BLACKSTONE RIVER WATERSHED
SMART MONITORING PROGRAM 2011-2013

Technical Memorandum CN 413.0

West River, Uxbridge

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TABLE OF CONTENTS

LIST OF TABLES

Cover photo by Therese Beaudoin, MassDEP. 30 January 2013.
All photos in document taken by Therese Beaudoin. MassDEP. CERO.
SMART monitoring logo designed by Robert Kimball and Barbara Kimball.

LIST OF FIGURES

LIST OF LATIN NAMES

Latin Name	Common name	Latin Name	Common name
Accipitridae family	hawk	*Lobelia cardinalis*	cardinal flower
Agelaius phoeniceus	red-winged blackbird	*Lythrum salicaria*	purple loosestrife
Anas platyrhynchos	mallard duck	*Martes pennanti*	fisher
Anura order	frogs	*Peltandra virginica*	arrow arum
Ardea herodias	great blue heron	*Pontederia cordata*	pickerelweed
Branta canadensis	Canada goose	*Potamogeton* spp.	pondweeds
Brasenia schreberi	watershield	*Potamogeton epihydrus*	ribbonleaf pondweed
Buteo jamaicensis	red-tailed hawk	*Procyon lotor*	raccoon
Callitriche sp.	water starwort	*Rana catesbeiana*	bullfrog
Cabomba caroliniana	fanwort	*Sagittaria* sp.	arrowhead
Elodea canadensis	waterweed	*Typha latifolia*	common cattail
Gerridae family	water strider	*Vallisneria americana*	wild celery
Gramineae family	true grasses	*Wolffia* sp.	watermeal
Juncus sp.	sedge	*Zizania aquatica*	wild rice
Lemna sp.	duckweed		

LIST OF ACRONYMS

% sat	percent oxygen saturation
305(b)	Section 305(b), Clean Water Act
7Q10	lowest 7-day average streamflow that occurs, on average, once every 10 years
BRP	Bureau of Resource Protection
BWR	Bureau of Water Resources
ºC	degrees Celsius
CERO	CEntral Regional Office
cfs	cubic feet per second
CSO	Combined Sewer Overflow
DO	dissolved oxygen
DWM	Division of Watershed Management
ºF	degree Fahrenheit
m	meter
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
mi^2	square mile
NH_3-N	Ammonia nitrogen
NOAA	National Ocean and Atmospheric Administration
NO_3NO_2-N	Nitrate-nitrite nitrogen
NTU	Nephelometric Turbidity Unit
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RI	Rhode Island
SR	State Road
SMART	Strategic Monitoring and Assessment for River basin Teams
Ssolids	total suspended solids
SOP	Standard Operating Procedure
SR	state road
SU	Standard Unit
T	Temperature
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UBWPAD	Upper Blackstone Water Pollution Abatement District
USACOE	United States Army Corps of Engineers
USGS	United States Geological Survey
WES	Wall Experiment Station
WWTP	wastewater treatment plant

INTRODUCTION

The purpose of this technical memo is to present observations and data collected in the Strategic Monitoring for River basin Teams (SMART) program in the Blackstone watershed, highlighting how the program supports and augments programs of the Massachusetts Department of Environmental Protection (MassDEP) Bureau of Resource Protection (BRP, now the Bureau of Water Resources, BWR) Central Regional Office (CERO) and the Division of Watershed Management (DWM).

Overview of Monitoring Plan

Bimonthly water quality monitoring began in March 2000. The sampling plan matrix for the SMART monitoring program Years 2011-2013 is presented in Table 1; the location of sampling stations is presented in Figure 1. Sampling components at all stations included:

- *in situ* measurements: dissolved oxygen (DO), percent oxygen saturation, pH, specific conductivity, temperature (T), depth and total dissolved solids (TDS);
- physical/chemical constituents: total alkalinity, chlorides, hardness, total suspended solids (TSS), turbidity;
- nutrients: ammonia-nitrogen (NH_3-N), nitrate-nitrite-nitrogen (NO_3–NO_2-N), total nitrogen (TN), and total phosphorus (TP);
- flow measurements (at existing USGS flow gaging stations); and
- general field observations.

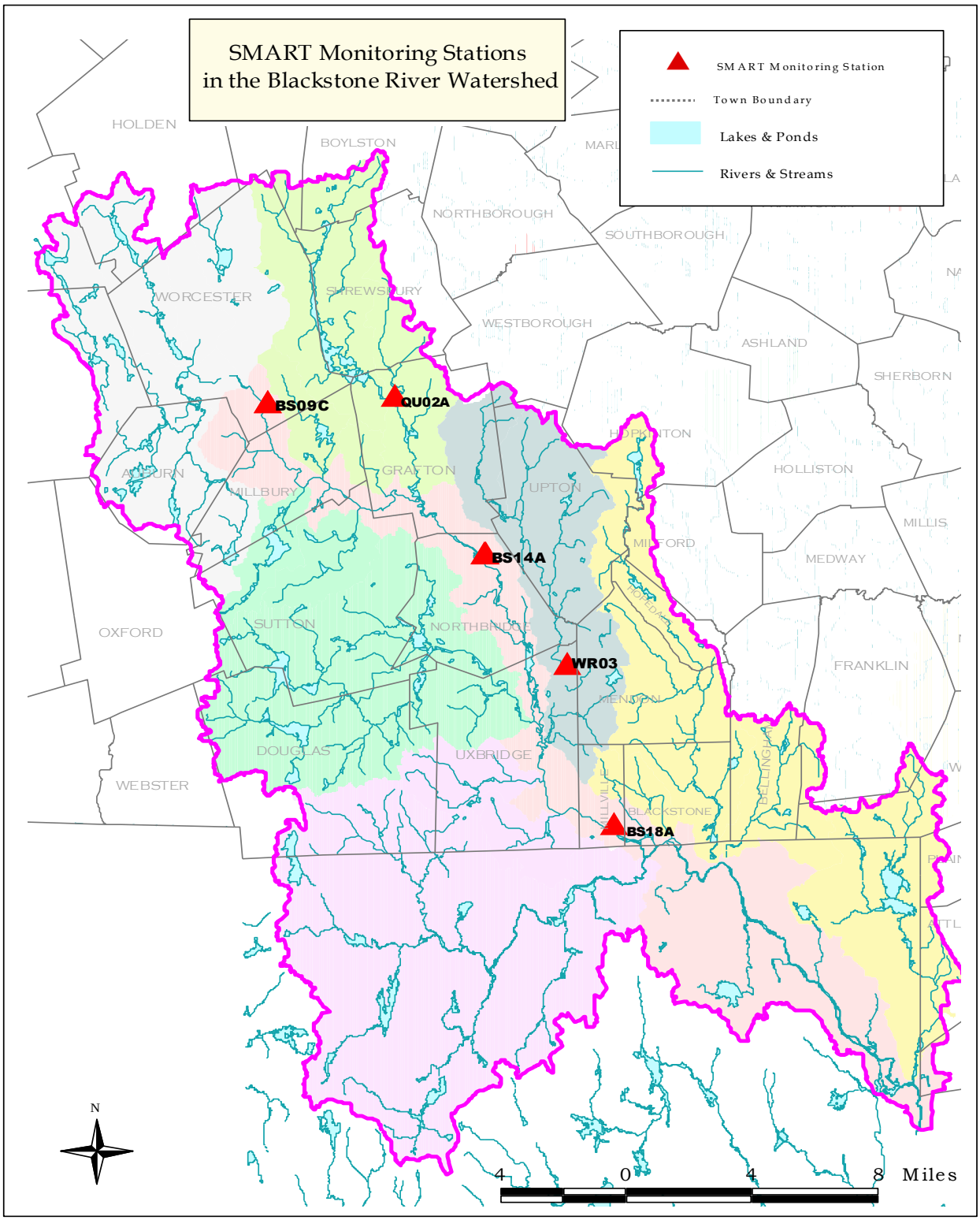
Table 1 Blackstone Basin SMART Sampling Summary – 2011 through 2013

Location and Segment Numbers	Station Name	Station Type	Dates Sampled[1]
Blackstone River @ Blackstone Valley Bikeway, Worcester MA51-03	BS09C	Impact	2011: 1/26/11, 3/30/11, 5/25/11,7/27/11, 9/28/11, 11/9/11 2012: 2/28/12, 4/25/12, 6/27/12, 8/29/12, 11/6/12 2013: 1/30/13, 3/27/13, 5/21/13, 8/27/13*, 9/23/13* *Station BS18A only
Blackstone River @ USGS flow gaging station, Sutton Street, Northbridge MA51-04	BS14A	Impact	
Blackstone River @USGS gaging station State Road (SR) 122 (3/5/2008-10/27/2010) Millville MA51-05	BS18A	Boundary	
Quinsigamond River @ historic Bridge Street, Grafton MA51-09	QU02A	Impact	
West River @ East Hartford Ave, Uxbridge MA51-12	WR03	Reference	

Hydrology

The Blackstone River flows approximately 46 miles from its beginning at the junction of Mill Brook and the Middle River, Massachusetts (MA) to the tidal Seekonk River in Pawtucket, Rhode Island (RI). The Blackstone River Watershed encompasses 540 square miles (mi^2) in these two states (approximately 335 mi^2 are in MA), and all or part of 28 towns and 2 cities. For an in-depth description of the watershed, see Blackstone River Watershed Water Quality Assessment Report 2003 - 2007 (MassDEP 2010). The river is characterized by impoundments created by dams built in the 1700 to 1800's for hydromechanical energy to power manufacturing mills; at one time, there were 44 dams in 46 miles, of which 19 remain. Annual precipitation ranges from 48 to 50 inches (in) over most of the watershed, with a region including all of Northbridge and small areas in abutting towns (Douglas, Grafton, Hopkinton, Sutton, Upton, and Uxbridge) receiving 46 to 48 inches (Ostiguy et al 2015).

Figure 1 MassDEP SMART Monitoring Blackstone River Watershed Water Quality Station Locations 2011-2013



The headwater streams of the Blackstone River flow through the municipalities of Auburn, Holden, Leicester, and Worcester; these include Kettle, Tatnuck, Beaver and Mill Brooks. Major Massachusetts tributaries of the Blackstone River include the Quinsigamond, Mumford, West, Mill and Peters Rivers.

Quality Assurance/Quality Control

The quality assurance/control plan (QAPP) for the SMART program is presented in CN 012.1*: Quality Assurance Project Plan Strategic Monitoring and Assessment for River basin Teams (SMART) (Blackstone, Chicopee, Concord, French/Quinebaug, Millers, and Nashua Watersheds) 2008-2012* (Beaudoin 2008). The QAPP presents data quality objectives, quality assurance procedures, and other program-specific information.

Aerial photos were obtained from Google Earth (2015a, 2015b, 2015c, 2015d, 2015e) at a height of approximately 4,000 feet (ft).

PROJECT OBJECTIVES

The primary water quality objectives of the SMART monitoring program are:

- Document baseline water quality by: providing information on low flow/event flow variation, seasonal variation and frequency of selected constituents; and establishing reference distributions of key constituents for ecoregion delineation and "clean water" sites;
- Estimate loads of detected water constituents at key locations by: quantifying nitrogen loadings to coastal waters; and calculating phosphorous loads upstream/downstream of representative land use areas;
- Define long term trends in water quality by: documenting improvements associated with major abatement projects; and identifying trends at least-impacted stations (that may result from factors such as acid precipitation and climate change);
- Assess attainment of water quality uses by: comparing existing water quality with water quality standards; and by assessing use support for the fishable/swimmable goal;
- Provide support for other programs by: determining reference distributions for ecoregion stations; conducting trend analysis for the 305(b) reports[1] and basin plans; quantifying nutrient loadings for load allocations (Total Maximum Daily Loads, or TMDLs); obtaining data on nonpoint source loadings for more intensive Year 2 sampling; providing guidance for volunteer monitoring; collecting data for development of statistically-based water quality standards and for improvement of Combined Sewer Overflow (CSO) and Stormwater policies; and developing a long-term database on conditions at key locations for the development of new programs and basic research.

As stated in the Introduction, this document presents observations and data collected in the Blackstone Watershed under the SMART program from 2011-2013. An assessment of the data will be presented in future reports.

METHODS

Water quality sampling procedures are included in *Grab Collection Techniques for DWM Water Quality Sampling, Standard Operating Procedure* (MassDEP 1999b). Use of the *in situ* monitoring equipment followed procedures set forth in *CN 4.0 Water Quality Multi-probe Instrument Use, Standard Operating Procedure* (MassDEP 1999a). Physical/chemical and nutrient samples were analyzed at the Senator William X. Wall Experiment Station (WES), the MassDEP analytical laboratory located in Lawrence, Massachusetts. All samples were collected, transported, analyzed, and discarded according to chain-of-custody procedures.

In addition to the measurements and analytes noted above, field observations were recorded at each station on standardized field sheets, field notebooks, and as photographs. Field observations included date/time, location, crewmembers, snow cover, canopy cover, water odors, colors, sheens, foams, estimated river height and velocity, weather conditions, observed uses, wildlife, aquatic algae and macrophytes, potential pollution sources, and unusual conditions. Number and type of samples were recorded, as well as the last set of *in situ* data collected. A summary of field observations by station collected during this sampling period are presented in Table 2 through Table 6 following the station descriptions.

Each station selected for the SMART Monitoring program is described according to key characteristics associated with water quality at that location, as follows:

- Reference: a reference station is located in a stream segment that is minimally influenced by anthropogenic activities;
- Impact: an impact station is located where several sources of pollution come together and can be used to calibrate a mass balance model, or where critical reactions take place such as at an oxygen sag point; and
- Boundary: a boundary station is located at a pour point i.e., where water leaves a designated river basin, or at a state line.

Field sheets, raw data files, chain of custody forms, lab reports, and other metadata used in this report are managed and maintained by the MassDEP DWM in the Water Quality Access Database in Worcester, MA. The validation of the water quality data included data entry into DWM databases, data entry quality control checks, analysis for outliers, blank contamination, duplicates, precision, and holding time violations, followed by project

[1] The 305(b) reports are the biannual reports to the U. S. Congress on water quality that are required under Section 305(b) of the Clean Water Act.

level review (MassDEP 2005). The project coordinator, as identified in the QAPP for the SMART program (CN 012.2), reviews the data for reasonableness, completeness and acceptability (Beaudoin 2008).

Due to resource limitations, SMART samples were collected only for nutrient and *E. coli* analyses on August 27 and September 23, 2013. During these periods, samples were not collected for alkalinity, hardness, total suspended solids and chloride analyses.

STATION OBSERVATIONS

Station BS09C – Blackstone River at Blackstone River Road, Worcester, MA (river mile 29.508)

Figure 2 Google Earth view of BS09C area

Figure 3 BS09C upstream 5/21/2013

Station BS09C is located on the Blackstone River in Worcester, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, Station BS09C was sampled 14 times, and the river was accessed from the Blackstone Valley Bikeway off Blackstone River Road at Tobias Boland Way. Samples were collected by wading in near the outlet of the stormwater detention basin located across the bikeway. Station BS09C serves as an impact station as it is located downstream of numerous point and nonpoint sources of pollution, as described below.

The surrounding land use immediately upstream of this station is comprised largely of the urban municipalities of Worcester and Auburn (Figure 2) (Google Earth 2015a). With some storm events, the Worcester CSO treatment facility discharges to the Mill Brook (underground culvert) approximately 1.25 miles upstream of Station BS09C. The station is upstream of the Upper Blackstone Water Pollution Abatement District (UBWPAD) in Millbury discharges 1.5 miles downstream, the most upstream of the major municipal discharges to the Blackstone River. Other than infrequent CSO facility discharges, the major sources of pollution to this segment of the Blackstone River are non-point, particularly urban runoff (the City of Worcester is comprised of approximately 65% impervious surfaces).

The river is channelized at this point, approximately 30 feet wide, typically 1 foot deep across the channel. The banks are undercut throughout this stretch. Deciduous trees provide canopy cover over much of the channel up- and downstream of the Blackstone River Road Bridge. The bottom consisted mainly of cobble, gravel and sand. No aquatic macrophytes were observed at Station BS09C during this 3-year period. A moderate to dense coverage of film or filamentous algae was noted on 7 of 13 sampling events. Wildlife noted at this station included mallard ducks (*Anas platyrhynchos*), fisher (*Martes pennanti*), unidentified small mammals (tracks on channel edge, scat), possibly including raccoon (*Procyon lotor*), and songbirds.

Observations of the water column were sometimes limited by solar reflection, turbidity and turbulence. Turbid conditions were observed on most events (9 of 13), ranging from slight (5 events, n=15) to highly murky (1); the water column was clear on 30% of the dates sampled. Water color varied, including clear, brown, light yellow, grey and red. Petroleum and musty were the most common water odors noted. Foam was present on approximately half of the events, and was typically very sparse/sparse; no sheens were observed during this time period. Minor quantities of trash were present on 11 of 13 events, including floatables, metals and miscellaneous unidentifiable objects; silt fencing, hay bales, bricks and woody debris were also observed.

Station BS14A – Blackstone River at Sutton Street, Northbridge, MA (river mile 17.716)

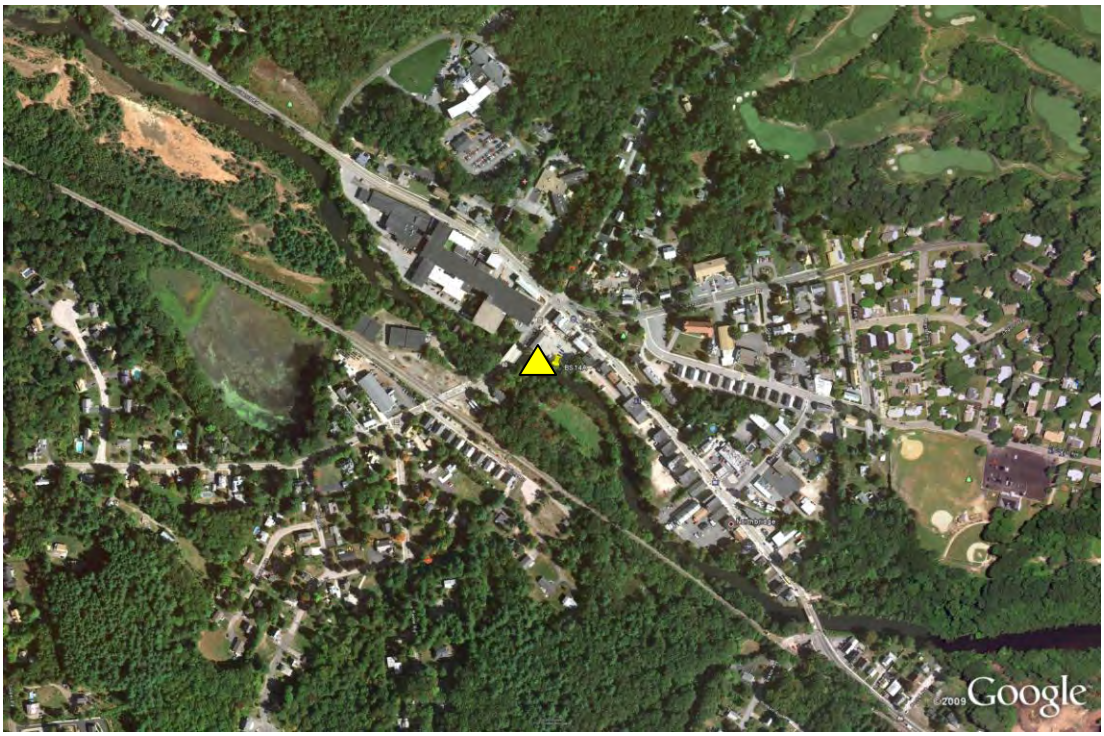


Figure 4 Google Earth view of BS14A area

Figure 5 BS14A upstream 5/25/2011

Station BS14A is located on the Blackstone River in Northbridge, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 13 times, and the river was accessed from the eastern shore downstream of the Sutton Street bridge. Station BS14A serves as an impact station as it is downstream of numerous point sources of pollution, including the Upper Blackstone Water Pollution Abatement District and the Grafton Wastewater Treatment Plant.

Station BS14A is also downstream of significant nonpoint sources of pollution. In addition to those described for Station BS09C, legacy pollutants retained in impoundment sediments are another nonpoint source. Above Station BS14A, the Blackstone River flows through several existing and former impoundments known to contain sediments contaminated with metals, polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), petroleum and other pollutants from historic discharges, spills and releases (USACOE 1994).

The land uses upstream of Station BS14A consist mainly of forest and sparse to moderate residential development (Figure 4) (Google Earth 2015b).

In addition to upstream activities, Station BS14A is influenced by downstream hydropower operations which result in periods of backwater in this segment and changes to the stage-discharge relationship concurrent with impounded conditions. The United States Geological Survey (USGS) flow gage at this location records river height for all stages; discharges records are only computed for flows of 500 cubic feet per second (cfs) or greater (Socolow 2011).

The river at this location is approximately 65 feet wide, and shaded along the shorelines (Figure 5). Elevated turbidity was observed on every sampling date, ranging from slight (5 events) to highly murky (4). In addition to turbidity, solar reflection limited observations of substrate composition, macrophytes, periphyton and trash. When visible, the substrate consisted mainly of boulder, cobble, gravel, sand and silt. Periphyton (when visible) was typically composed of sparse to moderate filamentous algae. No macrophytes were recorded at this station during this time period although, as noted, the water column was not sufficiently clear to view the channel clearly on most events. Wildlife observed at Station BS14A from 2011-2013 included water striders (family Gerridae), minnows (small unidentified fish) and songbirds. Samples were collected near the Sutton Street Bridge by wading in or from shore.

In frequent algal blooms were observed at Stations BS14A and BS18A (Blackstone River, Millville). At the Blackstone River in Northbridge, blooms were observed on 2 dates during this time period, including March 27 and May 21, 2013. Water color varied, including brown, clear, grey, green, light yellow and red. The water column typically lacked odor; when present, effluent was most often noted. Very sparse to sparse foam was observed on 69% of events. Sheens were absent except on one date (5/25/2011), when pollen was noted. Trash, when visible, included metals, bricks and floatables.

Station BS18A – Blackstone River near SR122, Millville, MA (river mile 3.271)

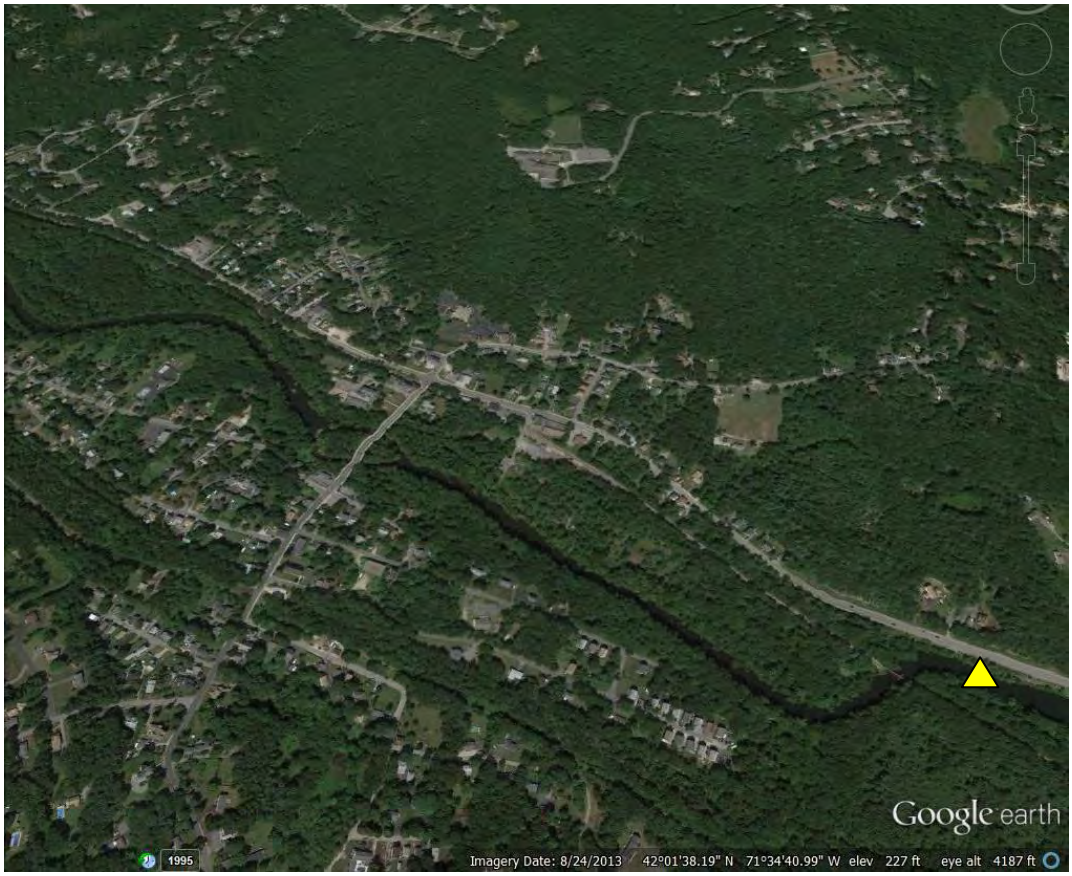


Figure 6 Google Earth view of BS18A area

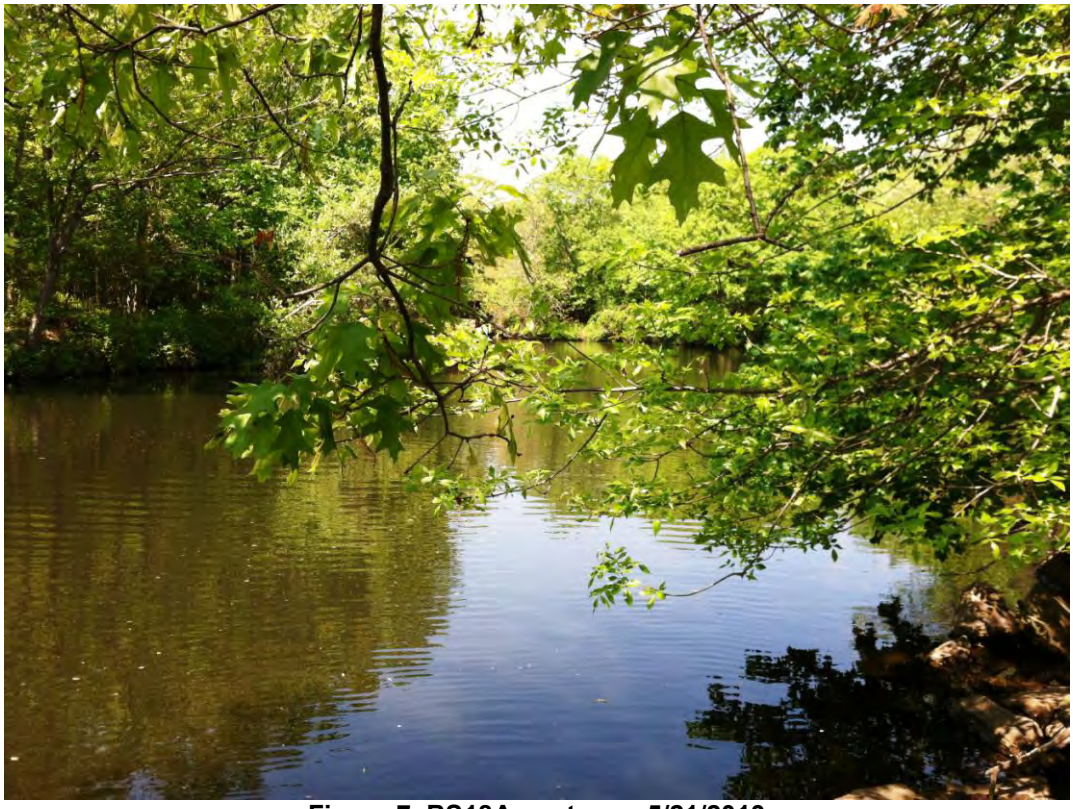


Figure 7 BS18A upstream 5/21/2013

Station BS18A is located on the Blackstone River in Millville, MA within the Southern New England Coastal Plains and Hills ecoregion. The station was sampled 15 times from 2011-2013, and the river was accessed from the USGS gaging station off Rte. 122 (Figure 7). Station BS18A serves as a boundary station, located approximately 1.2 mi upstream of the Massachusetts border with the State of Rhode Island.

Sources of water quality degradation at this station are both point and nonpoint in nature. Point sources include the municipal discharges noted above (UBWPAD, Grafton), in addition to the Northbridge and Uxbridge WWTPs, and two smaller facilities on the Mumford (Douglas) and West (Upton) Rivers. Other nonpoint sources include additional impoundments with contaminated sediments, particularly Rice City Pond, Northbridge/Uxbridge, as well as impervious surfaces in local village centers (Northbridge, Uxbridge, Millville).

The land uses above Station BS18A are mainly forest and sparse residential and commercial development (Figure 6) (2015c).

The river at this station is approximately 100 feet wide, and although heavily shaded along both shores, most of the channel is open to the sky (Figure 7). This section of river is impounded by the Rolling Dam at the head of the Blackstone Gorge, Blackstone and is affected by operations at the hydropower facility in the former Tupperware mill. The depth across the stream channel is unknown (too deep to wade). Visibility was often limited due to solar reflection and elevated turbidity (11 of 14 events). The substrate composition (when visible) consisted mainly of boulder, cobble, gravel, sand and silt. Whenever the water column was sufficiently observable, periphyton was present, including filamentous algae, algal film on rocks, and loose floc. Aquatic macrophytes were not observed at this station in this time period. Wildlife noted here included hawks (family Accipitridae), Canada goose (*Branta canadensis*), frogs (order Anura) and fish (unidentified species).

Infrequent algal blooms were observed at Stations BS18A and BS14A (Blackstone River, Northbridge). At the Blackstone River in Millville, a green water color (possibly indicating an ongoing algae bloom) was observed on 2 dates, February 28, 2012 and March 27, 2013. The water column was turbid on 86% of sampling events, typically moderately to highly turbid. Water color varied, including brown, clear, light yellow, red, green and grey. The river usually lacked odor, with infrequent observations of musty. Foam was absent on more than half of the monitoring dates, and sparse to very sparse when present. A pollen layer was present on more than half of events; sheens were absent on all other dates. Trash was unobservable in the water column on 11 of 14 sampling dates; when visible, trash was absent except for one observation of floatables (4/25/2012).

Station QU02A – Quinsigamond River at the historic Bridge Street Bridge, Grafton, MA (river mile 4.480)

Figure 8 Google Earth view of QU02A area

Figure 9 QU02A upstream 5/25/2011

Station QU02A is located on the Quinsigamond River in Grafton, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 13 times. The river was accessed from the northern shore above the historic stone arch Bridge Street Bridge; samples were collected by wading in or by sampling pole from the bridge. The station is located downstream of 3 large water bodies, including Lake Quinsigamond, Flint Pond, and Hovey Pond. Station QU02A serves as an impact station as it is located downstream of numerous nonpoint sources of pollution, mainly urban runoff.

The upstream land use is dominated by urbanization in the City of Worcester and areas of Shrewsbury, Millbury and Grafton; development is moderately dense in much of the contributing watershed (Figure 8) (Google Earth 2015d).

The river channel varies from 15 to 40 feet wide in this reach (the greater width includes the northern cove above the bridge) and heavily shaded during the growing season (Figure 9). Although it was usually difficult to see the bottom clearly due to staining and solar reflection, when visible, the substrate consisted mainly of embedded gravel, sand and silt. Periphyton was observable on 9 events, and absent from this area on 7 of these; on the 2 events when periphyton was noted, the community consisted of moderately dense filamentous algae. Sparse aquatic macrophytes were observed in the cove above the stone arch bridge, including *Brasenia schreberi* (watershield), *Cabomba caroliniana* (fanwort), *Elodea canadensis* (waterweed), *Lemna* sp. *(*duckweed), *Pontederia cordata (*pickerelweed), *Potamogeton* sp. (pondweed), *Sagittaria* sp. (arrowhead) and *Wolffia* sp. (watermeal). Songbirds were the only wildlife noted at Station QU02A.

The turbidity was typically clear, with one observation of slight turbidity. The water color usually lacked color, odor and sheens. Very sparse to sparse foam was present on 62% of the events sampled (absent on the remaining dates). Trash (when visible) was noted on all but one event, usually minor in quantity; items included glass bottles, planks, unidentifiable objects and floatables.

Station WR03 – West River at East Hartford Ave, Uxbridge, MA (river mile 3.409)

Figure 10 Google Earth view of WR03 area

Figure 11 WR03 upstream 5/25/2011

Station WR03 is located on the West River in Uxbridge, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 12 times, and access was gained from the eastern shore upstream or from the top of the culvert (under high water conditions) at East Hartford Ave. Station WR03 serves as a reference station for the Blackstone Watershed, minimally impacted by anthropogenic activities.

The land use upstream of this area is largely forested; long segments of the river flow through riverine wetlands within the United States Army Corps of Engineers (USACOE) West Hill Flood Control Project (Figure 10) (2015e). The West River has one major municipal discharge (Upton WWTP), approximately 5.5 miles upstream.

The river channel at this location is approximately 25 feet wide within a riverine wetland system. The stream bed consisted mainly of muck and sand, with some gravel and silt, and a few submerged granite blocks anchoring the bottom midstream. Periphyton was absent on more than half of the 12 events in this time period; when observed, growth ranged from sparse to moderate in the main channel, and consisted of filamentous algae, an algal film, or moss. Macrophytes were diverse and abundant at this station; plants observed during this period include included *Callitriche* sp. (water starwort), Gramineae (grasses), *Elodea canadensis (waterweed), Juncus* sp. (sedges), *Lobelia cardinalis* (cardinal flower), *Lythrum salicaria* (purple loosestrife), *Peltandra virginica* (arrow arum), *Pontedaria cordata* (pickerelweed), *Potamogeton* spp. (pondweeds), *Potamogeton epihydrus* (ribbonleaf pondweed), *Sagittaria* sp. (arrowhead), *Typha latifolia* (common cattail), *Vallisneria americana* (wild celery) and *Zizania aquatica* (wild rice). Wildlife observations note hawks (Accipitridae family), red-winged blackbird (*Agelaius phoeniceus*), frogs (Anura order), great blue heron (*Ardea herodias)*, red-tailed hawk (*Buteo jamaicensis),* water strides (Gerridae family), bullfrog (*Rana catesbeiana*) and minnows (unidentified small fish).

The water column was typically clear at this station, clear or red in color, and lacking odor, foam, sheens and trash.

Table 2 MassDEP SMART 2011 - 2013. Station BS09C. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/26/2011	Station not sampled on this date; not accessible due to snow/ice								
3/30/2011	Cobble/gravel/silt	Minor: bricks, metals, wood, floatables	Dense: green/grey film	Clear	Slight petroleum	None	None	Clear	Dry
5/25/2011	Cobble/gravel/sand	Moderate: floatables, miscellaneous debris	Dense: grey/brown film	Brown/red	Strong petroleum, sewage	Sparse	None	Moderate	Dry
7/27/2011	Boulder/cobble/gravel/sand; embedded	Minor: miscellaneous	Moderate: rust film	Red, slight	Very strong petroleum/musty	Very sparse	None	Slight	Wet
9/28/2011	Unobservable	Unobservable; floatables, metals, silt fence, hay bales where visible	Unobservable	Light yellow	"Dirt, soil"	Sparse	None	Slight	Wet
11/16/2011	Cobble/gravel/sand	None	Moderate: grey film on rocks	Clear	Petroleum, musty	Sparse	None	Slight	Dry
2/28/2012	Boulder/cobble/gravel/sand	Minor: floatables, silt fence	Moderate: grey filamentous; Sparse: green loose floc	Grey	Musty	None	None	Clear	Dry
4/25/2012	Unobservable	Miscellaneous metals, silt fence	None	Brown/red	Eutrophic pond, strong;petroleum, intermittent	Sparse	None	Moderate	Wet
6/27/2012	Cobble/gravel/sand/silt	Minor: floatables, woody debris	None	Light yellow	Raw sewage, petroleum, musty	None	None	Slight	Wet
829/2012	Boulder/cobble/gravel/sand	Minor: floatables	Dense rusty film	Light yellow	Musty	None	None	Clear	Wet
11/6/2012	Boulder/cobble/gravel/sand	None	Dense: grey film	Grey	None	Sparse	None	Moderate	Dry
1/30/2013	Unobservable	Unobservable; metals, silt fence, floatables where visible	Unobservable	Grey, olive/light tan	None	None	None	Highly murky	Wet
3/27/2013	Boulder/cobble/gravel/sand	Unidentifiable chunks, floatables, silt fence	None	Clear	None	None	None	Clear	Dry
5/21/2013	Cobble/gravel/sand/silt	Minor, mostly on banks	Dense clear film on rocks	Clear	None	None	None	Slight	Dry
-- : Data not available									

Table 3 MassDEP SMART 2011 - 2013. Station BS14A. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/26/2011	Station not sampled on this date; not accessible due to snow/ice								
3/30/2011	Boulder/cobble/gravel/sand/silt	Slight: metals, bricks, floatables	Moderate: green/grey filamentous	Clear	None	Very sparse	None	Slight	Dry
5/25/2011	Unobservable	Unobservable; trash visible on bottom	Unobservable	Chocolate	Slight effluent, musty	None	None	Highly murky	Dry
7/27/2011	Unobservable	Unobservable	Unobservable	Chocolate	Effluent	Very sparse	Pollen/dust	Highly murky	Wet
9/28/2011	Unobservable	Unobservable	Unobservable	Clear	None	Sparse	None	Slight	Wet
11/16/2011	Boulder/cobble/gravel/sand; embedded	Minor: metals	None	Clear	None	Sparse	None	Slight	Dry
2/28/2012	Boulder/cobble/gravel/sand/silt	Metals, floatables	Moderate: grey filamentous; sparse: loose floc	Grey	Musty	None	None	Slight	Dry
4/25/2012	Unobservable	Unobservable	None	Brown/red	Eutrophic pond, strong	Sparse	None	Moderate	Wet
6/27/2012	Unobservable	Unobservable; metal objects where visible	Unobservable; none where visible	Brown	Effluent, strong	Very sparse	None	Moderate	Wet
8/29/2012	Unobservable	Unobservable	Unobservable	Light yellow	Effluent	Sparse	None	Highly murky	Wet
11/6/2012	Boulder/cobble/gravel/sand/silt	Minor: metal pipes	Sparse: green filamentous	Grey	None	Moderate	None	Moderate	Dry
1/30/2013	Unobservable	Unobservable; metals, floatables where visible	Unobservable	Grey	None	Moderate, mid-channel only	None	Highly murky	Wet
3/27/2103	Boulder/cobble/gravel/sand/silt	Minor: pipe segment, floatables, unidentifiable objects	None	Green	None	Sparse	None	Slight	Dry
5/21/2013	Unobservable	Unobservable	Unobservable	Brown	Musty	Sparse	None	Moderate	Dry
-- : Data not available									

Table 4 MassDEP SMART 2011 - 2013. Station BS18A. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/26/2011	Station not sampled on this date; not accessible due to snow/ice								
3/30/2011	Boulder/cobble/silt	None	Dense: grey/green filamentous	Clear	None	None	None	Slight	Dry
5/25/2011	Unobservable	Unobservable	Unobservable	Brown/red	None	Sparse	Pollen/dust	Highly murky	Dry
7/27/2011	Unobservable	Unobservable	Unobservable	Brown	Slight musty	Sparse	Pollen/dust	Highly murky	Wet
9/28/2011	Unobservable	Unobservable	Unobservable	Brown	None	Very sparse	None	Moderate	Wet
11/16/2011	Unobservable	Unobservable	Very dense: grey film on rocks	Clear	None	Very sparse	Soarse pollen	Clear	Dry
2/28/2012	Boulder/cobble/gravel/sand/silt	None	Dense: brown filamentous; moss	Green	Musty	None	None	Moderate	Dry
4/25/2012	Unobservable	Unobservable; minor, floatables where visible	Unobservable	Brown/red	Eutrophic pond	None	None	Moderate	Wet
6/27/2012	Unobservable	Unobservable	Unobservable; dense rusty loose floc where visible	Brown	None	None	Pollen	Highly murky	Wet
8/29/2012	Unobservable	Unobservable	Unobservable	Light yellow, slight	Musty	None	Pollen	Highly murky	Wet
11/6/2012	Unobservable	Unobservable	Unobservable	Grey, slight	None	Sparse	None	Unobservable	Dry
1/30/2013	Station not sampled on this date; not accessible due to ice cover								
3/27/213	Boulder/cobble/gravel/sand/silt	None	Sparse: dark green film	Green	None	Sparse	None	Moderate	Dry
5/21/2013	Unobservable	Unobservable	Unobservable	Brown	None	None	Sparse pollen	Highly murky	Dry
8/27/2013	Unobservable	Unobservable	Unobservable	Light yellow, slight	Slight musty	None	Sparse pollen	Moderate	Dry
9/23/2013	Unobservable	Unobservable	Unobservable	Brown	None	None	Sparse pollen	Highly murky	Wet
-- : Data not available									

Table 5 MassDEP SMART 2011 - 2013. Station QU02A. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/26/2011	Station not sampled on this date; not accessible due to snow/ice								
3/30/2011	Unobservable	Moderate: metals, floatables, unknown	None	Clear	None	Very sparse	None	Clear	Dry
5/25/2011	Boulder/gravel/sand/silt	Minor: unidentified "junk'	Moderate: dark green filamentous	Slight red	None	Very sparse	None	Clear	Dry
7/27/2011	Cobble/gravel/sand/silt; embedded, dark stain	Minor: (1) beer can	Moderate: blue-green filamentous	Slight red	Eutrophic pond	None	None	Clear	Wet
9/28/2011	Unobservable	Unobservable	Unobservable	Clear	None	Sparse	None	Clear	Wet
11/16/2011	Unobservable	Minor: floatalbes	None	Clear	None	Very sparse	None	Clear	Dry
2/28/2012	Unobservable	Unobservable; floatables caught against dead wood where visible	Unobservable	Clear	Musty	Sparse	None	Unobservable	Dry
4/25/2012	Unobservable	Unobservable	Unobservable	Brown/red	Fishy	Sparse	None	Slight	Wet
6/27/2012	Unobservable	Minor: floatables	None	Light yellow	None	None	None	Clear	Wet
8/29/2012	Unobservable	Unobservable; floatables, glass bottles, planks where visible	Unobservable	Clear	None	Sparse	None	Unobservable	Wet
11/6/2012	Unobservable	Unobservable	None	Clear	None	None	None	Clear	Dry
1/30/2013	Unobservable	Unobservable; floatables where visible	None	Light yellow	None	None	None	Clear	Wet
3/27/2013	Unobservable	Minor: floatables, unidentifiable objects	None	Clear	None	Very sparse	None	Clear	Dry
5/21/2013	Unobservable	Unobservable; scum, floatables, cans, "junk" where visible	Unobservable	Clear	Musty, rotting vegetables	Sparse	None	Slight	Dry
-- : Data not available									

Table 6 MassDEP SMART 2011 - 2013. Station WR03. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/26/2011	Station not sampled on this date; not accessible due to snow/ice								
3/30/2011	Boulder/gravel/sand/silt	None	Sparse: green filamentous	Clear	None	None	None	Clear	Dry
5/25/2011	Boulder/sand/silt	None	None	Red, slight	None	None	None	Clear	Dry
7/27/2011	Unobservable; silted in	None	Moderate: brown film patches on plants	Red, slight	None	None	None	Slight	Wet
9/28/2011	Unobservable	Unobservable	Unobservable	Red	None	None	None	Clear	Wet
11/16/2011	Gravel/sand	None	None	Clear	None	None	None	Clear	Dry
2/28/2012	Boulder/cobble/gravel/sand	None	None	Clear	None	None	None	Clear	Dry
4/25/2012	Unobservable	None	None	Red	None	None	None	Clear	Wet
6/27/2012	Boulder/cobble/gravel/sand/silt/mud	None	None	Red, slight	None	None	None	Slight	Wet
8/29/2012	Boulder/cobble/gravel/sand/mud	None	Moderate: rusty brown film; sparse moss	Red, slight	None	None	None	Clear	Wet
11/6/2012	Unobservable	Unobservable	Sparse: green filamentous	Clear	None	None	None	Clear	Dry
1/30/2013	Station not sampled on this date; not accessible due to ice cover								
3/27/2013	Boulder/cobble/gravel/sand/silt	Very minor: few floatables	None	Clear	None	None	None	Clear	Dry
5/21/2013	Unobservable; partially obscured by plants	None	None	Clear	None	None	None	Clear	Dry
-- : Data not available									

SURVEY CONDITIONS

Stream discharge and precipitation data are used to determine hydrologic conditions and, consequently, if water quality surveys should be described as dry or wet weather events. During dry weather, trace amounts of precipitation may fall, but there is no measurable change in stream flow (discharge). Wet weather is defined as precipitation within a five-day antecedent period that leads to more than a slight increase in stream discharge. Additional data are used to determine if snowmelt affected water quality, including snowfall and maximum daily temperature; snow on the ground data were not available for any weather stations in the Blackstone watershed.

Precipitation data were obtained from the National Oceanic and Atmospheric Administration (NOAA). The presence/absence of precipitation during the five days prior to each sampling event was based on NOAA data available on their website NOAA Climatological Data Publications (NOAA 2015). Worcester, MA is the location of the weather station closest to the Blackstone watershed sampling stations; hence climate data collected in Worcester were utilized in this report.

The USGS operates numerous stream gaging stations on the Blackstone River and tributaries; those with relevant to the geographic area of the SMART program include:

- Blackstone River, W. Main St., At Millbury, MA (USGS 2015a) (http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01109730&PARAmeter_cd=00060,00065)
- Blackstone River at Northbridge, MA (USGS 2015b) (http://waterdata.usgs.gov/ma/nwis/uv?site_no=01110500)
- Blackstone River, Rte. 122 Bridge near Uxbridge, MA (USGS 2015c) (http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01111212&PARAmeter_cd=00060,00065)
- Blackstone River at Woonsocket, RI (USGS 2015d) (http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01112500&PARAmeter_cd=00060,00065)
- Quinsigamond River at North Grafton, MA (USGS 2015e) (http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01110000&PARAmeter_cd=00060,00065)
- West River below West Hill Dam near Uxbridge, MA (USGS 2015f) (http://waterdata.usgs.gov/ma/nwis/uv?site_no=01111200)

The USGS station on the Blackstone River in Woonsocket, RI is located several miles downstream of Station BS18A. There are numerous small streams, several large tributaries (the Branch, Mill, and Peters Rivers), and two hydropower generating facilities (the Tupperware Dam in Blackstone, MA and Thundermist in Woonsocket, RI) located on the Blackstone river mainstem between Station BS18A and the Woonsocket gaging station. Therefore, this gaging station is used as an estimate of discharge, rather than exact conditions, at Station BS18A.

Statistical streamflow values are based on 74-75 years of record (10/1/1928-9/30/2006) at the USGS Blackstone River gage in Woonsocket, RI (USGS station number 01112500). Daily discharge data are reported online at Daily mean discharge Woonsocket RI (USGS 2015g). The monthly data are reported at Monthly mean discharge Woonsocket RI (USGS 2015h). The point of record mean daily discharge statistics based on 82-83 years of record (10/1/1928-9/30/2011) are found at Daily Discharge Statistics Woonsocket RI (USGS 2015i).

The discharge values were also examined relative to the 7Q10 low flow (lowest 7-day average streamflow that occurs, on average, once every 10 years) from the *Gazetteer of Hydrologic Characteristics of Streams in Massachusetts – Blackstone River Basin* (Wandle and Phipps, 1984), and are as follows:

- Blackstone River at Northbridge = 45 cfs
- Blackstone River at Woonsocket = 101 cfs
- West River at West Hill Dam, Uxbridge = 1.5 cfs

At some of the Blackstone flow gaging stations, precipitation-related stream fluctuations were difficult to distinguish from manipulated fluctuations on some occasions (e.g., hydropower operations, wastewater discharges).

Table 2-6 (field observations), Table 10 (precipitation) and Table 11 (stream discharge) contain information on survey conditions during each sampling event. Both the precipitation and the stream discharge data were used

to estimate hydrological conditions during water quality sampling. Air temperature was measured at each station and recorded as degrees Fahrenheit (ºF).

January 26, 2011 – All stations in the Blackstone watershed were inaccessible on this date due to ice cover and/or unsafe conditions, therefore no data are available from this date.

March 30, 2011 – This early spring survey followed a dry period, with no precipitation measured during the five days preceding this event. Discharge decreased steadily at area gages during this period. Precipitation and discharge data indicate dry weather conditions. Air temperature ranged from 33 to 48°F under sunny skies.

May 25, 2011 – A storm on May 23-24, 2011 brought 0.31 in rain to the area (as measured at the Worcester gage). In general, discharge decreased steadily from May 20-25. Samples collected on this date reflect dry weather conditions. Air temperature ranged from 67 to 77ºF under sunny skies.

July 27, 2011 – This summer survey followed an event that brought 0.41 in rain to the area on July 25-26, 2011. In general, discharge generally reflected the precipitation pattern, with flow peaking on July 26th, then decreasing, but not to pre-storm levels by the completion of monitoring activities. Samples collected on this date reflect wet weather/runoff conditions. Air temperature ranged from 67 to 84°F with sunny skies until the last station (Blackstone River at Millville), at which time skies became mostly cloudy.

September 28, 2011 – A storm event on September 23-24, 2011 brought over an inch of rain to the area before this early fall monitoring event; although no further precipitation occurred between then and September 28, discharge had not returned to pre-storm levels by the completion of monitoring activities. Water clarity at the three stations on the Blackstone River ranged from slightly to moderately turbid. Data collected reflect wet weather/runoff conditions. Air temperature ranged from 66 to 74°F under clearing skies.

November 9, 2011 – This mid-fall sampling event followed a dry period in which no precipitation was recorded at the Worcester gage from November 4-9, 2011. Stream discharge at area gages generally decreased from November 4-9, 2011. Data collected during this event reflect dry weather conditions. Air temperature ranged from 50 to 70°F under sunny skies.

February 28, 2012 – In the five days preceding this winter monitoring event, 0.2 in of snow was recorded at the Worcester gage on February 25, 2011 (0.68 in as water); see Table 7 for climate data for this time period. Discharge at watershed gages generally mirrored the precipitation pattern during this period, returning to approximately pre-storm levels before commencement of monitoring activities. Data collected during this event reflect dry weather conditions. Air temperature ranged from 38 to 45°F under mostly sunny skies.

Table 7 Climate Conditions at Worcester, MA from February 23-28, 2012

Parameter	Feb 23	Feb 24	Feb 25	Feb 26	Feb 27	Feb 28
Max Temperature (ºF)	49	36	38	36	48	44
Precipitation (inches as water)	0.01	0.67	T	0	0	0
Snowfall (inches)	0	0.2	T	0	0	0
Data from the Foxborough weather station are available at NOAA Climatological Data Publications (NOAA 2015).						

A**pril 25, 2012 –** This spring sampling event followed a storm that brought 2.69 in to the area from April 22-23, 2012. Discharge at watershed gages rose with precipitation and did not return to pre-storm levels by the commencement of sampling activities. Data collected during this event reflect wet weather/runoff conditions. Air temperature ranged from 42 to 64°F under sunny skies.

June 27, 2012 – This early summer sampling event fell within a wet period, with1.451 in of rainfall recorded at the Worcester gage from June 22-27, 2012. In general, discharge at area gages reflected steadily the precipitation pattern. Data reflect wet weather/runoff conditions. Air temperature ranged from 65 to 74°F; overcast skies with intermittent sprinkles were mostly sunny at the last station (Blackstone River at Millville).

August 29, 2012 – Summer sampling followed a storm that brought 0.36 in of rain to the watershed on the day before this summer monitoring event. Discharge at area gages increased with the precipitation event, and had

generally not returned to pre-storm levels by the commencement of monitoring activities. Data collected during this event reflect wet weather/runoff conditions. Air temperature ranged from 61 to 69°F under clear skies.

November 6, 2012 – This mid-fall sampling event followed a relatively dry period, with only trace precipitation measured at Worcester from November 1-6, 2012; discharge at watershed gages reflected the pattern of precipitation. Water quality measured on this event reflects dry weather conditions. Air temperature ranged from 39 to 46°F; cloud cover ranged from 0 to 40%.

January 30, 2013 – From January 29-30, 2013, 0.28 in precipitation was recorded at the Worcester weather station (1.5 in as snow); see Table 8 for climate data during this time period. The maximum daily temperature recorded in Worcester during this period was 32 to 56ºF. In general, discharge at area gages reflected the precipitation pattern, not returning to pre-storm levels before commencement of monitoring activities. Data collected on this date reflect wet weather/runoff conditions. Air temperature ranged from 36 to 37°F, with foggy, overcast skies.

Table 8 Climate Conditions at Worcester, MA from January 25-30, 2013

Parameter	Jan 25	Jan 26	Jan 27	Jan 28	Jan 29	Jan 30
Max Temperature (ºF)	18	20	27	26	32	56
Precipitation (inches as water)	0.03	T	0	0.15	0.13	0.17
Snowfall (inches)	0.5	T	0	1.5	0	0
Data from the Foxborough weather station are available at NOAA Climatological Data Publications (NOAA 2015).						

March 27, 2013 – This early spring sampling event followed a dry period, with only trace precipitation measured at the Worcester station from March 22-27, 2013; see Table 9 for climate data from this time period. In general, discharge at area stations generally decreased during this period. Data collected during this event reflect dry weather conditions. Air temperature ranged from 39 to 49°F under sunny skies.

Table 9 Climate Conditions at Worcester, MA from March 22-27, 2013

Parameter	Mar 22	Mar 23	Mar 24	Mar 25	Mar 26	Mar 27
Max Temperature (ºF)	35	37	43	38	43	48
Precipitation (inches as water)	T	0	0	T	T	0
Snowfall (inches)	T	0	0	T	T	0
Data from the Foxborough weather station are available at NOAA Climatological Data Publications (NOAA 2015).						

May 21, 2013 – Less than 0.1 in of precipitation fell in the watershed within the 5 days prior to this spring monitoring event; although 0.31 in was recorded at the Worcester station on the sampling date, it fell after completion of monitoring activities. Discharge at some watershed gages generally reflected the precipitation pattern (Blackstone River at Millbury, Quinsigamond River at Grafton), although fluctuations not concurrent with precipitation were observed at several locations (Blackstone River at Northbridge, Uxbridge, Millville) and may reflect flow manipulation activities. Water quality during this event reflects dry weather conditions. Air temperature ranged from 67 to 83°F under mostly sunny to sunny skies.

August 27, 2013 – Due to a change in the program, only Station BS18A on the Blackstone River in Millville was sampled in August and September, 2013. A storm brought 0.28 in rain to the area on the sampling date, prior to the commencement of this summer monitoring event; discharge rose with the precipitation input. Data collected on this date reflect wet weather/runoff conditions. Air temperature was 68°F under overcast conditions.

September 23, 2013 – Due to changes in the SMART program, only Station BS18A on the Blackstone River in Millville was sampled in August and September, 2013. A half inch of rain was recorded at the Worcester climate station on September 21-22, 2013. Discharge at the Uxbridge gage (closest gage for which data are available during this period) rose with the precipitation input, and had not returned to pre-storm flows before sampling was conducted at this station. Water quality on this date is considered to reflect wet weather/runoff conditions. Air temperature was 53°F under sunny skies.

Table 10 Blackstone Basin Precipitation Data Summary 2011-2013

Survey Dates	5 Days Prior	4 Days Prior	3 Days Prior	2 Days Prior	1 Day Prior	Sample Date	Wet/Dry Conditions**
1/26/2011	0.46	0	T	0	0.18	0.13	Wet
3/30/2011	T	0	0	0	0	0	Dry
5/25/2011	0.10	0.01	0	0.23	0.08	0	Dry
7/27/2011	0	T	T	0.35	0.07	0	Wet
9/28/2011	0.85	0.27	0	0	0	0.16	Wet
11/9/2011	0	0	0	0	0	0	Dry
2/28/2012	0.01	0.67	T	0	0	0	Dry
4/25/2012	T	0	1.33	1.36	T	T	Wet
6/27/2012	0.48	0.18	0.01	0.76	0.02	T	Wet
8/29/2012	0	0	0	T	0.36	0	Wet
11/6/2012	T	T	0	0	0	0	Dry
1/30/2013	0.03	T	0	0.15	0.13	0.17	Wet
3/27/2013	T	0	0	T	T	0	Dry
5/21/2013	0	0	0	0.09	T	0.31	Dry
8/27/2013***	0	0	0	0	0.13	0.15	Wet
9/23/2013***	0	0	0	0.01	0.49	0	Wet

*NOAA National Weather Service station in Worcester, MA reported at (NOAA Climatological Data Publications NOAA 2015); data in inches of precipitation as water
T= trace amount
**Based on precipitation, stream flow and other relevant data.
*** Station BS18A only

Table 11 Discharge at the Blackstone River at Woonsocket, RI
USGS Flow Data Summary Discharge (cfs) 2011-2013*

Survey Dates	5 Days Prior	4 Days Prior	3 Days Prior	2 Days Prior	1 Day Prior	Sample Date	Monthly Mean**	POR Mean***
1/26/2011	619	576	543	514	494	513	536.8	1,320
3/30/2011	1,380	1,280	1,190	1,100	1,010	934	2,468	1,720
5/25/2011	1,460	1,300	1,080	954	951	882	840.4	780
7/27/2011	146	141	151	177	180	254	267.0	339
9/28/2011	649	1,330	1,470	1,150	944	809	1,417	376
11/9/2011	1,620	1,500	1,390	1,270	1,230	1,090	1,527	635
2/28/2012	512	441	713	680	596	543	689.0	1,130
4/25/2012	245	243	299	2,390	2,660	1,540	576.0	1,250
6/27/2012	273	291	294	330	531	389	496.0	456
8/29/2012	176	159	150	143	203	332	270.5	326
11/6/2012	1,260	1,000	857	751	661	584	539.7	597
1/30/2013	584	536	522	499	505	582	746.8	998
3/27/2013	1,360	1,270	1,210	1,190	1,150	1,070	1,661	1,570
5/21/2013	389	275	307	283	286	293	474.5	853
8/27/2013***	162	136	148	118	118	150	250.5	264
9/23/2013***	144	129	113	123	183	224	179.6	392

*Blackstone River at Woonsocket (01112500) daily discharge data found at Daily Discharge Data at Blackstone River, Woonsocket RI. All data approved for publication.
**Monthly mean statistics available through May 2008 only; data found at Monthly Statistics at Blackstone River at Woonsocket, RI
***POR-Period of Record daily mean value based on 85-86 years of record (10/1/1928-9/30/2014) found at Daily mean discharge Woonsocket RI
7Q10 = 101 cfs @ USGS gaging station, Blackstone River at Woonsocket, RI

RESULTS AND QUALITY ASSURANCE/QUALITY CONTROL

The results of SMART monitoring conducted in the Blackstone watershed from 2011 through 2013 are included below. Table 12 through Table 16 present *in-situ* multiprobe readings and Table 17 through Table 21 contain nutrient (ammonia-nitrogen, nitrate-nitrite-nitrogen, total phosphorus and either total Kjeldahl nitrogen or total nitrogen) and total suspended solids data. Most results are expressed as milligrams per liter (mg/L). Exceptions include: depth in meters (m); temperature in degrees Celsius (ºC); pH in standard units (SU); conductivity in microsiemens per centimeter (µS/cm); dissolved oxygen saturation in percent (%); and turbidity, in Nephelometric Turbidity Units (NTU).

Field sheets, chain of custody forms, raw data files, lab reports and other metadata are maintained by the CERO SMART Monitoring Manager in Worcester, MA and data are stored electronically in DWM's water quality database. Detailed information regarding the data validation process is explained in the separate document, *CN 56.2 Standard Operating Procedure: Data Validation and Usability* (MassDEP 2005). Specific validation criteria used for 2011-2013 data include, but are not limited to: conformance to DWM's Quality Assurance Project Plan and standard operating procedures, precision, accuracy, representativeness, holding times, sample preservation, frequency of field QC samples, contamination of field blanks, stability of multiprobe readings and documentation. The following data qualifiers were applied as needed:

Multiprobe data qualifiers:

** = Missing data.
-- = No data.
= Censored data (data that have been discarded for some reason).
c = Greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard.
i = Inaccurate readings from multiprobe likely.
m = Method not followed; one or more protocols contained in the DWM Multi-probe Standard Operating Procedure (SOP) not followed.
r = Data not representative of actual field conditions.
s = Field sheet recorded data were used to accept data, not data electronically recorded in the Multi-probe surveyor unit, due to operator error or equipment failure.
u = Unstable readings.

Laboratory sample data qualifiers:

** = Missing data.
-- = No data.
= Censored data (data that have been discarded for some reason).
[ ] = A result reported inside brackets has been censored, but is shown for informational purposes.
b = Blank contamination in lab reagent blanks and/or field blank samples.
d = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP.
h = Holding time violation (usually indicating possible bias low).
j = 'Estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the reporting detection limit (RDL) and greater than the method detection limit (MDL) (RDL > x > MDL). Also used to note where values have been reported at levels less than the MDL.
m = Method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (e.g. sediment in sample, floc formation), lab error (e.g. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

Table 12 MassDEP SMART 2011-2013. Station BS09C. *In Situ* Multiprobe Data

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/26/2011	SM-3468	7:50 AM	**	**	**	**	**	**	**
3/30/2011	SM-3540	7:52 AM	0.3	5.3	7.1	433	282	13.2	104
5/25/2011	SM-3612	8:02 AM	0.3	17.0	6.9	381	248	9.3	96
7/27/2011	SM-3684	8:14 AM	0.2	21.5	7.0	634	412	7.6	87
9/28/2011	SM-3756	8:03 AM	0.3	21.1	7.3	391	254	8.6	96
11/9/2011	SM-3828	8:07 AM	0.4	8.8	7.1	335	218	12.3	106
2/28/2012	SM-3900	8:09 AM	0.3	4.4	7.2	486	316	13.1	101
4/25/2012	SM-3972	8:06 AM	##i	11.9	7.1	351	228	10.9	101
6/27/2012	SM-4044	7:45 AM	##i	19.6	7.2	424	275	8.3	91
8/29/2012	SM-4116	7:51 AM	##i	21.7	7.2	429i	279i	7.7	88
11/6/2012	SM-4188	8:25 AM	##i	7.4	7.2	358	232	12.2	102
1/30/2013	SM-4260	8:08 AM	0.0i	2.9	7.1	1919	1247	13.1	98
3/27/2013	SM-4332	8:06 AM	0.0i	5.0	7.1	612	398	12.9	101
5/21/2013	SM-4392	8:00 AM	##i	19.0	7.2	639	415	9.1	98

Table 13 MassDEP SMART 2011-2013. Station BS14A. *In Situ* Multiprobe Data

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/26/2011	SM-3472	8:36 AM	**	**	**	**	**	**	**
3/30/2011	SM-3544	9:13 AM	1.1	5.8	7.3	560	364	13.0	104
5/25/2011	SM-3616	9:34 AM	0.9	17.1	7.2	499	324	9.6	100
7/27/2011	SM-3688	9:39 AM	1.1	21.7	7.1	667	434	7.4	84
9/28/2011	SM-3760	9:22 AM	1.1	20.8	7.4	456	297	8.5	95
11/9/2011	SM-3832	9:27 AM	0.6	9.9	7.4	479	311	12.0	106
2/28/2012	SM-3904	9:26 AM	1.3	5.4	7.5	513	333	13.1	104
4/25/2012	SM-3976	9:25 AM	##i	12.1	7.3	405	263	10.8	100
6/27/2012	SM-4048	9:08 AM	##i	19.8	7.4	481	313	8.2	91
8/29/2012	SM-4120	9:16 AM	##i	21.6	7.4	582i	378i	7.4	85
11/6/2012	SM-4192	9:37 AM	##i	8.4	7.4	429	279	12.0	102
1/30/2013	SM-4264	9:47 AM	##i	4.6	7.6	1041	677	13.1	102
3/27/2013	SM-4336	9:30 AM	0.0i	5.9	7.4	652	424	12.8	103
5/21/2013	SM-4396	9:19 AM	##i	19.7	7.4	681	443	8.7	95

Table 14 MassDEP SMART 2011-2013. Station BS18A. *In Situ* Multiprobe Data

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/26/2011	SM-3477	8:55 AM	**	**	**	**	**	**	**
3/30/2011	SM-3549	10:30 AM	1.6	5.9	7.0	436	283	12.7	102
5/25/2011	SM-3621	11:03 AM	2.9	17.8	6.9	393	255	8.9	94
7/27/2011	SM-3693	11:00 AM	1.4	22.5	7.1	571	371	7.7	89
9/28/2011	SM-3765	10:52 AM	1.2	21.2	7.1	341	222	8.2	92
11/9/2011	SM-3837	10:51 AM	0.8	9.2	7.1	339	220	11.8	103
2/28/2012	SM-3909	10:56 AM	2.5	4.7	7.2	384	249	13.4	104
4/25/2012	SM-3981	10:43 AM	##i	12.6	7.0	281	183	10.4	98
6/27/2012	SM-4053	10:37 AM	##i	20.2	7.2	389	253	7.9	87
8/29/2012	SM-4125	10:45 AM	##i	22.4	7.4	458i	298i	7.8	89
11/6/2012	SM-4197	11:14 AM	##i	7.6	7.2	341	221	11.8	99
1/30/2013	SM-4269	10:40 AM	**	**	**	**	**	**	**
3/27/2013	SM-4341	11:01 AM	0.0i	5.7	7.2	452	294	12.6	101
5/21/2013	SM-4401	11:07 AM	##i	20.2	7.3	529	344	8.6	95
8/27/2013	SM-4415	9:36 AM	##i	21.1	7.3	588	382	7.4	83
9/23/2013	SM-4433	9:53 AM	0.0i	17.0	7.2	624	405	8.1	84

Table 15 MassDEP SMART 2011-2013. Station QU02A. *In Situ* Multiprobe Data

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/26/2011	SM-3470	8:09 AM	**	**	**	**	**	**	**
3/30/2011	SM-3542	8:27 AM	0.7	5.0	7.2	561	365	13.4	105
5/25/2011	SM-3614	8:40 AM	0.4	18.9	7.1	558	363	8.8	95
7/27/2011	SM-3686	8:55 AM	0.3	23.9	7.0	583	379	7.0	83
9/28/2011	SM-3758	8:41 AM	0.7	22.6	7.1	444	289	8.0	92
11/9/2011	SM-3830	8:43 AM	0.4	9.4	7.2	471	306	12.0	105
2/28/2012	SM-3902	8:49 AM	0.7	3.9	7.3	505	328	13.3	101
4/25/2012	SM-3974	8:45 AM	##i	12.6	7.2	464	301	10.5	99
6/27/2012	SM-4046	8:25 AM	##i	21.4	7.1	485	315	7.9	90
8/29/2012	SM-4118	8:33 AM	##i	23.1	7.0	469i	305i	7.1	83
11/6/2012	SM-4190	9:01 AM	##i	6.9	7.2	450	292	12.4	102
1/30/2013	SM-4262	8:55 AM	0.0i	0.3	7.1	589	383	14.1	98
3/27/2013	SM-4334	8:46 AM	0.0i	5.8	7.3	638	414	12.8	102
5/21/2013	SM-4394	8:43 AM	##i	21.4	7.2	673	438	8.2	93

Table 16 MassDEP SMART 2011-2013. Station WR03. *In Situ* Multiprobe Data

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/26/2011	SM-3474	8:53 AM	**	**	**	**	**	**	**
3/30/2011	SM-3546	9:48 AM	0.5	4.7	6.3	230	149	11.9	93
5/25/2011	SM-3618	10:21 AM	0.4	18.4	6.1	220	143	5.9	63
7/27/2011	SM-3690	10:19 AM	0.2	22.4	6.2	233	152	3.2	37
9/28/2011	SM-3762	10:05 AM	0.5	20.5	6.3	177	115	4.1	45
11/9/2011	SM-3834	10:14 AM	0.5	7.6	6.5	169	110	10.4	87
2/28/2012	SM-3906	10:20 AM	0.6	3.3	6.6	175	114	12.7	95
4/25/2012	SM-3978	10:06 AM	##i	12.1	6.3	135	88	8.5	79
6/27/2012	SM-4050	9:45 AM	##i	19.8	6.5	221	144	5.8	63
8/29/2012	SM-4122	10:03 AM	##i	21.8	6.5	221i	144i	4.7	54
11/6/2012	SM-4194	10:25 AM	##i	4.9	6.5	197	128	10.7	84
1/30/2013	SM-4266	10:20 AM	**	**	**	**	**	**	**
3/27/2013	SM-4338	10:23 AM	0.0i	4.8	6.5	217	141	12.0	94
5/21/2013	SM-4398	10:27 AM	##i	20.9	6.7	251	163	7.8	88

Table 17 MassDEP SMART 2011-2013. Station BS09C. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/26/2011	SM-3466	**	**	**	**	**	**	**	**	**	**	**
3/30/2011	SM-3538	7:35	21	58	110	548	1.8	1.7	0.65	0.05d	0.44	0.017
5/25/2011	SM-3610	7:50	24	56	88	387	3.6d	2.8	0.80	0.12	0.37	0.043
7/27/2011	SM-3682	8:04	43	92	160	435f	3.3	3.3	0.89	0.08	0.50	0.044
9/28/2011	SM-3754	7:50	44d	54	98	248	4.5	2.9h	0.62	0.05	0.27	0.037
11/9/2011	SM-3826	7:55	25	49	79	1300	2.8	2.5	0.67	0.05	0.34	0.027
2/28/2012	SM-3898	7:55	30	66	110	1200	3.0	2.6	0.81	0.04	0.54	0.024
4/25/2012	SM-3970	7:52	23	44	83	579	5.3	3.4	0.64	0.06	0.23	0.043
6/27/2012	SM-4042	7:35	32	58	100	816	6.8	4.7b	0.71	0.09	0.32	0.059
8/29/2012	SM-4114	7:40	36	62	100	1200	4.3h	3.2	0.73	0.07	0.32	0.060
11/6/2012	SM-4186	8:10	30	51	74	365	6.1	4.7	0.76	0.04	0.22	0.043
1/30/2013	SM-4258	8:00 AM	35	91	580h	1050	28	34.0	1.5	0.29	0.68	0.086
3/27/2013	SM-4330	7:55 AM	26	68	160	205	2.3	1.9	0.77	0.02	0.55	0.017
5/21/2013	SM-4390	7:55 AM	39	88	150	345	9.1	3.9	0.95	0.15	0.48	0.065

Table 18 MassDEP SMART 2011-2013. Station BS14A. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/26/2011	SM-3471	**	**	**	**	**	**	**	**	**	**	**
3/30/2011	SM-3543	9:03	34	67	130	>2419.6	4.3	1.9	2.8	1.6	0.67	0.085
5/25/2011	SM-3615	9:25	29	62	110	210	8.4	2.9	1.4	0.08	0.91	0.10
7/27/2011	SM-3687	9:26	42	81	150	1200f	8.1	4.2	2.8	0.27	1.7	0.65
9/28/2011	SM-3759	9:10	29	59	110	276	5.3	2.4h	1.5	0.13	0.94	0.098
11/9/2011	SM-3831	9:24	31	67	110	548	3.1	1.9	1.6	0.28	0.98	0.13
2/28/2012	SM-3903	9:10	34	64	110	1050	3.4	2.1	2.0	0.21	1.3	0.13
4/25/2012	SM-3975	9:16	27	50	91	727	7.7	3.0	1.4	0.18	0.78	0.22
6/27/2012	SM-4047	9:00	40	62	110	345	10	4.6b	1.5	0.13	0.99	0.16
8/29/2012	SM-4119	9:07	52	71	120	1410	4.5h	3.1	2.2	0.23	1.6	0.11
11/6/2012	SM-4191	9:25	37	58	82	161	3.5	2.8	1.7	0.25	0.96	0.077
1/30/2013	SM-4263	9:25 AM	52	80	270h	461	11	3.1	2.6	0.25	1.3	0.13
3/27/2013	SM-4335	9:23 AM	36	72	160	210	3.2	1.6	1.7	0.42	0.88	0.044
5/21/2013	SM-4395	9:12 AM	52	81	150	199	9.8	3.4	2.3	0.25	1.5	0.13

Table 19 MassDEP SMART 2011-2013. Station BS18A. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/26/2011	SM-3475	**	**	**	**	**	**	**	**	**	**	**
3/30/2011	SM-3547	10:19	21	50	100	517	3.7	1.9	1.7	0.68	0.71	0.050
5/25/2011	SM-3619	10:52	21	48	90	79	9.3	3.3	1.1	0.06	0.71	0.11
7/27/2011	SM-3691	12:45	36	69	130	272f	4.7	2.8	1.9	0.03	1.3	0.12
9/28/2011	SM-3763	10:43	22	44	84	91	5.5	1.8h	1.0	0.03	0.60	0.10
11/9/2011	SM-3835	10:44	21	44	74	199	4.2	2.3	1.1	0.06	0.71	0.086
2/28/2012	SM-3907	12:45	22	47	82	167	3.3	1.8	1.2	0.04	0.90	0.052
4/25/2012	SM-3979	10:37	17	33	62	461	9.7	3.7	0.98	0.07	0.46	0.13
6/27/2012	SM-4051	10:25	30	47	87	121	8.0	4.4b	1.5	0.08	1.1	0.14
8/29/2012	SM-4123	10:40	39	57	98	98	7.5h	3.3	1.6	<0.05	1.1	0.11
11/6/2012	SM-4195	11:03	27	45	52	45	3.7	2.2	1.0	<0.04	0.70	0.063
1/30/2013	SM-4267	**	**	**	**	**	**	**	**	**	**	**
3/27/2013	SM-4339	10:54 AM	20	48	110	41	3.1	1.7	1.1	0.15	0.70	0.042
5/21/2013	SM-4399	11:02 AM	36	60	120	50	6.2	2.7	1.5	0.07	1.0	0.10
8/27/2013	SM-4414	9:23 AM	N/A	N/A	130	172	N/A	N/A	1.4	<0.02	1.2	0.092
9/23/2013	SM-4432	9:35 AM	N/A	N/A	##h,m	326	N/A	N/A	2.4h,m	##h,m	##h,m	0.12h,m

Table 20 MassDEP SMART 2011-2013. Station QU02A. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/26/2011	SM-3469	**	**	**	**	**	**	**	**	**	**	**
3/30/2011	SM-3541	8:17	20	66	140	2	1.5	1.4	0.64	0.04	0.41	0.012
5/25/2011	SM-3613	8:31	21	66	140	13	4.3	1.9	0.60	0.10	0.21	0.018
7/27/2011	SM-3685	8:46	27	68	140	26f	1.5	0.7	0.40	0.03	0.04	0.022
9/28/2011	SM-3757	8:35	24	58	120	39	1.2	0.8h	0.32	0.03	0.04	0.012
11/9/2011	SM-3829	8:35	24	59	120	1	1.5	1.0	0.45	0.04	0.14	0.013
2/28/2012	SM-3901	8:35	22	63	120	4	4.7	1.7	0.75	0.07	0.46	0.011
4/25/2012	SM-3973	8:37	24	58	120	39	2.9	2.2	0.58	0.11	0.08	0.024
6/27/2012	SM-4045	8:18	26	62	120	22	2.1	1.5b	0.37	0.04	0.04	0.024
8/29/2012	SM-4117	8:20	28	63	120	12	1.0h	0.9	0.40	0.04	0.05	0.018
11/6/2012	SM-4189	8:52	26	61	100	2	1.4	0.8	0.28	<0.02	<0.02	0.010
1/30/2013	SM-4261	8:45 AM	32	73	150	1	1.6	1.4	0.72	0.14	0.34	0.012
3/27/2013	SM-4333	8:40 AM	23	69	170	3	2.0	1.2	0.62	0.03	0.36	0.013
5/21/2013	SM-4393	8:35 AM	24	73	170	7	2.9	1.2	0.45	0.09	0.06	0.023

Table 21 MassDEP SMART 2011-2013. Station WR03. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/26/2011	SM-3473	**	**	**	**	**	**	**	**	**	**	**
3/30/2011	SM-3545	9:40	7	24	53	3	<1.0	0.7	0.56	0.02	0.37	0.010
5/25/2011	SM-3617	10:11	10	25	50	50	2.6	1.6	0.69	0.11	0.17	0.032
7/27/2011	SM-3689	10:07	18	31	50	108f	1.4	1.9	0.63	0.07	0.21	0.033
9/28/2011	SM-3761	9:55	10	22	42	36	1.4	1.3h	0.52	0.02	0.10	0.032
11/9/2011	SM-3833	10:05	8	19	39	14	1.2	1.0	0.48	<0.02	0.26	0.015
2/28/2012	SM-3905	10:05	7	20	34	4	2.1	1.3	0.64	<0.02	0.44	0.014
4/25/2012	SM-3977	9:53	6	15	27	73	2.0	1.6	0.54	<0.02	0.12	0.028
6/27/2012	SM-4049	9:40	15	25	50	121	2.0	2.7b	0.81	0.06	0.42	0.037
8/29/2012	SM-4121	9:55	18	27	49	135	1.8h	1.3	0.53	0.04	0.08	0.027
11/6/2012	SM-4193	10:15	13	24	39	64	2.2	1.4	0.66	<0.02	0.16	0.025
1/30/2013	SM-4265	**	**	**	**	**	**	**	**	**	**	**
3/27/2013	SM-4337	10:10 AM	6	21	53	7	<1.0	0.6	0.50	<0.02	0.34	0.007
5/21/2013	SM-4397	10:20 AM	13	28	58	44	3.9	2.3	0.82	0.06	0.43	0.030

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