Massachusetts Department of ENVIRONMENTAL PROTECTION

2018 DWM ENVIRONMENTAL MONITORING OVERVIEW

(CN 444.0)

A brief overview of the surface water monitoring performed in 2018 by personnel of the MassDEP's Division of Watershed Management (DWM) is presented here. Information pertaining to the individual components of DWM's Surface Water Monitoring Program is presented at http://www.mass.gov/eea/agencies/massdep/water/watersheds/water-quality-monitoring-program.html#1.

The main programmatic objectives of the DWM related to surface water quality monitoring are to:

- Collect chemical, physical and biological data to assess the degree to which designated uses, such as aquatic life, primary and secondary contact recreation, fish consumption and aesthetics, are being met in waters of the Commonwealth;
- Collect chemical, physical and biological data to support analysis and development of implementation plans to reduce pollutant loads to waters of the Commonwealth;
- Screen fish in selected waterbodies for fish tissue contaminants (metals, PCBs and organochlorine pesticides) to provide for public health risk assessment;
- To the extent feasible, locate pollution sources and promote and facilitate timely correction;
- Identify and assess new and emerging water contaminants of concern;
- Over the long term, collect water quality data to enable the determination of trends in parameter concentrations and/or loads;
- Develop new or revised standards, which may require short-term research monitoring directed towards the establishment or revision of water quality policies and standards; and to
- Measure the effectiveness of water quality management projects or programs such as the effectiveness of implementing TMDLs or watershed-based plans to control nonpoint source pollution.

Quality assurance is maintained for DWM's watershed monitoring program to ensure implementation of an effective and efficient sampling design, to meet programmatic goals and to provide data meeting specific data quality objectives. The U.S. Environmental Protection Agency (USEPA) has approved a comprehensive Quality Assurance Program Plan (QAPP) that applies to the generation and use of surface water quality data by DWM for a five-year period (2015 – 2019). This five-year *program* QAPP is annually supplemented by project-specific Sampling and Analysis Plans (SAPs), which provide detailed information regarding individual *project* organization, tasks,

background, sampling design and non-direct measurements. More information pertaining to the DWM's Quality Management Program and the 2015 – 2019 QAPP can be found on-line at http://www.mass.gov/eea/agencies/massdep/water/watersheds/environmental-monitoring-quality-management-program.html.

In accordance with the DWM's long-range monitoring strategy, the 2018 monitoring program consisted of the ongoing implementation of both probabilistic (random) and deterministic (targeted) sampling networks designed to support the multiple objectives listed above. The EPA encourages states to adopt networks of randomly selected sampling sites that will allow for statistically unbiased assessments that can be applied at larger scales (e.g., statewide). During 2011 – 2015 the DWM surface water monitoring program carried out probabilistic monitoring and assessment (MAP2) surveys of Massachusetts' shallow (i.e., "wadable") streams. In 2016 the DWM initiated a new statistically-valid (probabilistic) sampling design for Massachusetts' lakes to be carried out over three years (i.e., 2016 – 2018). With the exception of some limited targeted monitoring on specific lakes of special concern (e.g., fish toxics, TMDL development), lake monitoring and assessment had largely been absent from DWM's monitoring program for many years, so the probabilistic lake surveys are filling an existing and longstanding monitoring gap.

A number of targeted monitoring projects were also carried out to meet multiple water quality assessment and management objectives. For example, monitoring efforts continued at the five northeast climate change network sites located in Massachusetts. In addition, fish samples were collected from 26 lakes to obtain the data and information needed to inform risk assessment and management activities pertaining to fish edibility. Monitoring projects were also carried out to measure the effectiveness of TMDL implementation, to assess the impacts of chlorides on surface waters, and to support the assessment and management of harmful algae blooms (HAB). These, as well as other monitoring activities performed in 2018, are described in more detail below.

PROBABILISTIC MONITORING & ASSESSMENT PROGRAM (MAP2) – The goals of the probabilistic survey are to provide an unbiased assessment of the support status of the aquatic life, recreational, fish consumption and aesthetic uses of lakes throughout Massachusetts. The random sampling design allows for the determination, with a known statistical confidence, of the percentage of lake acres supporting and not supporting their designated uses. To implement the survey, the major river basins of Massachusetts were regionally assigned to three groups (i.e., "West", "Northeast" and "Southeast") with each group containing an approximately equal number of lakes. Each year focuses on one of the regions. The target sample size in each region and year is 25 lakes which will result in a total of 75 lakes statewide at the end of the survey. The "Southeast Group" was the focus of monitoring in 2018 (Table 1). This group includes the Taunton and Ten Mile watersheds and the Buzzards Bay, Cape Cod, Islands, Mount Hope Bay, Narragansett Bay and South Shore coastal drainage systems.

Selected water quality and ecological variables were measured at index (i.e. deep hole) and shoreline sites, as well as throughout the whole lake. These are listed along with their sampling frequencies in Table 2.

Table 1. Location of randomly selected lakes in the southeastern watersheds of Massachusetts that were sampled in 2018 as part of the probabilistic lakes survey.

Site	Watershed	Waterbody	Town
MAP2L-257	Buzzards Bay	Halfway Pond	Plymouth
MAP2L-258	Cape Cod	Shubael Pond	Barnstable
MAP2L-259	Narragansett Bay	South Watuppa Pond	Fall River
MAP2L-263	Taunton	Cleveland Pond	Abington
MAP2L-264	Cape Cod	Williams Pond	Wellfleet
MAP2L-268	Ten Mile	Falls Pond, North Basin	North Attleborough
MAP2L-269	Cape Cod	Stillwater Pond	Chatham
MAP2L-270	Cape Cod	Long Pond	Yarmouth
MAP2L-274	Cape Cod	Long Pond	Barnstable
MAP2L-275	Taunton	Ames Long Pond	Stoughton
MAP2L-280	Cape Cod	Jemima Pond	Eastham
MAP2L-285	South Coastal	Fresh Pond	Plymouth
MAP2L-289	Buzzards Bay	Ezekiel Pond	Plymouth
MAP2L-290	Cape Cod	Mashpee Pond	Mashpee
MAP2L-294	South Coastal	Furnace Pond	Pembroke
MAP2L-295	Taunton	Watson Pond	Taunton
MAP2L-296	Cape Cod	Hinckleys Pond	Harwich
MAP2L-297	Buzzards Bay	Marys Pond	Rochester
MAP2L-301	South Coastal	Island Pond	Plymouth
MAP2L-304	Cape Cod	Coonamessett Pond	Falmouth

Table 1. Location of randomly selected lakes in the southeastern watersheds of Massachusetts that were sampled in 2018 as part of the probabilistic lakes survey.

Site	Watershed	Waterbody	Town
MAP2L-305	Buzzards Bay	Parker Mills Pond	Wareham
MAP2L-306	South Coastal	Cooks Pond	Plymouth
MAP2L-307	Taunton	Robbins Pond	East Bridgewater
MAP2L-312	Cape Cod	Mill Pond	Harwich
MAP2L-315	Cape Cod	White Pond	Dennis

Table 2. Sampling frequency of water quality and ecological variables measured at probabilistic lakes.

Location	Variable	Sample Frequency (Minimum)
Index site	Vertical profile (dissolved oxygen, temperature, pH, conductivity)	3
	Secchi disk transparency	3
	Nutrients (total phosphorus, total nitrogen)	3
	Water chemistry (true color, alkalinity, hardness, turbidity, dissolved silica, chloride, dissolved organic carbon)	3
	Chlorophyll a	3
	Phytoplankton community (including Diatoms once in August)	3
Shoreline site	Pathogens (*E. coli*)	5
	Cyanobacteria	3
	Algal toxins (microcystins and anatoxin-a)	3
Whole lake	Littoral macroinvertebrate community	1
	Fish tissue (mercury organochlorine pesticides, metals)	1
	Macrophytes (percent cover, biovolume, exotics)	1
	Aesthetics observations	1
	Human disturbance observations	1
	Bathymetry	1

The various components of the lake surveys are briefly summarized below.

***Index Site – Water Quality (Chemical, Biological and Physical)*:** Water quality (vertical DO/temperature/pH/conductivity profile, nutrients, dissolved silica, chlorophyll a, phytoplankton, true color, alkalinity, hardness, turbidity, chloride) samples were collected approximately once a month between June and September (3 sampling events) at the index site of each lake using techniques described in DWM standard operating procedures (SOP). The index site was located at the maximum depth point in each lake. Samples were field-preserved, as appropriate, and delivered to the Senator William Wall Experiment Station in Lawrence (WES) for nutrient

(total nitrogen, total phosphorus), chloride, dissolved silica, alkalinity and hardness analyses; the DWM lab in Worcester for chlorophyll a, turbidity and color analyses; PhycoTech (Saint Joseph, MI) for phytoplankton taxonomy, enumeration and biovolume (including Diatoms once); and TestAmerica Buffalo (Amherst, NY) for the analysis of dissolved organic carbon. A minimum of one duplicate and one blank sample per analyte were tested for QC for each sampling week (approx.10% of the samples).

***Shoreline Site – Water Quality (Biological and Microbiological)*:** Water quality (*E. coli*, cyanobacteria and algal toxins) samples were collected at the designated shoreline site for each lake using techniques described in the DWM SOPs. The shoreline site was located at a bathing beach if one was present or at a shoreline point where the lake is easily accessible by the public (e.g. adjacent road or culvert) for recreation. *E. coli* were sampled once a month between May and September (5 sampling events) while cyanobacteria and algal toxins were sampled once a month between July and September (3 sampling events). Samples were field-preserved, as appropriate, and delivered to the Senator William Wall Experiment Station in Lawrence (WES) for algal toxins analyses; the DWM lab in Worcester for *E. coli* analysis; and PhycoTech (Saint Joseph, MI) for cyanobacteria counts. A minimum of one duplicate and one blank sample per analyte were tested for QC for each sampling week (approx.10% of the samples).

***Whole Lake – (Bathymetry, Macrophyte and macroinvertebrate community, Fish tissue)*:**

Macrophyte Community – Bathymetry and the macrophyte community (percent cover, biovolume and species composition) were surveyed once during the summer in each lake using protocols described in DWM SOPs. The percent cover and biovolume of macrophytes were estimated using CI BioBase (Navico, Inc., Merrimack, NH). CI BioBase is cloud-based software that automates the processing of depth finder sonar log files to make aquatic vegetation and bathymetric maps. Macrophyte species composition was estimated by identifying macrophyte species from periodic, spatially diverse rake drags within each lake until no new species were identified by the survey crew with the goal of producing a dominant species list. Samples of macrophyte species that could not be identified by the survey crew were delivered to the DWM lab in Worcester for identification.

Littoral Macroinvertebrate Community - The littoral macroinvertebrate community was sampled at all lakes on one occasion during late summer or early fall, using protocols developed for the EPA's 2012 National Lake Assessments (NLA). These organisms can integrate environmental conditions (chemical – including nutrients and toxics; and physical – including shoreline alteration and water level fluctuations) over a long period of time and are an excellent measure of the waterbody's health. Specimens were placed into 2L Nalgene jars, preserved with denatured 95% ethanol and transported to the DWM lab for storage. A contractor will process (i.e. subsample) the macroinvertebrate samples and complete the necessary taxonomic identifications. In addition, habitat evaluations were completed at all lakes sampled for littoral macroinvertebrates.

Fish Tissue - Fish tissue samples were collected at all 25 lakes (see Table 1) on one occasion during late spring/early summer using a variety of techniques (electrofishing, gill nets, etc.) described in the DWM SOP. Composite samples of filets from three individuals of edible and legal size from a species were collected for 3-5 target species for the analysis by the WES of mercury, organochlorine pesticides, and metals. In addition, 10-12 individual whole fish from a single species were analyzed for mercury.

DETERMINISTIC ("TARGETED") MONITORING PROGRAM (TMP) – Several waters were selected, or "targeted", for monitoring activities designed to fulfill one or more of the monitoring program objectives listed on page 1. While the probabilistic monitoring described above was focused in the "Southeast" Group of watersheds, targeted monitoring activities were carried out in watersheds scattered throughout Massachusetts. More detail pertaining to the targeted monitoring activities of the DWM in 2018 is presented below.

Field and Lab Support for the Assessment and Management of Cyanobacteria Blooms: MassDEP continued to provide technical expertise and laboratory support for the investigation of potentially toxic algae (cyanobacteria) blooms. Working from MassDEP's DWM-Worcester and Southeast Regional (SERO) offices, respectively, and in collaboration with MassDPH, staff biologists performed cyanobacteria counts and identifications on water samples to determine whether cell counts exceeded MassDPH advisory levels for recreational waters. In addition, samples were collected and/or analyzed *ad hoc* from lakes in DWM's MAP2 and Lakes Baseline networks if blooms were observed by DWM sampling crews or if water samples exhibited elevated chlorophyll levels in the lab. Cyanobacteria counts and identifications were forwarded to MassDPH for risk assessment and management. A list of waterbodies from which MassDEP processed samples in 2018 is presented in Table 3.

Table 3. Waterbodies for which MassDEP staff performed cyanobacteria cell counts (C) and/or taxonomic identifications (ID) in 2018, either at the request of the MassDPH or in response to a bloom observed by sampling crews while conducting lake monitoring activities of the DWM.

Waterbody	Municipality	Number of sampling events	Sample Processing (No./Type)
Lake Chauncey	Westborough	1	1/C
Cook's Pond	Plymouth	3	2/C; 1/I
Furnace Pond	Pembroke	5	5/C
Halfway Pond	Plymouth	2	1/C; 1/I
Indian Lake	Worcester	3	2/C; 1/I
Mill Pond	Harwich	1	1/C
South Watuppa Pond	Fall River	6	6/C
East Monponsett Pond	Halifax/Hanson	23	23/C
West Monponsett Pond	Halifax/Hanson	21	21/C
Great Pond	Weymouth	1	1/C
Micah Pond	Plymouth	1	1/C
Bartlett Pond	Plymouth	3	3/C
Weymouth Great Pond	Weymouth	4	4/I
Hinckley's Pond	Harwich	1	1/I

Phycocyanin Sampling

Phycocyanin measurements were included as part of the cyanobacteria investigations conducted in 2018. Phycocyanin is a pigment found primarily in cyanobacteria. DWM staff members are evaluating the performance of several different analytical instruments while also working to develop a predictable relationship between the cell count of cyanobacteria and phycocyanin levels so that phycocyanin can be used as a surrogate for cell counts. Cell counts and identifications require more skill and time than does obtaining phycocyanin readings. As part of the MAP2 probabilistic lake surveys, shoreline samples were collected on three different occasions and analyzed for phycocyanin using a Turner Design fluorometer

Aquafluor and FluorQuik (AmniScience), on loan from EPA. Both instruments can be used to measure phycocyanin as well as chlorophyll. A total of 119 samples were analyzed for these two parameters. The samples were from the probabilistic monitoring, while Chauncey and Indian Lakes were included to gather data for the EPA Cyanobacteria Collaborative.

Fish Toxics Monitoring: In addition to the fish toxics monitoring performed at the 25 MAP2 lakes, the DWM obtained fish samples from Fivemile Pond (Springfield) at the recommendation of the Inter-agency Fish Toxics Committee. Edible fillets were analyzed for the presence of mercury and additional metals, PCB arochlors and organochlorine pesticides. If necessary, fish consumption advisories will be issued by the Massachusetts Department of Public Health (MassDPH).

Baseline Lake Sampling of Monponsett Pond, Halifax: The 2018 Baseline Lakes Survey focused on obtaining additional water quality information from East Monponsett Pond and West Monponsett Pond in Halifax. The specific objectives of this monitoring were to:

- Evaluate the lakes to determine if Massachusetts's water quality standards are met
- Provide data to show improvement from the implementation of phosphorus TMDLs

Assisted by staff from MassDEP's southeast regional office (SERO), DWM sampled the epilimnetic waters (surface and bottom) at the deep holes of both East and West Monponsett ponds on June 21st, July 18th, August 15th and September 12th. Samples were analyzed for total phosphorus and total nitrogen along with chlorophyll a and Secchi disk transparency. Vertical DO/temperature/pH/conductivity profiles were also obtained on all but the June sampling date.

Monitoring the Effects on Water Quality of Road-Salt Application: DWM continued to monitor seasonal chloride levels and dynamics in selected waters potentially impaired by road salt application. Continuous conductivity loggers were deployed at eight sites in the Neponset River watershed from August, 2017 through May, 2018. This work included the collection of chloride grab samples to check the accuracy of the specific conductance-chloride regression model. Nine sites on five rivers along the I-91 corridor (Connecticut River Watershed) have been selected as the next study area. Conductivity probes will be deployed from October, 2018 through June, 2019.

Monitoring Water Quality in Mount Hope Bay: In 2016, MassDEP acquired two YSI marine water quality monitoring buoys to address data gaps in the Massachusetts waters of Narragansett Bay and its sub-embayment Mount Hope Bay. The deployment of these buoys is intended to expand the existing Narragansett Bay Fixed-Site Monitoring Network (NBFSMN) currently administered by the Rhode Island Department of Environmental Management (RIDEM) and the University of Rhode Island Graduate School of Oceanography (URI). Until now, there were no NBFSMN stations located in the eastern portion of Mount Hope Bay and the Taunton River in Massachusetts. The addition of the two new monitoring buoys in Massachusetts will help to define ambient water quality conditions for dissolved oxygen, nitrate-nitrogen, algal abundance, temperature and other parameters. Specifically, the data may be used to assess trends over time, identify impaired waters, assess the effectiveness of management decisions (i.e. wastewater treatment facilities (WWTF) upgrades, TMDL efforts, and stormwater management) and support refinement, calibration and validation of water quality models.

MassDEP's long-term plan for the two buoy systems is to collect continuous, real-time data

seasonally from May-November for the next several years; however, the 2016 "pilot" deployment was considerably shorter (i.e., September–November) due to the timing of the procurement of the buoys. Furthermore, the "pilot" deployment was needed to become familiar with URI's protocols, establish near real-time data retrieval remotely via cellular communication and to troubleshoot technical problems that are inherent in the installation and proper functioning of new monitoring systems.

After the initial deployment from September-November 2016, MassDEP redeployed the two buoys from May-November in both 2017 and 2018 at approximately the same locations in the bay. Bi-monthly grab water samples were collected for water chemistry analyses at each buoy location within one meter of the deployed sensors during each deployment (2016-2018). Instantaneous grab sample data will be compared to corresponding sensor data to validate the accuracy of sensor measurements.

Monitoring to Assess Climate Change: DWM staff continued to monitor air and water temperature and collect macroinvertebrate samples at five sites in Massachusetts as part of an ongoing collaborative effort among multiple federal and state agencies, NGOs, and academic institutions across New York and New England to assess the effects of climate change in the Northeast. Spearheaded by the EPA, this effort is aimed at coordinating temperature and biological data collection across the region. Similar "regional" collaborations have been established across the country.

In Massachusetts the five sites are Hubbard Brook in Granville, Brown's Brook in Holland, Parker's Brook in Oakham, West Branch Swift River in Shutesbury, and Cold River in Florida. UMass/Amherst and MassWildlife's Division of Ecological Restoration (DER) are the other partners on the "Massachusetts Team." DER has installed flow-gaging equipment at the two sites without USGS gages and is developing flow rating curves for them. UMass is playing a coordinating role and also plans to address the fisheries component.

Continuous Stream Temperature Monitoring: DWM deployed temperature or temperature/conductivity sondes and dataloggers from June - September, 2018 at a total of 18 sites on 14 streams (Table 4) in the Farmington and Westfield river watersheds and on Martha's Vineyard as part of its ongoing short-term stream temperature monitoring network. Sensors were deployed to capture the maximum water temperatures anticipated during the summer season and the data will be used to identify or confirm the presence of cold-water fishery resources and to inform aquatic life use assessment.

Table 4. 2018 short-term temperature monitoring network.

Watershed	Stream Name	Number of Sites
Islands	Mill Brook	1
Islands	Paint Mill Brook	1
Islands	Witch Brook	1
Islands	Roaring Brook	1
Farmington	Clam River	3
Farmington	Dimmock Brook	1
Farmington	Silver Brook	1
Farmington	Sandy Brook	2
Farmington	Cherry Brook	1
Farmington	Spectacle Pond Brook	1
Farmington	Pond Brook	1

Farmington	Unnamed tributary	1
Westfield	Little River	2
Westfield	Cook Brook	1
Total sites		**18**

Site Investigation at Weymouth Great Pond: On February 21, 2018, DWM and USGS personnel conducted a site visit at the Weymouth Great Pond drinking water facility in Weymouth as part of an ongoing investigation to assess the implications of the EPA's new dissolved aluminum criteria for water treatment facilities in Massachusetts. A small portion of the pond was identified as a future sampling site since it received overflow from a solids settling lagoon and filtration system backwash from the facility. Upon return to this site on March 30th, DWM and USGS personnel found that the pond bottom was 50-100% covered by an orange gel material with 1-3 ft. of anoxic black mud below it. This observation was reported to water resources staff at MassDEP's Southeast Regional Office (SERO) and on April 26th DWM and SERO personnel collected bottom samples from the pond for microscopic and chemical analysis. Based on these analyses, it was concluded that the material was likely overflow from the settling lagoon and that remediation would be necessary. Follow-up activities are being managed by SERO personnel.

Monitoring at Fixed Locations to Estimate Contaminant Loadings: Massachusetts' long-term monitoring strategy identifies, as one of its key monitoring objectives, monitoring to support the development, implementation and evaluation of pollution control strategies, and indicates that "limited fixed-site monitoring may be required to quantify pollutant loadings." In 2017-2018 the USGS installed a flow monitoring station in the Connecticut River near Northfield, MA (No. 01161280) and initiated monthly co-located water-quality sampling to provide data for the estimation of nutrient loads entering Massachusetts from upstream sources. In addition, the water sampling frequency was increased at the USGS monitor in the Connecticut River at Thompsonville CT to refine estimates of nutrient loads leaving Massachusetts. Funded collaboratively by the Springfield Water and Sewer Commission, MassDEP, and USGS, this project will provide a greater understanding of the nutrient contributions from Massachusetts to Long Island Sound. Similar water monitoring efforts are planned to commence in 2018-2019 at existing USGS gaging stations near the pour points to the Connecticut River of the Deerfield, Millers, Chicopee and Westfield rivers. Monitoring these locations will assist in prioritizing areas for nitrogen load reductions and making informed nutrient management decisions. A similar monitoring design is proposed for the Taunton River watershed to quantify nutrient loadings to the lower Taunton River and Mount Hope Bay (see **Monitoring Water Quality in Mount Hope Bay** above). Water sampling will be initiated in late 2018 at existing USGS flow gages on the Taunton, Threemile, Mill and Segreganset rivers.

Bacteria Source Tracking Activities of the Southeast Regional Office (SEROBST): The DWM regional monitoring coordinator used the IDEXX quanti-tray system on site in the Southeast Region lab to determine the concentration of "indicator bacteria" (*E.coli* and Enterococcus) in surface water, at stormdrain outfalls and within drainage infrastructure (manholes).

Additional source tracking tools used were:

- Hach test kits: to determine detergent concentrations.
- Ammonia and potassium meters: to determine ammonia/potassium ratios

These data were combined with field observations and, in some cases, discussions with local

watershed groups and/or municipal officials to refine sampling locations, in an attempt to track and isolate the dry-weather source(s) of *E. coli* and/or Enterococcus bacteria. A small number of opportunities for "Human Marker" analyses (fluorescent whitening agents, DNA, and caffeine) were made available by the WES State Lab. These analyses were utilized in cases where bacteria concentrations were high but no obvious source could be immediately located, in an attempt to determine if the bacteria were from a human or animal source.

Subwatersheds where bacteria source tracking was conducted are presented below in Table 5.

Highlights of the 2018 sampling season

Thanks to summer intern, Andrew Bayliss, for field, lab and data entry assistance.

- The partnership with EPA Region-1 and Rhode Island DEM continued into this year, with the goal of monitoring water quality in the lower section of the Palmer River Watershed. Monitoring was focused in areas that were deemed most vulnerable to agricultural impacts and with the long-term goal of assessing trends over time in correlation with ongoing installation of agricultural BMPs. Samples were collected from April through November at 14 fixed stations on an outgoing tide (weather independent). EPA supplied YSI meters to measure temperature, specific conductance and salinity. Grab samples were tested (by EPA Region 1 lab) for *E.coli* (some *E.coli* analyses run by MassDEP SERO lab), enterococcus, total nitrogen, ammonia, nitrate/nitrite, total phosphorus, orthophosphate and total suspended solids (TSS). Samples were also collected for the "future analysis" of DNA, with the "new" PhyloChip/qPCR method for human fecal indicator. It has now been confirmed that EPA has succeeded in acquiring SNP grant funding for the Palmer River study. This money will be used (in part) to send these samples (frozen from the past couple of years) to Dr. Gary Andersen, of Lawrence Berkley National Laboratory who will run the PhyloChip/qPCR analysis.

- The successful multi-year partnership with the City of Taunton continued with:

    - An outfall pipe (draining Ingell Street) was discovered in 2016 to be discharging water with high concentrations of *E. coli*. One direct sewer connection to the drain from a house on Ingell Street was found and severed at that time. Follow-up samples were collected at the outfall in 2018 and bacteria concentrations were still significant. The City (contractor Don Allsop) worked with SEROBST to find and correct remaining sources.

    - Additional joint source tracking was conducted for an outfall discharging to the Mill River at the Spring Street Bridge. High bacteria concentrations have been observed intermittently at this outfall for years as well as Human Marker analysis results coming back positive, however no "smoking gun" has been found up until now. The City continued to commit time and resources to assisting with source tracking sampling in this area

- The successful partnership with the City of Brockton continued with:

    - SEROBST worked with City employees to follow up on a number of hotspot source areas, building on our work from the previous few years. The City has now invested in a state of the art camera truck and has been dedicated to the

BST process.

1. The Grove Street outfall (Salisbury Plain River): Continued joint source tracking efforts with the emergence of a new source.
2. Belmont Ave outfall/Weston Street/Forsman Ave (Salisbury Brook watershed): The City arranged to have numerous drains in this area investigated by camera. This exercise ruled out a number of suspected source areas.
3. Pleasant/Carrlyn/Irving (Lovett Brook watershed): The City arranged to have some additional suspected hotspot sections of drain line in this area investigated by camera. This exercise ruled out a number of suspected source areas. Human Marker analysis was conducted for the Keene Street outfall to keep track of prior correction efforts made in this drainage area.
4. Prospect Ave: The City arranged to dye test a drain with suspected hotspot underdrain influence.

- The Town of Plymouth requested BST assistance for Bartlett Pond. *E.coli* concentrations were found to be low.

- The Town of Westport requested BST assistance for "Dunhams Brook". Locals were concerned about smell and fungus in a tributary to Dunhams, as well as elevated counts of fecal coliform in Hicks Cove which has been causing closure of shellfish beds there. SEROBST investigated the watershed with assistance from the conservation agent and other town employees, as well as a concerned citizen. The source tracking efforts culminated in a sample collected from Dunhams Brook at Main Road being analyzed for human markers. The results showed no evidence of a human source.

Table 5. Subwatersheds where bacteria source tracking was conducted over the course of approximately 30 sample days. Note: This table includes only the names of those municipalities where sampling took place. New sub-watersheds are highlighted in **bold.**

Name	Basin	Segment	Municipalities sampled	Number of sample days
Coles Brook	**Ten Mile**	**52-11**	**Seekonk**	**1**
Palmer River project (incl. Rocky Run Brook and Torrey Creek)	Narragansett Bay	53-05 53-16 53-17	Seekonk & Rehoboth	8
Coles River	Mount Hope Bay	61-04	Swansea	1
Taunton River	Taunton	62-01 & 62-02	Taunton	3
Salisbury Plain River	Taunton	62-05	Brockton	4
Trout Brook	Taunton	62-07	Brockton	4
Salisbury Brook	Taunton	62-08	Brockton	4
Mill River	Taunton	62-29	Taunton	3
Lovett Brook	Taunton	62-46	Brockton	1
Plantingfield Brook	**Neponset**	**73-23**	**Norwood**	**1**
Old Swamp River	**Weymouth & Weir**	**74-03**	**Hingham & Weymouth**	**3**
Plymouth River	**Weymouth & Weir**	**74-20**	**Hingham**	**3**
Third Herring Brook	South Coastal	94-27	Norwell	2

Dunhams Brook (tributary to West Branch Westport River)	**Buzzards Bay**	**Tributary to 95-37**	**Westport**	**4**
Acushnet River	**Buzzards Bay**	**95-32_**	**New Bedford/Acushnet**	**2**