0.24	<0.05	**0.24**	0.61	0.82	**0.72**	0.39	<0.06	**0.4**	5.73	1.24	**3.49**
BB05A	0.23	0.61	**0.42**	0.23	0.21	**0.22**	1.01	0.26	**0.64**	0.33	**R**	**0.49**	0.13	<0.06	**0.1**	1.62	1.68	**1.65**

Station	Lead (µg/L)			Manganese (µg/L)			Total Iron (µg/L)			Zinc (µg/L)			TOC (mg/L)	
	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08	Mean	7/16/08	9/10/08
BB00	0.59	<0.07	**0.59**	637	732	**685**	732	522	**627**	35.7	28.2	**32.0**	NA	1,900
BB02	0.44	<0.07	**0.44**	469	448	**459**	648	824	**736**	57.9	13.9	**35.9**	NA	580
BB03	1.93	NS	**1.93**	12	NS	**12**	186	NS	**186**	137.0	NS	**137.0**	NA	NS
TA01	0.90	NS	**0.90**	988	NS	**988**	11,586	NS	**11,586**	48.9	NS	**48.9**	NA	NS
OF08	0.45	NS	**ND**	880	NS	**880**	2,844	NS	**2,844**	22.1	NS	**22.1**	NA	NS
AP01	NS	<0.07	**<0.07**	NS	505	**505**	NS	3,008	**3,008**	NS	10.4	**10.4**	NA	17,000
BB04	1.62	0.18	**0.90**	335	142	**239**	2,078	1,258	**1,668**	30.2	7.1	**18.7**	NA	1,700
BB05A	0.51	<0.07	**0.51**	321	203	**262**	1,347	1,439	**1,393**	17.2	7.8	**12.5**	NA	2,500

NS = Not Sampled; ND = Non Detect; NA = Not Applicable; R=Rejected because data did not meet data quality objectives

Table 3.13 Buckeye Brook Chemistry Data for Wet Weather 1 (December9-11, 2008)

BOD_5 (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	<1.0	2.0	2.0	**2.0**
BB02	2.0	6.0	3.0	**3.7**
BB03	1.0	2.0	3.0	**2.0**
TA01	2.0	2.0	5.0	**3.0**
OF08	5.0	6.0	6.0	**5.7**
BB04	6.0	5.0	9.0	**6.7**
BB05A	6.0	5.0	7.0	**6.0**

Chloride (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	80.4	77.8	54.6	**70.9**
BB02	46.6	70.8	31.0	**49.5**
BB03	33.8	33.8	33.7	**33.8**
TA01	44.5	29.6	34.3	**36.1**
OF08	51.7	47.1	14.7	**37.8**
BB04	44.0	22.7	38.5	**35.1**
BB05A	44.7	47.6	35.8	**42.7**

TSS (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	<1.0	3.0	7.0	**5.0**
BB02	4.0	9.0	8.0	**7.0**
BB03	2.0	9.0	3.0	**4.7**
TA01	5.0	9.0	40.0	**18.0**
OF08	<1.0	9.0	8.0	**8.5**
BB04	6.0	10.0	6.0	**7.3**
BB05A	4.0	8.0	9.0	**7.0**

pH

Station	Pre-storm	Run 1	Run 2	Mean
BB00	6.67	6.15	6.52	**6.45**
BB02	7.23	6.30	6.58	**6.70**
BB03	7.76	7.29	7.46	**7.50**
TA01	7.18	6.80	6.99	**6.99**
OF08	7.21	6.47	6.72	**6.80**
BB04	7.05	6.60	6.89	**6.85**
BB05A	7.44	6.90	7.18	**7.17**

Hardness (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	51.0	44.0	37.0	**44.0**
BB02	52.0	32.0	24.0	**36.0**
BB03	51.0	42.0	52.0	**48.3**
TA01	98.0	45.0	50.0	**64.3**
OF08	42.0	15.0	15.0	**24.0**
BB04	58.0	53.0	45.0	**52.0**
BB05A	57.0	52.0	44.0	**51.0**

Total Phosphorus (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	<0.02	0.03	0.04	**0.04**
BB02	<0.02	0.05	0.03	**0.04**
BB03	<0.02	0.03	0.03	**0.03**
TA01	0.20	0.24	0.92	**0.45**
OF08	<0.02	0.11	0.07	**0.09**
BB04	<0.02	0.03	0.04	**0.04**
BB05A	0.03	0.04	0.04	**0.04**

TKN (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	0.37	ND	ND	**0.37**
BB02	ND	ND	ND	**ND**
BB03	0.31	0.25	0.36	**0.31**
TA01	7.28	31.10	5.26	**14.55**
OF08	ND	ND	ND	**ND**
BB04	0.80	0.96	0.66	**0.81**
BB05A	0.82	0.75	0.49	**0.69**

Ammonia-N (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	0.26	0.15	0.16	**0.16**
BB02	0.14	0.14	0.11	**0.13**
BB03	0.29	0.30	0.26	**0.28**
TA01	5.87	2.68	3.12	**2.90**
OF08	ND	0.13	ND	**0.13**
BB04	0.85	1.02	0.64	**0.83**
BB05A	0.75	0.66	0.44	**0.55**

Nitrate-N (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	1.53	1.07	0.98	**1.19**
BB02	1.59	0.83	<0.05	**1.21**
BB03	0.34	0.34	0.36	**0.35**
TA01	<0.05	0.10	0.09	**0.10**
OF08	0.79	0.30	0.31	**0.47**
BB04	0.34	0.30	0.30	**0.31**
BB05A	0.64	0.56	0.46	**0.55**

Arsenic (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	0.50	0.28	0.38	**0.39**
BB02	0.46	0.24	0.53	**0.41**
BB03	0.67	0.96	0.81	**0.81**
TA01	1.80	0.88	1.41	**1.36**
OF08	1.36	0.66	0.62	**0.88**
BB04	0.94	0.52	0.65	**0.70**
BB05A	0.62	0.62	0.40	**0.55**

Cadmium (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	0.40	0.17	0.16	**0.24**
BB02	0.18	0.22	0.39	**0.26**
BB03	0.15	<0.06	<0.06	**0.15**
TA01	0.58	0.08	0.09	**0.25**
OF08	0.17	0.19	0.19	**0.18**
BB04	0.11	<0.06	<0.06	**0.11**
BB05A	0.31	0.29	<0.06	**0.30**

Copper (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	1.80	2.04	2.22	**2.02**
BB02	1.03	3.37	2.19	**2.20**
BB03	0.98	0.89	0.72	**0.86**
TA01	2.01	1.04	1.83	**1.63**
OF08	0.74	4.26	2.66	**2.55**
BB04	1.21	0.90	0.88	**1.00**
BB05A	3.24	1.56	1.63	**2.14**

Lead (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	0.27	0.30	0.49	**0.35**
BB02	R	0.78	0.49	**0.64**
BB03	0.18	<0.07	0.18	**0.18**
TA01	1.51	0.94	1.70	**1.38**
OF08	0.08	1.08	0.20	**0.45**
BB04	0.61	<0.07	<0.07	**0.61**
BB05A	0.66	0.24	0.22	**0.37**

Manganese (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	932	821	598	**784**
BB02	796	382	387	**522**
BB03	220	199	176	**198**
TA01	1,197	489	389	**692**
OF08	962	228	176	**455**
BB04	621	634	528	**594**
BB05A	613	365	382	**453**

Total Iron (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	654	897	1,082	**878**
BB02	1,185	1,377	1,419	**1,327**
BB03	308	296	470	**358**
TA01	19,180	4,725	18,912	**14,272**
OF08	4,334	2,049	1,726	**2,703**
BB04	3,112	2,385	3,287	**2,928**
BB05A	1,112	1,991	1,423	**1,509**

Zinc (µg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	24.88	25.48	27.19	**25.85**
BB02	R	28.71	24.48	**26.60**
BB03	6.93	<6.46	<6.46	**6.93**
TA01	27.20	9.18	21.80	**19.39**
OF08	10.46	33.51	26.17	**23.38**
BB04	12.21	7.09	8.25	**9.18**
BB05A	9.87	20.64	25.43	**18.65**

Proplyene Glycol (mg/L)

Station	Pre-storm	Run 1	Run 2	Mean
BB00	ND	ND	ND	**ND**
BB02	ND	ND	ND	**ND**
BB03	---	---	---	---
TA01	---	---	---	---
OF08	ND	ND	ND	**ND**
BB04	ND	ND	ND	**ND**
BB05A	ND	ND	ND	**ND**

Sampling Dates: Prestorm -12/09/08; Run 1-12/10/08; Run 2- 12/11/08; ND = Non Detect; R=Rejected because data did not meet data quality objectives

Table 3.14 Buckeye Brook Chemistry Data for Wet Weather 2 (February 1-8, 2011)

BOD_5 (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	1.0	2.0	2.0	<1.0	**1.7**
BB02	3.0	15.0	15.0	14.0	**11.8**
BB03	1.0	1.0	R	<1.0	**1.0**
TA01	2.0	4.0	14.0	4.0	**6.0**
OF08	20.0	15.0	15.0	15.0	**16.3**
BB04	5.0	15.0	15.0	15.0	**12.5**
BB05A	4.0	15.0	14.0	11.0	**11.0**

Chloride (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	98.9	136.0	91.0	88.0	**103.5**
BB02	81.4	175.0	119.0	233.0	**152.1**
BB03	40.4	39.0	29.8	33.8	**35.8**
TA01	52.5	49.8	81.0	89.6	**68.2**
OF08	74.6	168.0	113.0	544.0	**224.9**
BB04	53.6	150.0	106.0	94.6	**101.1**
BB05A	55.3	203.0	156.0	93.6	**127.0**

TSS (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	3.0	13.0	8.0	28.0	**13.0**
BB02	4.0	2.0	3.0	12.0	**5.3**
BB03	1.0	2.0	R	<1.0	**1.5**
TA01	37.0	14.0	7.0	30.0	**22.0**
OF08	2.0	2.0	1.0	4.0	**2.3**
BB04	2.0	6.0	<1.0	R	**4.0**
BB05A	5.0	<1.0	7.0	4.0	**4.0**

pH

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	6.08	6.38	6.18	6.58	**6.31**
BB02	6.48	6.62	6.52	7.21	**6.71**
BB03	7.06	7.31	6.81	6.89	**7.02**
TA01	6.45	7.27	6.48	6.78	**6.75**
OF08	6.93	6.89	6.46	6.67	**6.74**
BB04	6.76	6.80	6.66	7.13	**6.84**
BB05A	6.81	7.07	6.72	6.98	**6.90**

Hardness (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	59.4	52.2	32.3	43.4	**46.8**
BB02	49.9	41.0	28.4	34.4	**38.4**
BB03	53.7	79.2	43.8	35.2	**53.0**
TA01	96.6	42.7	62.2	77.4	**69.7**
OF08	45.3	33.0	16.2	24.2	**29.7**
BB04	59.1	56.8	40.4	50.7	**51.8**
BB05A	60.4	59.0	36.2	44.4	**50.0**

Total Phosphorus (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	0.03	0.09	0.06	0.03	**0.05**
BB02	0.03	0.04	0.04	0.05	**0.04**
BB03	0.03	<0.02	<0.02	0.03	**0.03**
TA01	0.23	0.18	0.22	0.45	**0.27**
OF08	0.02	0.03	0.02	0.04	**0.03**
BB04	0.04	0.03	0.03	0.03	**0.03**
BB05A	0.04	0.02	0.04	0.03	**0.03**

TKN (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	1.19	1.03	1.06	1.15	**1.11**
BB02	1.07	1.33	1.34	1.42	**1.29**
BB03	1.18	1.22	1.21	1.16	**1.19**
TA01	2.80	2.47	2.33	3.07	**2.67**
OF08	0.87	1.10	1.05	1.22	**1.06**
BB04	1.63	2.21	1.57	1.57	**1.75**
BB05A	1.74	1.86	1.53	1.43	**1.64**

Ammonia-N (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	0.28	0.21	0.26	0.25	**0.25**
BB02	0.22	0.20	0.18	0.18	**0.20**
BB03	0.15	ND	0.16	0.20	**0.17**
TA01	1.99	1.14	1.44	1.38	**1.49**
OF08	0.13	ND	0.11	ND	**0.12**
BB04	0.74	0.64	0.62	0.53	**0.63**
BB05A	0.66	0.62	0.53	0.45	**0.57**

Nitrate-N (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	1.65	1.66	0.97	1.36	**1.41**
BB02	1.79	1.64	0.92	1.01	**1.34**
BB03	0.35	0.36	0.32	0.33	**0.34**
TA01	<0.05	<0.05	0.14	0.10	**0.12**
OF08	0.53	0.51	0.39	0.43	**0.47**
BB04	0.32	0.31	0.26	0.34	**0.31**
BB05A	0.42	0.39	0.30	0.38	**0.37**

Arsenic (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	0.14	0.26	0.38	0.27	**0.26**
BB02	0.21	0.37	0.52	0.41	**0.38**
BB03	0.27	0.35	0.57	0.44	**0.41**
TA01	0.24	0.61	0.49	0.55	**0.47**
OF08	0.67	0.37	0.64	0.48	**0.54**
BB04	0.24	0.30	0.35	0.25	**0.29**
BB05A	0.17	0.27	0.24	0.62	**0.33**

Cadmium (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	0.26	0.21	0.09	0.16	**0.18**
BB02	0.09	0.14	0.12	0.13	**0.12**
BB03	<0.05	<0.05	<0.05	<0.05	**<0.05**
TA01	0.09	<0.05	<0.05	<0.05	**0.09**
OF08	0.06	0.10	<0.05	0.20	**0.12**
BB04	0.14	<0.05	<0.05	0.06	**0.10**
BB05A	0.05	0.06	<0.05	0.14	**0.08**

Copper (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	1.33	2.16	2.17	1.53	**1.80**
BB02	1.30	2.32	4.05	3.32	**2.75**
BB03	2.94	1.05	1.63	0.81	**1.61**
TA01	1.40	1.48	1.34	1.36	**1.40**
OF08	1.03	1.74	3.59	4.22	**2.65**
BB04	1.52	1.71	2.35	1.46	**1.76**
BB05A	2.51	8.48	2.02	1.26	**3.57**

Lead (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	0.09	0.16	1.**28**	0.16	**0.42**
BB02	0.11	0.35	0.51	0.17	**0.29**
BB03	0.29	0.10	0.33	<0.08	**0.24**
TA01	0.73	0.19	0.22	0.37	**0.38**
OF08	<0.08	2.62	0.22	0.11	**0.98**
BB04	1.50	0.13	0.38	<0.08	**0.67**
BB05A	0.37	0.53	0.15	0.20	**0.31**

Manganese (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	768	810	512	726	**704**
BB02	858	1,169	481	526	**759**
BB03	393	467	433	391	**421**
TA01	1,247	1,012	689	835	**946**
OF08	1,599	945	383	494	**855**
BB04	663	713	555	550	**620**
BB05A	724	723	713	398	**640**

Total Iron (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	741	2,307	948	648	**1,161**
BB02	1,989	1,747	1,475	2,403	**1,904**
BB03	432	449	462	1,617	**740**
TA01	9,088	4,976	1,250	3,693	**4,752**
OF08	3,954	2,454	1,928	2,441	**2,694**
BB04	1,892	3,112	1,605	1,799	**2,102**
BB05A	1,010	1,168	981	1,172	**1,083**

Zinc (µg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	4.49	17.51	21.13	5.55	**12.17**
BB02	<1.12	13.60	22.60	<1.13	**18.10**
BB03	1.97	1.15	1.94	<1.13	**1.69**
TA01	3.36	1.44	1.91	<1.13	**2.24**
OF08	2.86	10.29	15.40	9.26	**9.45**
BB04	5.99	<1.13	3.30	<1.13	**4.65**
BB05A	4.13	14.86	2.68	<1.13	**7.22**

Proplyene Glycol (mg/L)

Station	Pre-storm	Run 1	Run 2	Run 3	Mean
BB00	ND	ND	ND	ND	**ND**
BB02	ND	45	44	45	**45**
BB03	ND	ND	ND	ND	**ND**
TA01	---	---	---	---	
OF08	ND	99	34	105	**79**
BB04	ND	23	ND	21	**22**
BB05A	---	---	---	---	

Sampling Dates: Prestorm -02/01/11; Run 1-02/03/11; Run 2- 02/06/11; Run 3- 02/08/11; ND = Non Detect; R=Rejected because data did not meet data quality objectives.

3.7 Biological Field Survey

The Biological Field survey for the two watersheds was conducted on September 10, 2008 to further characterize the extent and severity of the impairment while bracketing potential stressors from outfalls and tributaries to Warwick Pond and Buckeye Brook. Table 3.15 lists those stations selected for biological sampling, their locations and the type of assessment that was conducted by ESS Group, Inc. (ESS). Stations that were tested for toxicity are listed in Tables 3.2 and 3.3 for the dry and wet weather events.

Table 3.15 Stations Sampled by ESS in September, 2008

Station	Location	Assessments Conducted
Tributaries to Warwick Pond (RI0007024R-05)		
BB00	northern Tributary to Warwick Pond above Airport Road	Habitat Periphyton/Macroinvertebrate CPOM/FPOM
BB02	northern Tributary to Warwick Pond at Lakeshore Drive	Habitat Periphyton/Macroinvertebrate CPOM/FPOM
Buckeye Brook Watershed (RI0007024R-01)		
BB04	Buckeye Brook at Rufus Road	Habitat Periphyton/Macroinvertebrate CPOM/FPOM
BB05A	Buckeye Brook downstream of Old Warwick Avenue	Habitat Periphyton/Macroinvertebrate CPOM/FPOM
TA01	Unnamed tributary channel from Truk-Away Landfill	Habitat
OF08	Unnamed tributary channel from T.F. Green Airport Outfall 008	Habitat
AP01	Downstream channel combining flows from OF08 and TA01	Habitat Periphyton/Macroinvertebrate CPOM/FPOM
Adamsville Bk Reference Site	At the USGS Gage off of Route 81 in Little Compton, RI	Macroinvertebrate

Macroinvertebrates and periphyton are useful in biological monitoring because of the wide range of tolerances among taxa to various physical, chemical, and biological stressors. Coarse particulate organic matter (CPOM) and fine particulate organic matter (FPOM) were evaluated to assess the potential contribution of carbon availability and processing on observed patterns in the biological community. An evaluation of habitat quality is critical to any assessment as habitat and biological diversity in streams are closely linked. Habitat incorporates all aspects of

physical and chemical constituents along with the biotic interactions. The presence of an altered habitat structure is considered one of the major stressors of aquatic systems.

3.8 Results of Biological Sampling

The full report for the biological sampling on Buckeye Brook conducted by the ESS Group can be requested through RIDEM. Excerpts from the full report summarizing the conditions found in the Buckeye Brook watershed when compared against a reference site at Adamsville Brook (ESS45) are provided.

3.8.1 Stream Habitat

Overall stream habitat scores ranged from 83 to 144 on a 200 point scale and were compared against the reference site at Adamsville Brook (ESS45). Although the reference site was not assessed for stream habitat as part of the Buckeye Brook surveys, it was assessed in 2008 by ESS as part of the statewide wadeable stream biomonitoring effort. Table 3.16 lists the EPA stream habitat classifications and Table 3.17 shows the total habitat scores for each Buckeye Brook site as compared against the reference site.

Stream habitat was in the best condition above the T.F. Green Airport (BB00) and below Warwick Pond (BB04 and BB05A) and poorest in the tributary channels sourced from the airport outfalls and the Truk-Away Landfill. Compared to the reference site (ESS45), which received a score of 142, three stations (BB00, BB04, and BB05A) were comparable to reference, one station (BB02) was supporting and three stations (AP01, OF08, and TA01) were partially supporting. One station (BB05A) scored marginally higher on the stream habitat assessment than the reference site. These results indicate fairly poor stream habitat conditions exist throughout these two watershed areas and may be contributing to these stream's poor biological health. Stormwater discharges are likely contributing to at least some of these degraded habitat conditions (e.g. embeddedness, channel alteration, and sediment deposition).

3.8.2 Macroinvertebrate Results

Assessment of macroinvertebrate community in Buckeye Brook suggests that moderate to severe biological impairment exists across most, if not all, of the watershed. The moderate level of impairment at BB05A is consistent with assessments conducted by ESS just upstream at BB05 in previous years, as part of the statewide wadeable stream biomonitoring program. However, stations on and just downstream of the drainage channels sourced by T.F. Green Airport and the Truk-Away Landfill (BB02, AP01, and BB04) appear to be more severely impaired. At these stations, sensitive taxa are found in very low abundances, if at all, indicating high levels of disturbance. Table 3.18 shows the dominant taxon for the six biological stations.

Table 3.16 U.S EPA Habitat Attributes Assessed and Stream Habitat Classification

Site	Total Habitat Score	Instream Cover	Epifaunal Substrate	Embeddedness	Channel Alteration	Sediment Deposition	Frequency of Riffles	Channel Flow Status	Bank Vegetation Status	Bank Stability	Riparian Vegetative Zone Width
Tributaries to Warwick Pond (RI0007024R-05)											
BB00	SO	SO	M	SO	SO	SO	O	O	O	O	SO
BB02	SO	SO	M	**M**	SO	**M**	**M**	SO	O	O	O
Buckeye Brook Watershed (RI0007024R-01)											
BB04	SO	SO	M	M	O	O	M	SO	O	O	O
BB05A	SO	SO	M	M	O	O	M	SO	O	O	O
OF08	M	M	SO	O	SO	**M**	SO	**M**	SO	**P**	M
TA01	M	**P**	**P**	**P**	SO	O	**P**	**M**	O	O	SO
AP01	M	**P**	M	**P**	SO	**M**	M	O	SO	O	M
ESS45*	SO	O	M	O	SO	O	SO	O	SO	SO	SO

Classification Range: Poor (P) = 0-5; Total Score <50; Marginal (M) = 6-10; Total Score 51-100; Sub-optimal (SO) = 11-15; Total Score 101-150; Optimal (O) = 16-20; Total Score>150; Blue **Bold indicates values were <58% of the Reference Station**

Table 3.17 Summary Statistics for Stations Assessed under the Biological Survey

Summary Statistic	Tributaries to Warwick Pond		Buckeye Brook			ESS45
	BB00	BB02	BB04	BB05A	*AP01	
Total Taxa Richness	8.7	9.0	10.0	12.0	10.7	18.7
EPT Taxa Richness	1	0.7	1.7	2.0	0.0	7.0
EPT Abundance Per Kick Sample	94	1	16	80	0	282
Hilsenhoff-Biotic Index	5.94	8.26	8.02	6.26	7.59	4.08
Hilsenhoff-Water Quality	Fair	Poor	Poor	Fair	Poor	Very Good
Shannon Weaver Diversity Index	1.77	1.37	1.69	1.86	1.30	2.51
% Contribution of Dominant Taxon	45.1	56.2	46.0	34.5	65.2	22.0
Ratio of EPT to Chironomid Abundance	1.26	0.13	0.99	0.40	0.00	6.01
% Hydropsychidae to Total Trichoptera*	100	0.00	44.05	86.03	NA	45.53
Ratio Shredders/Total Number of Invertebrates	.02	0.03	0.00	0.03	0.00	0.02
Ratio Scrapers/Filterers	0.00	0.00	0.00	0.00	0.50	9.26
Community Loss Index	1.35	1.19	0.97	0.64	1.00	0.00
Relative Percent Similarity	30.4	26.1	17.4	39.1	17.4	NA
Biological Impairment Category	Moderately Impaired	Moderately Impaired	Severely Impaired	Moderately Impaired	Severely Impaired	Reference

*AP01 is the combined flows from the landfill (TA01) and the airport outfall 008.

Table 3.18 Dominant Taxon at the Biological Sampling Sites

Station	Dominant Taxon	Number
Tributaries to Warwick Pond		
BB00	Trichoptera (*Cheumatopsyche sp.*)	281
BB02	Oligochaeta (Tubificudae)	101
Buckeye Brook		
BB04	Amphipoda (*Gammarus sp.*)	284
BB05A	Diptera (*Tanytarsus sp.*)	214
AP01	Diptera (Tanytarsini)	427
ESS45	Trichoptera (*Chimarra sp.*)	208

Although measurements of dissolved oxygen in 2006 and 2008 have consistently shown a dissolved oxygen sag to marginal levels (near 5 mg/L) in the vicinity of BB04 and BB05A, there was no obvious sign of additional metabolic stress due to low dissolved oxygen within the macroinvertebrate community at these stations. However, the overall level of impairment within the Buckeye Brook watershed and the fact that riffle habitats - generally the best oxygenated habitats of each stream reach - were sampled for macroinvertebrates make it difficult to discern the specific biological impacts of the observed low dissolved oxygen concentrations. Overall, the macroinvertebrate sampling results indicate moderate to severe biological impairments across

most if not all of the watershed. The most severe impairments are found downstream of the tributaries fed by the airport outfalls and the landfill.

3.8.3 Periphyton Results

In the absence of a true reference site for periphyton, it is difficult to quantify the level of biological impairment over the Buckeye Brook watershed as a whole. However, there is some indication that certain periphyton metrics, such as taxa richness, may be somewhat less than expected for small streams in the ecoregion. Additionally, the relatively high contribution of taxa that tend to be associated with some form of instream disturbance (e.g., siltation, nutrient enrichment, flashiness) may be reflective of an overall depression in biological and habitat condition throughout the Buckeye Brook watershed. Habitat observations by ESS and nutrient data collected by RIDEM would appear to support this connection. Table 3.19 shows the Periphyton summary for the Buckeye Brook surveys while Table 3.20 shows the dominant Periphyton Taxa collected during the field surveys.

Table 3.19 Periphyton Summary Table for the September 10, 2008 Survey

Site	Average Generic Richness	Average % *Achanathes minutissima*	Average Diatom Pollution Tolerance Index	Average Biovolume ($\mu m^3/cm^2$)	Species Group	Average Biovolume ($\mu m^3/cm^2$)	Relative Biovolume (%)
Tributaries to Warwick Pond							
BB00	9.0	32.3	2.8	2.75E+05	blue-green	954	0.3
					cryptophyte	166	0.1
					diatom	210,728	76.7
					euglenoid	62,752	22.9
BB02	16.3	3.8	2.6	1.80E+06	blue-green	80,682	4.5
					cryptophyte	1,504	0.1
					diatom	1,665,236	92.6
					euglenoid	6,617	0.4
					green	43,303	2.4
Buckeye Brook							
BB04	14.7	5.2	2.4	5.46E+07	cryptophyte	510,937	0.9
					diatom	49,723,045	91.0
					euglenoid	1,132,075	2.1
					green	3,263,984	6.0
BB05A	16.7	1.0	2.3	7.52E+06	blue-green	581,101	7.7
					cryptophyte	340,210	4.5
					diatom	6,082,084	80.9
					euglenoid	483,790	6.4
					green	31,192	0.4
AP01	8.3	17.9	2.6	1.60E+07	cryptophyte	193,269	1.2
					diatom	11,365,208	69.3
					green	4,844,355	29.5

Table 3.20 Dominant Periphyton Taxa Collected for 2008 Biological Survey

Station	Group	Dominant Taxa (by Biovolume)
Tributaries to Warwick Pond		
BB00	Crytophytes	Rhodomonas
	Diatoms	Achnanthes, Cymbella, Epithemia, Cocconeis, Gomphonema, Tabellaria
	Euglenoids	Trachelomonas
BB02	Blue-greens	Oscillatoria
	Diatoms	Eunotia, Synedra, Nitzschia
Buckeye Brook		
BB04	Diatoms	Eunotia, Synedra, Navicula, Gomphoneis, Frustrulia
BB05A	Blue-greens	Oscillatoria
	Diatoms	Eunotia, Fragilaria, Synedra
	Euglenoids	Trachelomonas
AP01	Diatoms	Eunotia, Gomphonema, Synedra, Navicula, Achnanthes
	Greens	Cladophora

However, the trends in the periphyton community do not implicate a particular stressor or source in Buckeye Brook or the northern tributaries. This may be due, in part, to the fact that the periphyton community is generally responsive to shorter term impacts than the macroinvertebrate community.

The presence of an orange to brown-colored flocculent was noted at several stations but was heaviest at OF08, AP01, and TA01. This flocculent material is characteristic of the bacterial colonies that oxidize the iron associated with both natural sources and landfill groundwater leachate, including *Gallionella ferruginea* and *Leptothrix ochracea*. In excess, the flocculent material can smother coarse substrates and clog the interstitial areas used as refuge by macroinvertebrates.

Patterns in the concentration of CPOM and FPOM did not display any significant trend in the downstream direction. However, when the two size fractions are combined, a trend of steady increase is apparent in the downstream direction. Nonetheless, it is difficult to infer an association with the observed biological patterns from a single measurement of POM. Adjustment of sampling frequency to include additional samples, especially over a full event hydrograph, may be useful for future efforts.

3.9 Aquatic Toxicity Study

Two of the four surveys conducted for the biodiversity study had stations that were tested for aquatic toxicity by the EPA Laboratory in Chelmsford, MA. Section 4 of this report discusses the type of testing conducted and the stations selected for the testing. The section below will summarize the results of the dry and wet weather toxicity study. The full report is available at RIDEM upon request.

3.9.1 Dry Weather Toxicity Study

The dry weather toxicity survey was conducted from July 16-21, 2008 on six of the nine stations that were sampled during the biodiversity study for Buckeye Brook. The first sampling run on July 16, 2008 collected field data (Dissolved Oxygen, Specific Conductivity, and Temperature), chemistry and toxicity samples at the northern tributary station BB02, and at the Buckeye Brook stations BB03, BB04, BB05A, as well as the Truk-Away landfill (TA01) and airport (OF08) stations. Two other sampling runs were conducted every other day to collect water samples to replenish the water used in the toxicity tests at the EPA laboratory. This ensured that the water used in the toxicity tests would be fresh throughout the 7-day testing period.

Pimephales promelas (fathead minnow)
The results for the fathead minnow showed that neither the survivability nor the growth test (biomass) showed any statistically significant impact. One location (BB03) had a 5% lower survival rate when compared to the control and is not considered to be biologically significant. Examination of the test endpoint, growth, as shown by mean biomass, indicates that all but BB03 was equal to or greater than the mean biomass of the laboratory control sample. The biomass for the sample from BB03 was 18% lower, but not statistically different than the laboratory control as the 18% represents a difference of 0.11mg.

Ceriodaphnia dubia (daphnid)
The results for the *C. dubia* indicate that there was no statistically significant reduction in survival for any of the site location samples when compared to the laboratory control. However, statistical analysis of the reproduction data does show a statistically significant reduction in the number of neonates produced in samples from Truk-Away landfill (TA01) and from the airport outfall (OF08). Both TA01 and OF08 reproduction mean values were 44% below the laboratory control sample.

In summary, during the dry weather sampling, there were not any significant issues for toxicity for the fathead minnow at any station but that the daphnid did show some effects from the landfill and from the discharge for OF08 which drains the main passenger terminal at the airport. Results from the chemical analysis show that at these stations, total iron and dissolved cadmium exceeded the chronic fresh water criteria for the dry survey. The criteria for iron is 1000 µg/L and the values at TA01 and OF08 were 11,586 µg/L and 2,844 µg/L respectively. However, the

chronic criteria for iron was also exceed at Stations BB04 and BB05A but the results from the toxicity tests did not indicate any impact on the fathead minnow or the daphnid at these locations. The dissolved cadmium at TA01 and OF08 exceeded the chronic criteria by 30% and 6% respectively.

3.9.2 Wet Weather Toxicity Study

The second toxicity study was conducted during a winter, deicing conditions. Four sampling runs were conducted over a period of eight days starting February 1, 2011. Field measurements and chemistry samples were collected for all stations on every run, while toxicity sampling was only conducted at Stations BB00, BB02, BB03, BB04, OF08, and TA01 for the last three runs of the storm event. A summary of the results from the winter toxicity survey is given below.

The test acceptability criteria (TAC) and nonlethal variability limits (PMSDs) were met for *Pimephales promelas* (fathead minnow). TAC for the *Ceriodaphnia dubia* (daphnid) was met for the survival endpoint, however the test TAC for reproduction fell below criteria.

Pimephales promelas (fathead minnow)
All but one field sample, BB02, showed no significant statistical effect for survival. However, it was noted that due to the filamentous floc that developed in the test sample, it was a distinct possibility that the reduction in survival for BB02 may have been due to a physical impairment, rather than a true chemical effect. The survival rate for BB02 was 48% below the control sample, while all other stations were not affected.

There was a statistically significant reduction in biomass observed for Stations BB02, BB04, OF08, and TA01, while Stations BB00 and BB03 showed no signs of growth impairment. However, interpretation of the results for the stations showing growth impairment was difficult base solely upon the test findings due in part to difficulties maintaining dissolved oxygen levels throughout the test period. While dissolved oxygen levels for these samples dropped below the minimum 4 mg/L but it may have been more a physical entrainment issue caused by the filamentous floc that contributed to the reduction in growth. Station BB02 had the largest biomass deficit below the control sample at 64%, with stations BB04 at 22%, TA01 at 20% and OF08 at 34% below the control for the wet weather survey. The dissolved oxygen sags that occurred during the toxicity test may have been influenced by the propylene glycol levels for these samples. The mean glycol at BB02 was 45 mg/L and the associated BOD_5 demand was 16.3 mg/L. OF08 and BB04 had mean glycol values of 79 mg/L and 22 mg/L respectively, with the BOD_5 levels at 16.3 mg/L and 11.8 mg/L respectively.

Ceriodaphnia dubia (daphnid)
No significant effect on survival was observed for any sample stations for *Ceriodaphnia dubia*. The test failed to meet reproduction criteria. However, due to the difficulties capturing a winter storm event that met the parameters that occurred in this storm and the associated cost that would be incurred in doing so, the laboratory staff made the following observations in order to glean as much information from this test.

"The TAC are measured on the laboratory control organisms to evaluate, at least in part, test organism health. The laboratory controls represent the test organisms in the absence of any stressors. Therefore, it would be assumed that, barring lab personnel performance issues, any improvement in health would be reflected across all test exposures. The current neonate production data indicates a maximum reduction in production at 10% is associated with sample location at BB02. All other neonate production is equal to or greater than the laboratory control response."

The laboratory staff stated that if the test organism health was improved and the test did meet TAC or it was redone, a finding of no significant difference in reproduction for any of the samples would be the same. Therefore, it was decided to accept the results of the testing conducted on the *C. dubia* for this storm event.

In summary, the fathead minnow survival rate was not significantly impacted at any station except BB02 during the wet weather de-icing study. The reduced survival rate for BB02 was not a toxic response but likely due to a physical impairment from the filamentous floc in the sample. There was a significant difference in biomass growth for the minnow at stations BB02, BB04, TA01, and OF08 which may again be connected to the filamentous floc that developed in the test sample. The dissolved oxygen sag observed in the samples could be in response to the propylene glycol which uses oxygen during the degradation process.

The daphnid survival rate was not affected for the toxicity testing but the reproduction data failed to meet test criteria. Again the dissolved oxygen levels in the test samples may have been the cause of the low reproduction

REFERENCES

APHA, AWWA, WPCF. 1998. *Standard Methods for the Examination of Water and Wastewater. 20th Edition*. American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, D.C.

Center for Watershed Protection, March 2003, "Impacts of Impervious Cover on Aquatic Systems." (www.cwp.org)

EPA/ENSR, 2005. *Pilot TMDL Applications using the Impervious Cover Method*, October 2005.

ESS, 2002. *Quality Assurance Project Plan for Taxonomic Identification of Benthic Macroinvertebrates, Rhode Island. ESS Project No. R298-001*. Environmental Science Services, Inc., Wellesley, MA.

RIDEM 2006. *Water Quality Regulations, July 2006, Amended December 2010*, Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI. http://www.dem.ri.gov/pubs/regs/regs/water/h2oq10.pdf

RIDEM 2008. *Quality Assurance Project Plan: Sampling Plan to Characterize Buckeye Brook Biodiversity Impairment and Potential Causes and/or Pollution Sources Contributing to the Impairment, July, 2008*, Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.

RIDEM, 2012. State of RI and Providence Plantations 2012 Integrated Water Quality Monitoring and Integrated Report. Rhode Island Department of Environmental Management, Providence, RI. http://www.dem.ri.gov/programs/benviron/water/quality/pdf/iwqmon12.pdf

RIDEM, 2014. *State of RI and Providence Plantations, Consolidated Assessment and Listing Methodology For the Preparation of The Integrated Water Quality Monitoring and Assessment Report Pursuant to Clean Water Act Sections 303(d) and 305(b), 2014 Assessment and Listing Cycle*. Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.
http://www.dem.ri.gov/programs/benviron/water/quality/pdf/calm14.pdf

The Louis Berger Group, 2007. *Technical Report Data Analysis Summary for Odor and Iron Bacteria Investigation, T.F. Green Airport, Warwick, RI.* Albany, NY

APPENDIX A

Dry Weather Trace Metal Criteria Evaluations

CADMIUM (Cd)

Hardness as $CaCO_3$ (mg/L)		
Station	7/16/08	9/10/08
BB00	50.0	40.0
BB02	48.0	41.0
BB03	47.0	NS
BB04	66.0	45.0
BB05A	64.0	44.0
TA01	91.0	NS
OF08	50.0	NS
AP01	NS	43.0
WR01A	148.0	39.0

Cadmium Criteria (µg/L)				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00	1.03	**0.15**	0.83	0.13
BB02	0.99	0.15	0.85	0.13
BB03	0.97	**0.15**		
BB04	1.34	**0.18**	0.93	0.14
BB05A	1.30	0.18	0.91	0.14
TA01	1.84	**0.23**		
OF08	1.03	**0.15**		
AP01			0.89	0.14
WR01A	2.95	0.32	0.81	0.13

Cadmium Observed (µg/L)		
Station	7/16/08	9/10/08
BB00	**0.16**	0.08
BB02	0.10	0.11
BB03	**0.28**	NS
BB04	**0.39**	<0.06
BB05A	0.13	<0.06
TA01	**0.30**	NS
OF08	**0.16**	NS
AP01	NS	<0.06
WR01A	<0.06	<0.06

Dry Wx Cadmium Exceedances				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00		EXD		
BB02				
BB03		EXD		
BB04		EXD		
BB05A				
TA01		EXD		
OF08		EXD		
AP01				
WR01A				

COPPER (Cu)

Hardness as $CaCO_3$ (mg/L)		
Station	7/16/08	9/10/08
BB00	50.0	40.0
BB02	48.0	41.0
BB03	47.0	NS
BB04	66.0	45.0
BB05A	64.0	44.0
TA01	91.0	NS
OF08	50.0	NS
AP01	NS	43.0
WR01A	148.0	39.0

Copper Criteria (µg/L)				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00	6.99	4.95	5.67	4.09
BB02	6.73	4.78	5.80	4.18
BB03	6.60	4.70		
BB04	9.09	6.28	6.33	4.53
BB05A	8.83	6.12	6.20	4.44
TA01	12.30	8.26		
OF08	6.99	4.95		
AP01			6.07	4.35
WR01A	19.44	12.52	5.53	4.01

Copper (µg/L) Observed		
Station	7/16/08	9/10/08
BB00	1.82	2.10
BB02	3.53	1.19
BB03	2.35	NS
BB04	5.73	1.24
BB05A	1.62	1.68
TA01	1.40	NS
OF08	0.67	NS
AP01	NS	1.08
WR01A	1.81	2.76

Dry Wx Copper Exceedances				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00				
BB02				
BB03				
BB04				
BB05A				
TA01				
OF08				
AP01				
WR01A				

LEAD(Pb)

Hardness as $CaCO_3$ (mg/L)		
Station	7/16/08	9/10/08
BB00	50.0	40.0
BB02	48.0	41.0
BB03	47.0	NS
BB04	66.0	45.0
BB05A	64.0	44.0
TA01	91.0	NS
OF08	50.0	NS
AP01	NS	43.0
WR01A	148.0	39.0

Lead Criteria (µg/L)				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00	30.14	1.17	23.51	0.92
BB02	28.80	1.12	24.17	0.94
BB03	28.13	**1.10**		
BB04	40.97	**1.60**	26.81	1.04
BB05A	39.60	1.54	26.14	1.02
TA01	58.27	2.27		
OF08	30.14	1.17		
AP01			25.48	0.99
WR01A	98.70	3.85	22.86	0.89

Lead Observed (µg/L)		
Station	7/16/08	9/10/08
BB00	0.59	<0.07
BB02	0.44	<0.07
BB03	**1.93**	NS
BB04	**1.62**	0.18
BB05A	0.51	<0.07
TA01	0.90	NS
OF08	0.45	NS
AP01	NS	<0.07
WR01A	0.27	0.08

Dry Wx Lead Exceedances				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00				
BB02				
BB03		EXD		
BB04		EXD		
BB05A				
TA01				
OF08				
AP01				
WR01A				

ZINC (Zn)

Hardness as $CaCO_3$ (mg/L)		
Station	7/16/08	9/10/08
BB00	50.0	40.0
BB02	48.0	41.0
BB03	47.0	NS
BB04	66.0	45.0
BB05A	64.0	44.0
TA01	91.0	NS
OF08	50.0	NS
AP01	NS	43.0
WR01A	148.0	39.0

Zinc Criteria (µg/L)				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00	65.13	65.66	53.91	54.35
BB02	62.92	63.43	55.05	55.50
BB03	**61.81**	**62.31**		
BB04	82.41	83.08	59.57	60.06
BB05A	80.28	80.94	58.45	58.92
TA01	108.18	109.07		
OF08	65.13	65.66		
AP01			57.32	57.79
WR01A	163.35	164.69	52.77	53.20

Zinc Observed (µg/L)		
Station	7/16/08	9/10/08
BB00	35.70	28.20
BB02	57.90	13.90
BB03	**137.00**	NS
BB04	30.20	7.14
BB05A	17.20	7.75
TA01	48.90	NS
OF08	22.10	NS
AP01	NS	10.40
WR01A	19.20	17.20

Dry Wx Zinc Exceedances				
Station	7/16/08		9/10/08	
	Acute	Chronic	Acute	Chronic
BB00				
BB02				
BB03	EXD	EXD		
BB04				
BB05A				
TA01				
OF08				
AP01				
WR01A				

Cadmium (Cd) Wet Weather 1 Chronic Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

AVE Hardness

Station	(mg/L)
BB00	44.0
BB02	36.0
BB03	48.3
BB04	52.0
BB05A	51.0
TA01	64.3
OF08	24.0
WR01A	47.3

WW1 Chronic Criteria

Station	Cd (µg/L)
BB00	**0.14**
BB02	**0.12**
BB03	0.15
BB04	0.16
BB05A	**0.15**
TA01	**0.18**
OF08	**0.09**
WR01A	0.15

Cadmium Observed (µg/L)

Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	0.40	0.17	0.16
BB02	0.18	0.22	0.39
BB03	0.15	<0.06	<0.06
BB04	0.11	<0.06	<0.06
BB05A	0.31	0.29	<0.06
TA01	0.58	0.08	0.09
OF08	0.17	0.19	0.19
WR01A	0.12	0.06	0.07

AVE Observed Cd

Station	(µg/L)
BB00	**0.24**
BB02	**0.26**
BB03	0.15
BB04	0.11
BB05A	**0.30**
TA01	**0.25**
OF08	**0.18**
WR01A	0.08

WW1 Cd Chronic Exceedances

Station	Chronic
BB00	EXD
BB02	EXD
BB03	
BB04	
BB05A	EXD
TA01	EXD
OF08	EXD
WR01A	

Cadmium (Cd) Wet Weather 1 Acute Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

Cd WW1 Acute Criteria (µg/L)

Station	Prestm	Run 1	Run 2
BB00	1.05	0.91	0.77
BB02	1.07	0.66	0.50
BB03	1.05	0.87	1.07
BB04	1.19	1.09	0.93
BB05A	1.17	1.07	0.91
TA01	1.97	0.93	1.03
OF08	0.87	0.32	0.32
WR01A	1.21	0.93	0.79

Cadmium Observed (µg/L)

Station	Prestm	Run 1	Run 2
BB00	0.40	0.17	0.16
BB02	0.18	0.22	0.39
BB03	0.15	<0.06	<0.06
BB04	0.11	<0.06	<0.06
BB05A	0.31	0.29	<0.06
TA01	0.58	0.08	0.09
OF08	0.17	0.19	0.19
WR01A	0.12	0.06	0.07

WW1 Cadmium Acute Exceedances

Station	Prestm	Run 1	Run 2
BB00			
BB02			
BB03			
BB04			
BB05A			
TA01			
OF08			
WR01A			

Cadmium (Cd) Wet Weather 2 Chronic Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

AVE Hardness (mg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	55.8	42.3	37.9
BB02	45.5	34.7	31.4
BB03	66.5	61.5	39.5
BB04	58.0	48.6	45.6
BB05A	59.7	47.6	40.3
TA01	69.7	52.5	69.8
OF08	39.2	24.6	20.2
WR01A	61.7	57.7	51.7

WW2 Chronic Criteria (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	**0.16**	**0.14**	0.13
BB02	0.14	**0.12**	**0.11**
BB03	0.19	0.18	0.13
BB04	0.17	0.15	0.14
BB05A	0.17	0.15	0.13
TA01	0.19	0.16	0.19
OF08	0.13	0.09	**0.08**
WR01A	0.18	0.17	0.16

Cadmium Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	0.26	0.21	0.09	0.16
BB02	0.09	0.14	0.12	0.13
BB03	<0.05	<0.05	<0.05	<0.05
BB04	0.14	<0.05	<0.05	0.06
BB05A	0.05	0.06	<0.05	0.14
TA01	0.09	<0.05	<0.05	<0.05
OF08	0.06	0.10	<0.05	0.20
WR01A	0.05	0.08	0.06	0.07

AVE Observed Cd (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	**0.24**	**0.15**	0.13
BB02	0.12	**0.13**	**0.13**
BB03	<0.05	<0.05	<0.05
BB04	0.14	<0.05	0.06
BB05A	0.06	0.06	0.14
TA01	0.09	<0.05	<0.05
OF08	0.08	0.10	**0.20**
WR01A	0.07	0.07	0.07

WW2 Cd Chronic Exceedances

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	**EXD**	**EXD**	
BB02		**EXD**	**EXD**
BB03			
BB04			
BB05A			
TA01			
OF08			**EXD**
WR01A			

Cadmium (Cd) Wet Weather 2 Acute Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

Cd WW2 Acute Criteria (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	1.21	1.07	0.67	0.89
BB02	1.02	0.85	0.59	0.71
BB03	1.10	1.61	0.90	0.73
BB04	1.21	1.16	0.83	1.04
BB05A	1.23	1.21	0.75	0.91
TA01	1.95	0.88	1.27	1.57
OF08	0.93	0.68	0.34	0.50
WR01A	1.22	1.30	1.06	1.06

Cadmium Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	0.26	0.21	0.09	0.16
BB02	0.09	0.14	0.12	0.13
BB03	<0.05	<0.05	<0.05	<0.05
BB04	0.14	<0.05	<0.05	0.06
BB05A	0.05	0.06	<0.05	0.14
TA01	0.09	<0.05	<0.05	<0.05
OF08	0.06	0.10	<0.05	0.20
WR01A	0.05	0.08	0.06	0.07

WW2 Cadmium Acute Exceedances

Station	Prestm	Run 1	Run 2	Run 3
BB00				
BB02				
BB03				
BB04				
BB05A				
TA01				
OF08				
WR01A				

Copper (Cu) Wet Weather 1 Chronic Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)			
Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

AVE Hardness	
Station	(mg/L)
BB00	44.0
BB02	36.0
BB03	48.3
BB04	52.0
BB05A	51.0
TA01	64.3
OF08	24.0
WR01A	47.3

WW1 Chronic Criteria	
Station	Cu (µg/L)
BB00	4.44
BB02	3.74
BB03	4.81
BB04	5.12
BB05A	5.04
TA01	6.14
OF08	2.65
WR01A	4.73

Copper Observed (µg/L)			
Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	1.80	2.04	2.22
BB02	1.03	3.37	2.19
BB03	0.98	0.89	0.72
BB04	1.21	0.90	0.88
BB05A	3.24	1.56	1.63
TA01	2.01	1.04	1.83
OF08	0.74	4.26	2.66
WR01A	1.15	1.42	1.47

AVE Observed Cu	
Station	(µg/L)
BB00	2.02
BB02	2.20
BB03	0.86
BB04	1.00
BB05A	2.14
TA01	1.63
OF08	2.55
WR01A	1.35

WW1 Cu Chronic Exceedances	
Station	Chronic
BB00	
BB02	
BB03	
BB04	
BB05A	
TA01	
OF08	
WR01A	

Copper (Cu) Wet Weather 1 Acute Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)			
Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

Cu WW1 Acute Criteria (µg/L)			
Station	Prestm	Run 1	Run 2
BB00	7.13	6.20	5.27
BB02	7.26	4.59	3.50
BB03	7.13	5.93	7.26
BB04	8.04	7.39	6.33
BB05A	7.91	7.26	6.20
TA01	13.2	6.33	6.99
OF08	5.93	**2.25**	**2.25**
WR01A	8.17	6.33	5.40

Copper Observed (µg/L)			
Station	Prestm	Run 1	Run 2
BB00	1.80	2.04	2.22
BB02	1.03	3.37	2.19
BB03	0.98	0.89	0.72
BB04	1.21	0.90	0.88
BB05A	3.24	1.56	1.63
TA01	2.01	1.04	1.83
OF08	0.74	**4.26**	**2.66**
WR01A	1.15	1.42	1.47

WW1 Copper Acute Exceedances			
Station	Prestm	Run 1	Run 2
BB00			
BB02			
BB03			
BB04			
BB05A			
TA01			
OF08		EXD	EXD
WR01A			

Copper (Cu) Wet Weather 2 Chronic Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

AVE Hardness (mg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	55.8	42.3	37.9
BB02	45.5	34.7	31.4
BB03	66.5	61.5	39.5
BB04	58.0	48.6	45.6
BB05A	59.7	47.6	40.3
TA01	69.7	52.5	69.8
OF08	39.2	24.6	20.2
WR01A	61.7	57.7	51.7

WW2 Chronic Criteria (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	5.44	4.29	3.90
BB02	4.57	3.63	**3.33**
BB03	6.32	5.91	4.05
BB04	5.62	4.83	4.57
BB05A	5.76	**4.75**	4.12
TA01	6.57	5.16	6.59
OF08	4.02	2.70	**2.28**
WR01A	5.92	5.59	5.09

Copper Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	1.33	2.16	2.17	1.53
BB02	1.30	2.32	4.05	3.32
BB03	2.94	1.05	1.63	0.81
BB04	1.52	1.71	2.35	1.46
BB05A	2.51	8.48	2.02	1.26
TA01	1.40	1.48	1.34	1.36
OF08	1.03	1.74	3.59	4.22
WR01A	2.61	2.63	3.08	2.43

AVE Observed Cu (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	1.75	2.17	1.85
BB02	1.81	3.19	**3.69**
BB03	2.00	1.34	1.22
BB04	1.62	2.03	1.91
BB05A	5.50	**5.25**	1.64
TA01	1.44	1.41	1.35
OF08	1.39	2.67	**3.91**
WR01A	2.62	2.86	2.76

WW2 Cu Chronic Exceedances

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00			
BB02			EXD
BB03			
BB04			
BB05A		EXD	
TA01			
OF08			EXD
WR01A			

Copper (Cu) Wet Weather 2 Acute Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

Cu WW2 Acute Criteria (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	8.23	7.28	4.63	6.12
BB02	6.98	5.80	4.10	4.92
BB03	7.48	10.8	6.17	5.02
BB04	8.19	7.89	5.72	7.09
BB05A	8.36	**8.17**	5.16	6.25
TA01	13.0	6.03	8.59	10.6
OF08	6.37	4.73	**2.42**	**3.53**
WR01A	8.25	8.79	7.20	7.22

Copper Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	1.33	2.16	2.17	1.53
BB02	1.30	2.32	4.05	3.32
BB03	2.94	1.05	1.63	0.81
BB04	1.52	1.71	2.35	1.46
BB05A	2.51	**8.48**	2.02	1.26
TA01	1.40	1.48	1.34	1.36
OF08	1.03	1.74	**3.59**	**4.22**
WR01A	2.61	2.63	3.08	2.43

WW2 Cu Acute Exceedances

Station	Prestm	Run 1	Run 2	Run 3
BB00				
BB02				
BB03				
BB04				
BB05A		EXD		
TA01				
OF08			EXD	EXD
WR01A				

Lead (Pb) Wet Weather 1 Chronic Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

AVE Hardness

Station	(mg/L)
BB00	44.0
BB02	36.0
BB03	48.3
BB04	52.0
BB05A	51.0
TA01	64.3
OF08	24.0
WR01A	47.3

WW1 Chronic Criteria

Station	Pb (µg/L)
BB00	1.02
BB02	0.81
BB03	1.13
BB04	1.23
BB05A	1.20
TA01	1.55
OF08	0.52
WR01A	1.11

Lead Observed (µg/L)

Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	0.27	0.30	0.49
BB02	0.34	0.78	0.49
BB03	0.18	<0.07	0.18
BB04	0.61	<0.07	<0.07
BB05A	0.66	0.24	0.22
TA01	1.51	0.94	1.70
OF08	0.08	1.08	0.20
WR01A	0.26	0.44	0.54

AVE Observed Pb

Station	(µg/L)
BB00	0.35
BB02	0.54
BB03	0.18
BB04	0.61
BB05A	0.37
TA01	1.38
OF08	0.45
WR01A	0.41

WW1 Pb Chronic Exceedances

Station	Chronic
BB00	
BB02	
BB03	
BB04	
BB05A	
TA01	
OF08	
WR01A	

Lead (Pb) Wet Weather 1 Acute Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

Pb WW1 Acute Criteria (µg/L)

Station	Prestm	Run 1	Run 2
BB00	30.81	26.14	21.55
BB02	31.48	18.32	13.26
BB03	30.81	24.82	31.48
BB04	35.52	32.15	26.81
BB05A	34.84	31.48	26.14
TA01	63.18	26.81	30.14
OF08	24.82	7.30	7.30
WR01A	36.20	26.81	22.20

Lead Observed (µg/L)

Station	Prestm	Run 1	Run 2
BB00	0.27	0.30	0.49
BB02	0.34	0.78	0.49
BB03	0.18	<0.07	0.18
BB04	0.61	<0.07	<0.07
BB05A	0.66	0.24	0.22
TA01	1.51	0.94	1.70
OF08	0.08	1.08	0.20
WR01A	0.26	0.44	0.54

WW1 Lead Acute Exceedances

Station	Prestm	Run 1	Run 2
BB00			
BB02			
BB03			
BB04			
BB05A			
TA01			
OF08			
WR01A			

Lead (Pb) Wet Weather 2 Chronic Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

AVE Hardness (mg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	55.8	42.3	37.9
BB02	45.5	34.7	31.4
BB03	66.5	61.5	39.5
BB04	58.0	48.6	45.6
BB05A	59.7	47.6	40.3
TA01	69.7	52.5	69.8
OF08	39.2	24.6	20.2
WR01A	61.7	57.7	51.7

WW2 Chronic Criteria (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	1.33	0.97	0.86
BB02	1.06	0.78	0.70
BB03	1.61	1.48	0.90
BB04	1.38	1.14	1.06
BB05A	1.43	1.11	0.92
TA01	1.69	1.24	1.70
OF08	**0.89**	**0.53**	0.43
WR01A	1.48	1.37	1.22

Lead Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	0.09	0.16	1.28	0.16
BB02	0.11	0.35	0.51	0.17
BB03	0.29	0.10	0.33	<0.08
BB04	1.50	0.13	0.38	<0.08
BB05A	0.37	0.53	0.15	0.20
TA01	0.73	0.19	0.22	0.37
OF08	<0.08	2.62	0.22	0.11
WR01A	0.34	0.49	0.64	0.48

AVE Observed Pb (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	0.13	0.72	0.72
BB02	0.23	0.43	0.34
BB03	0.20	0.22	0.33
BB04	0.82	0.26	0.38
BB05A	0.45	0.34	0.18
TA01	0.46	0.21	0.30
OF08	**2.62**	**1.42**	0.17
WR01A	0.42	0.57	0.56

WW2 Pb Chronic Exceedances

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00			
BB02			
BB03			
BB04			
BB05A			
TA01			
OF08	**EXD**	**EXD**	
WR01A			

Lead (Pb) Wet Weather 2 Acute Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

Pb WW2 Acute Criteria (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	36.47	31.61	18.51	27.75
BB02	30.07	24.17	16.02	19.86
BB03	32.62	50.06	26.01	20.38
BB04	36.27	34.71	23.77	30.60
BB05A	37.15	36.20	21.03	26.41
TA01	62.19	25.29	38.37	48.81
OF08	37.01	18.96	8.50	13.38
WR01A	36.61	39.39	31.21	31.27

Lead Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	0.09	0.16	1.28	0.16
BB02	0.11	0.35	0.51	0.17
BB03	0.29	0.10	0.33	<0.08
BB04	1.50	0.13	0.38	<0.08
BB05A	0.37	0.53	0.15	0.20
TA01	0.73	0.19	0.22	0.37
OF08	<0.08	2.62	0.22	0.11
WR01A	0.34	0.49	0.64	0.48

WW2 Lead Acute Exceedances

Station	Prestm	Run 1	Run 2	Run 3
BB00				
BB02				
BB03				
BB04				
BB05A				
TA01				
OF08				
WR01A				

Zinc (Zn) Wet Weather 1 Chronic Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)			
Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

AVE Hardness	
Station	(mg/L)
BB00	44.0
BB02	36.0
BB03	48.3
BB04	52.0
BB05A	51.0
TA01	64.3
OF08	24.0
WR01A	47.3

WW1 Chronic Criteria	
Station	Zn (µg/L)
BB00	58.92
BB02	49.71
BB03	63.81
BB04	67.88
BB05A	66.78
TA01	81.30
OF08	35.26
WR01A	62.68

Zinc Observed (µg/L)			
Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	24.88	25.48	27.19
BB02	13.32	28.71	24.48
BB03	6.93	<6.46	<6.46
BB04	12.21	7.09	8.25
BB05A	9.87	20.64	25.43
TA01	27.20	9.18	21.80
OF08	10.46	33.51	26.17
WR01A	15.06	15.17	14.43

AVE Observed Zn	
Station	(µg/L)
BB00	25.9
BB02	22.2
BB03	6.93
BB04	9.18
BB05A	18.6
TA01	19.4
OF08	23.4
WR01A	14.9

WW1 Zn Chronic Exceedances	
Station	Chronic
BB00	
BB02	
BB03	
BB04	
BB05A	
TA01	
OF08	
WR01A	

Zinc (Zn) Wet Weather 1 Acute Criteria Evaluation

WW1 Hardness as $CaCO_3$ (mg/L)			
Station	Prestm 12/9/08	Run 1 12/10/08	Run 2 12/11/08
BB00	51.0	44.0	37.0
BB02	52.0	32.0	24.0
BB03	51.0	42.0	52.0
BB04	58.0	53.0	45.0
BB05A	57.0	52.0	44.0
TA01	98.0	45.0	50.0
OF08	42.0	15.0	15.0
WR01A	59.0	45.0	38.0

Zn WW1 Acute Criteria (µg/L)			
Station	Prestm	Run 1	Run 2
BB00	66.23	58.45	50.47
BB02	67.33	44.62	34.97
BB03	66.23	56.19	67.33
BB04	73.86	68.43	59.57
BB05A	72.78	67.33	58.45
TA01	115.19	59.57	65.13
OF08	56.19	**23.48**	**23.48**
WR01A	74.94	59.57	51.62

Zn Observed (µg/L)			
Station	Prestm	Run 1	Run 2
BB00	24.88	25.48	27.19
BB02	13.32	28.71	24.48
BB03	6.93	<6.46	<6.46
BB04	12.21	7.09	8.25
BB05A	9.87	20.64	25.43
TA01	27.20	9.18	21.80
OF08	10.46	**33.51**	**26.17**
WR01A	15.06	15.17	14.43

WW1 Zinc Acute Exceedances			
Station	Prestm	Run 1	Run 2
BB00			
BB02			
BB03			
BB04			
BB05A			
TA01			
OF08		EXD	EXD
WR01A			

Zinc (Zn) Wet Weather 2 Chronic Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

AVE Hardness (mg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	55.8	42.3	37.9
BB02	45.5	34.7	31.4
BB03	66.5	61.5	39.5
BB04	58.0	48.6	45.6
BB05A	59.7	47.6	40.3
TA01	69.7	52.5	69.8
OF08	39.2	24.6	20.2
WR01A	61.7	57.7	51.7

WW2 Chronic Criteria (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	72.06	56.93	51.87
BB02	60.56	48.19	44.27
BB03	83.56	78.25	53.78
BB04	74.41	64.10	60.68
BB05A	76.31	62.98	54.70
TA01	86.96	68.38	87.11
OF08	53.37	36.00	30.47
WR01A	78.42	74.08	67.50

Zinc Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	4.49	17.51	21.13	5.55
BB02	<1.12	13.60	22.60	<1.12
BB03	1.97	1.15	1.94	<1.12
BB04	5.99	<1.12	3.30	<1.12
BB05A	4.13	14.86	2.68	<1.12
TA01	3.36	1.44	1.91	<1.12
OF08	2.86	10.29	15.40	9.26
WR01A	13.64	29.74	28.00	16.72

AVE Observed Zn (µg/L)

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00	11.00	19.32	13.34
BB02	13.60	18.10	22.60
BB03	1.56	1.55	1.94
BB04	5.99	3.30	3.30
BB05A	9.50	8.77	2.68
TA01	2.40	1.68	1.91
OF08	6.58	12.85	12.33
WR01A	21.69	28.87	22.36

WW2 Zn Chronic Exceedances

Station	Ave Pre+R1	Ave R1+R2	Ave R2+R3
BB00			
BB02			
BB03			
BB04			
BB05A			
TA01			
OF08			
WR01A			

Zinc (Zn) Wet Weather 2 Acute Criteria Evaluation

WW2 Hardness as $CaCO_3$ (mg/L)

Station	Prestm 02/01/11	Run 1 02/03/11	Run 2 02/06/11	Run 3 02/08/11
BB00	59.4	52.2	32.3	43.4
BB02	49.9	41.0	28.4	34.4
BB03	53.7	79.2	43.8	35.2
BB04	59.1	56.8	40.4	50.7
BB05A	60.4	59.0	36.2	44.4
TA01	96.6	42.7	62.2	77.4
OF08	45.3	33.0	16.2	24.2
WR01A	59.6	63.7	51.6	51.7

Pb WW2 Acute Criteria (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	75.37	67.55	44.98	57.77
BB02	65.02	55.05	40.33	47.44
BB03	69.19	96.17	58.22	48.38
BB04	75.04	72.56	54.37	65.90
BB05A	76.44	74.94	49.54	58.90
TA01	113.80	56.98	78.37	94.32
OF08	59.91	45.80	25.07	35.22
WR01A	75.58	79.97	66.89	67.00

Zinc Observed (µg/L)

Station	Prestm	Run 1	Run 2	Run 3
BB00	4.49	17.51	21.13	5.55
BB02	<1.12	13.60	22.60	<1.12
BB03	1.97	1.15	1.94	<1.12
BB04	5.99	<1.12	3.30	<1.12
BB05A	4.13	14.86	2.68	<1.12
TA01	3.36	1.44	1.91	<1.12
OF08	2.86	10.29	15.40	9.26
WR01A	13.64	29.74	28.00	16.72

WW2 Zinc Acute Exceedances

Station	Prestm	Run 1	Run 2	Run 3
BB00				
BB02				
BB03				
BB04				
BB05A				
TA01				
OF08				
WR01A				

Total Iron (Fe) Chronic Criteria Evaluation

Total Iron (µg/L) Dry Weather Chronic Criteria Evaluation

Station	7/16/08	9/10/08
BB00	732	522
BB02	648	824
BB03	186	NS
BB04	**2,078**	**1,258**
BB05A	**1,347**	**1,439**
TA01	**11,586**	NS
OF08	**2,844**	NS
AP01	NS	**3,008**
WR01A	810	673

Total Iron (µg/L) Wet Weather 1 Chronic Criteria Evaluation

Station	Prestorm 12/9/08	Run 1 12/10/08	Run 2 12/11/08	Mean
BB00	654	897	1,082	878
BB02	1,185	1,377	1,419	**1,327**
BB03	308	296	470	358
BB04	3,112	2,385	3,287	**2,928**
BB05A	1,112	1,991	1,423	**1,509**
TA01	19,180	4,725	18,912	**14,272**
OF08	4,334	2,049	1,726	**2,703**
WR01A	353	481	723	519

Total Iron (µg/L) Wet Weather 1 Chronic Criteria Evaluation

Station	Prestorm 02/01/11	Run 1 02/03/11	Ave Pre-Run1	Run 2 02/06/11	Ave Run 1-2	Run 3 02/08/11	Ave Run 2-3
BB00	741	2,307	**1,524**	948	**1,628**	648	798
BB02	1,989	1,747	**1,868**	1,475	**1,611**	2,403	**1,939**
BB03	432	449	441	462	456	1,617	**1,040**
BB04	1,892	3,112	**2,502**	1,605	**2,359**	1,799	**1,702**
BB05A	1,010	1,168	**1,089**	981	**1,075**	1,172	**1,077**
TA01	9,088	4,976	**7,032**	1,250	**3,113**	3,693	**2,472**
OF08	3,954	2,454	**3,204**	1,928	**2,191**	2,441	**2,185**
WR01A	300	338	319	283	311	293	288

Bold and Shaded = Exceeded Criteria (1000 µg/L)