2019 WATER QUALITY MONITORING REPORT FOR

SPRUCE CREEK

FOR THE TOWN OF KITTERY, ME

April 2020

FB ENVIRONMENTAL ASSOCIATES

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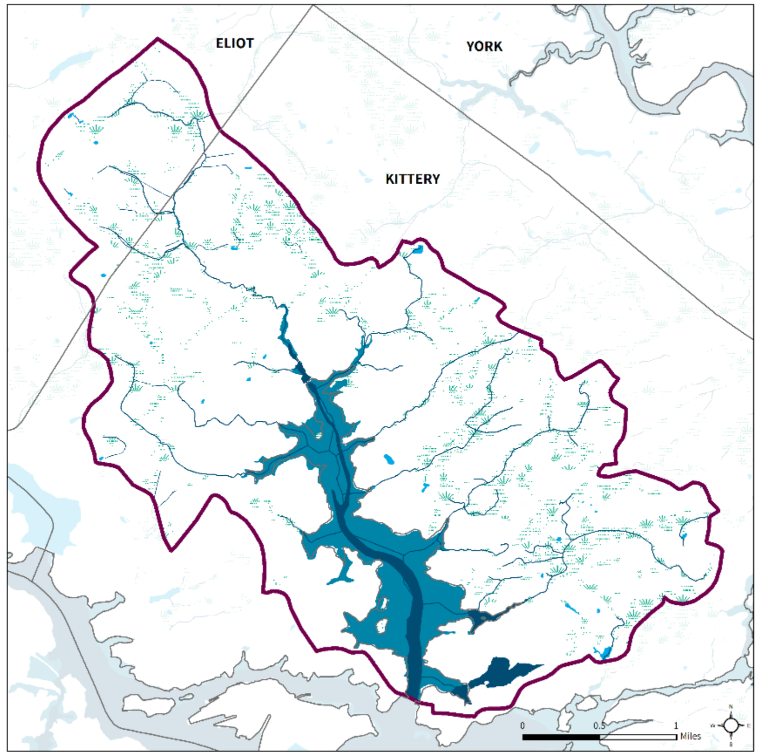
Volunteer Don Craig boating away from the middle estuary site in Spruce Creek. 2019. © FBE.

BACKGROUND



The Spruce Creek watershed covers 9.5 square miles in the Towns of Kittery (90%) and Eliot (10%), Maine. Drained by seven major freshwater streams (Barters Creek, Wilson Brook, Fuller Brook, Hill Brook, Hutchins Creek, Chickering Creek, and Crocketts Brook), the watershed feeds the Spruce Creek estuary, which in turn empties into the Piscataqua River, 1.5 miles north of the Piscataqua River's mouth to the Gulf of Maine. Approximately 3-square miles of the watershed's area are tidal, comprised of high salt marsh, ledge, and mud flats within the estuary. Watershed land cover is characterized by a mix of residential neighborhoods, commercial business corridors, conserved forest and shoreland, and agricultural areas, serviced by both municipal sewer and private septic systems. Many parks, boat launches, and residential homes provide both public and private access to the Creek, which also provides an iconic vista for travelers along Route 1 and Interstate 95 (or direct recreational enjoyment through boating, kayaking, and fishing) and is an integral part of Kittery's identity and local quality of life.

Fecal contamination (as evidenced through elevated fecal indicator bacteria or FIB) comprise the primary pollutant of concern in the Spruce Creek watershed. The estuarine portion of Spruce Creek is listed in the Maine DEP's 2016 Integrated Water Quality Monitoring and Assessment Report as impaired under Category 5-B-1: Estuarine and Marine Waters Impaired for Bacteria Only (fecal pollutants) – TMDL Required (refer to Waterbody ID 812-1 for Kittery). Spruce Creek is also identified by Maine DEP on the Threatened Stream and Marine Watersheds Priority List due to negative water quality indicators and its status as an MS4 (Municipal Separate Stormwater Sewer Systems) priority water. Shellfish beds (Department of Marine Resources (DMR) Closed Area 1-B) within Spruce Creek have been closed since July 2005 because the beds reside within the Prohibited/Safety Zone defined as high risk for sewage contamination following possible disinfection failure at the Pierce Island Wastewater Treatment Facility. Per a Consent Decree, the City of Portsmouth is required to upgrade its facility from primary to secondary treatment by June 2020. The upgrade is expected to greatly reduce the number of bacterial and viral pathogens in effluent. This will likely allow reopening of administratively-closed shellfish beds. Lowering that contamination risk could result in a complete reclassification of the Spruce Creek area following reinstatement of sanitary surveys and monitoring by the Maine DMR.

Monitoring conducted by the Town of Kittery, Spruce Creek Association (SCA), Maine DMR, and Maine Healthy Beaches program has shown elevated FIB levels exceeding USEPA's recommendations and Maine state criteria. Dry and wet weather sampling since 2008 have shown multiple "hotspots" of fecal contamination to Spruce Creek. Many of these "hotspots" have been addressed through the implementation of Phases I – IV and are continuing to be addressed in the current Phase V of the USEPA-funded (Maine DEP-administered) Spruce Creek Watershed Restoration Project (SCWRP), along with other important town-funded remediation efforts. Since the SCWRP began in 2008, more than 60 best management practices (BMPs) have been implemented throughout the watershed. As these remediation efforts are now underway, monitoring data becomes essential to assess the trajectory of any changes in the water quality of Spruce Creek.

Beginning in 2018, FB Environmental Associates (FBE) was hired by the Town of Kittery to complete water quality monitoring per the Spruce Creek Watershed-Scale Water Quality Monitoring Quality Assurance Project Plan (QAPP) for the Spruce Creek Watershed Restoration Project, Phase V (dated July 26, 2018). The following report summarizes 2019 results and details next step recommendations.

WATER QUALITY MONITORING

In 2019, FBE completed continuous data logger monitoring with grab sampling following the Spruce Creek Watershed-Scale Water Quality Monitoring QAPP for the Spruce Creek Watershed Restoration Project, Phase V (dated July 26, 2018) (refer to Appendix A for quality assurance-quality control review). FBE deployed and maintained town-owned data loggers at the upper and middle estuary of Spruce Creek and collected three sets of grab sampling during logger maintenance at the two sites. The Town of Kittery and volunteers were unable to collect targeted grabs samples due to Town scheduling constraints, but this effort is slated for summer 2020.

CONTINUOUS MONITORING (DATA LOGGERS)

METHODS

Data loggers were first deployed in Spruce Creek in 2012. The loggers collect water quality data at 15-minute intervals, providing a picture of in-estuary conditions over the course of multiple days and tidal cycles during the peak growing season (August-September). The use of loggers ensures continuity of data and maintains a baseline from which to compare future conditions as restoration work progresses in the watershed.

In 2019, continuous Onset HOBO® data loggers were deployed at two locations in the main channel of Spruce Creek (upper and middle estuary) from 8/9/19-10/2/19 (55 days). The middle estuary loggers were secured inside a metal eel trap using cable ties. The eel trap was mounted on top of a lobster trap to keep loggers out of the mucky estuary bottom. The eel trap was tied with thick rope to a bright orange buoy that floated on the surface of the water for retrieval. Two bricks were placed inside the bottom lobster trap to help anchor the trap in place and prevent any drift. The upper estuary loggers were secured to a PVC pipe using cable ties and tied with rope to a metal handle that was attached to the inside of the concrete culvert under Picott Road. Rocks were placed around and on top of the PVC pipe to secure the loggers and hide them from public view. Loggers recorded depth (i.e., relative tidal stage), conductivity, temperature, and dissolved oxygen (mg/L) at 15-minute intervals. FBE computed the percent saturation through the HOBOware® Pro Dissolved Oxygen Data Assistant by using local barometric pressure data retrieved from the nearest quality-controlled weather station. Field observations indicated there was above average algae growth during the 2019 monitoring season. It was apparent that more biofouling occurred on the loggers than previous monitoring years, so FBE increased maintenance events to once a week. Maintenance consisted of taking calibrated field meter readings near the deployed logger sensors, cleaning the loggers, and downloading data recorded by the loggers using a portable HOBO® Waterproof

Shuttle. FBE coordinated with a local resident (Don Craig) for transport to the middle estuary site. Quality assurance and quality control of the data followed the USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitors, as well as the HOBO® logger user manuals and best professional judgement.

RESULTS

Stacked eel and lobster traps for logger deployment in the middle estuary site. 2019. © FBE.

The upper estuary (PICOTT) of Spruce Creek experienced large swings in daily dissolved oxygen, specific conductivity, and temperature compared to the middle estuary (MIDEST) (Figures 1-2). The upper estuary site is located further upstream where the Creek narrows considerably above Picott Road and becomes more directly connected to freshwater influences from the landscape (e.g., surface runoff and groundwater). The middle estuary site (MIDEST) is located where the Creek is much wider and more influenced by marine waters. As observed in previous years, large precipitation events caused a drop in specific conductivity as freshwater runoff from the watershed flowed to the Creek. Specific conductivity and dissolved oxygen were higher at high tide and lower at low tide in the upper estuary (Appendix B). Temperature was generally cooler at high tide and warmer at low tide in the middle estuary.

Dissolved oxygen saturation fell below the minimum state criterion of 85% for tidal waters at a minimum of one reading interval for 55 of 55 days (100%) or 67% of all readings in the upper estuary and 35 of 54 days (64%) or 27% of all dissolved oxygen saturation readings in the middle estuary. Low dissolved oxygen may indicate high concentrations of nutrients and/or organic matter entering the Creek. Excess nutrients can stimulate rapid growth of algae and other aquatic plants; excess organic matter has a high potential biological oxygen demand as decomposition can deplete oxygen in the water column, causing stressful conditions for aquatic organisms, such as fish and shellfish.

We hypothesize that the decrease in dissolved oxygen at the middle estuary site that occurs in late September could be due to plant senescence at the end of the summer season, as death and decomposition of plants often contributes to oxygen depletion in estuaries (Figure 2). Additionally, a pattern across the two months of deployment show dissolved oxygen decreasing during a spring tide (time period where there is a greater difference between high and low tide that occurs after a new or full moon) and increasing during a neap tide. Thus, the confounding impacts of algae die off and the tidal cycle could contribute to this decrease in dissolved oxygen during late September at the middle estuary site.

A decrease in specific conductivity occurs in the middle estuary after the first maintenance period on August 19, and this is likely due to the logger being deployed in a different position in the water column. Given the conditions of the estuary, it is impossible to deploy the loggers in the exact same spot after each maintenance period, and the change in relative depth of deployment are also depicted in the depth panel of Figure 2.

GRAB SAMPLES

The Town of Kittery and volunteers were unable to complete targeted water quality sampling at nine sites in the upper portion of Spruce Creek during the 2019 sampling season. This effort has been rescheduled for the 2020 sampling season.

Three water quality samples were collected by FBE at PICOTT and MIDEST during logger deployment (8/9/19), maintenance (9/10/19), and retrieval (10/2/19) and analyzed for Enterococci at Absolute Resource Associates and for nitrate-nitrite, total Kjeldahl nitrogen, total phosphorus, ortho-phosphate, total suspended solids, and total organic carbon at Alpha Analytical Services. Results from the three grab samples are reported in Table 1.

PICOTT has been a consistently elevated fecal "hotspot" in the upper portion of Spruce Creek, draining a large area upstream of Interstate 95 and Route 1. Land use is more rural in the PICOTT drainage than in other areas of the watershed and includes agricultural fields such as Rustlewood Farm and several hobby farms. Historic nonpoint source watershed surveys in 2008 and 2013 identified agricultural stormwater runoff as a potential contributor of fecal contamination to the Creek. Historic water quality monitoring and analysis (including 2019 results) concluded that the upper estuary at PICOTT showed evidence of nutrient and organic enrichment during both wet and dry weather events. The upper estuary experienced large swings in daily dissolved oxygen, daily minimum dissolved oxygen that regularly exceeded the state criterion of 85% saturation, and elevated total nitrogen concentrations (~0.8-1.0 ppm) and biological oxygen demand. These results are consistent year to year and suggest that a possible source of pollution from upstream agricultural, residential, or wetland areas is impacting the upper estuary (with excess nutrients driving recurrent algae blooms).

MIDEST did not exceed the state criterion for single sample on any sample date but had elevated nutrients (nitrogen), likely from upstream contributing sources, such as from PICOTT.

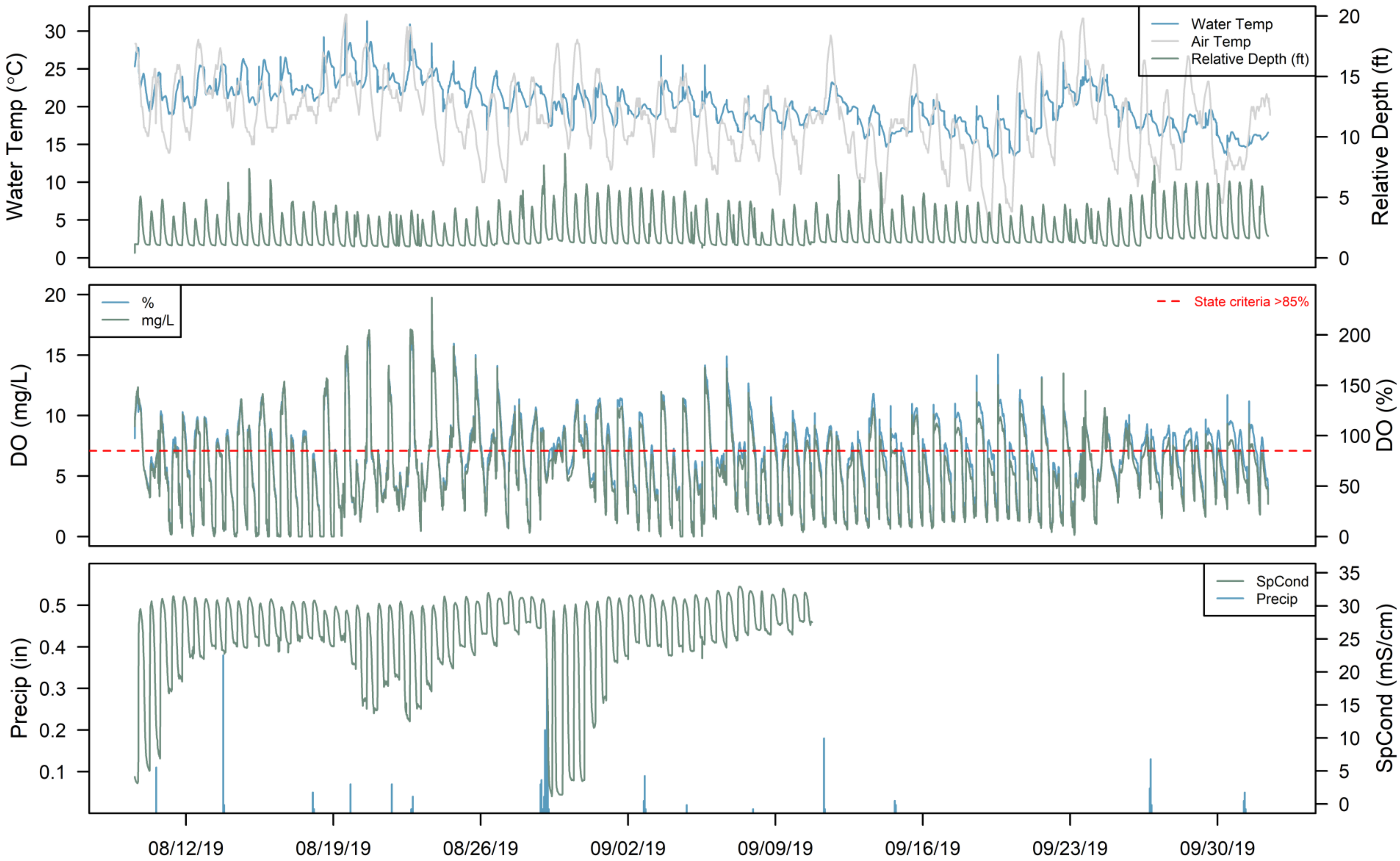


FIGURE 1. Continuous data collected in the upper estuary of Spruce Creek (PICOTT). Specific conducivity readings were removed after September 10, 2019 due to the logger being buried in sediment.

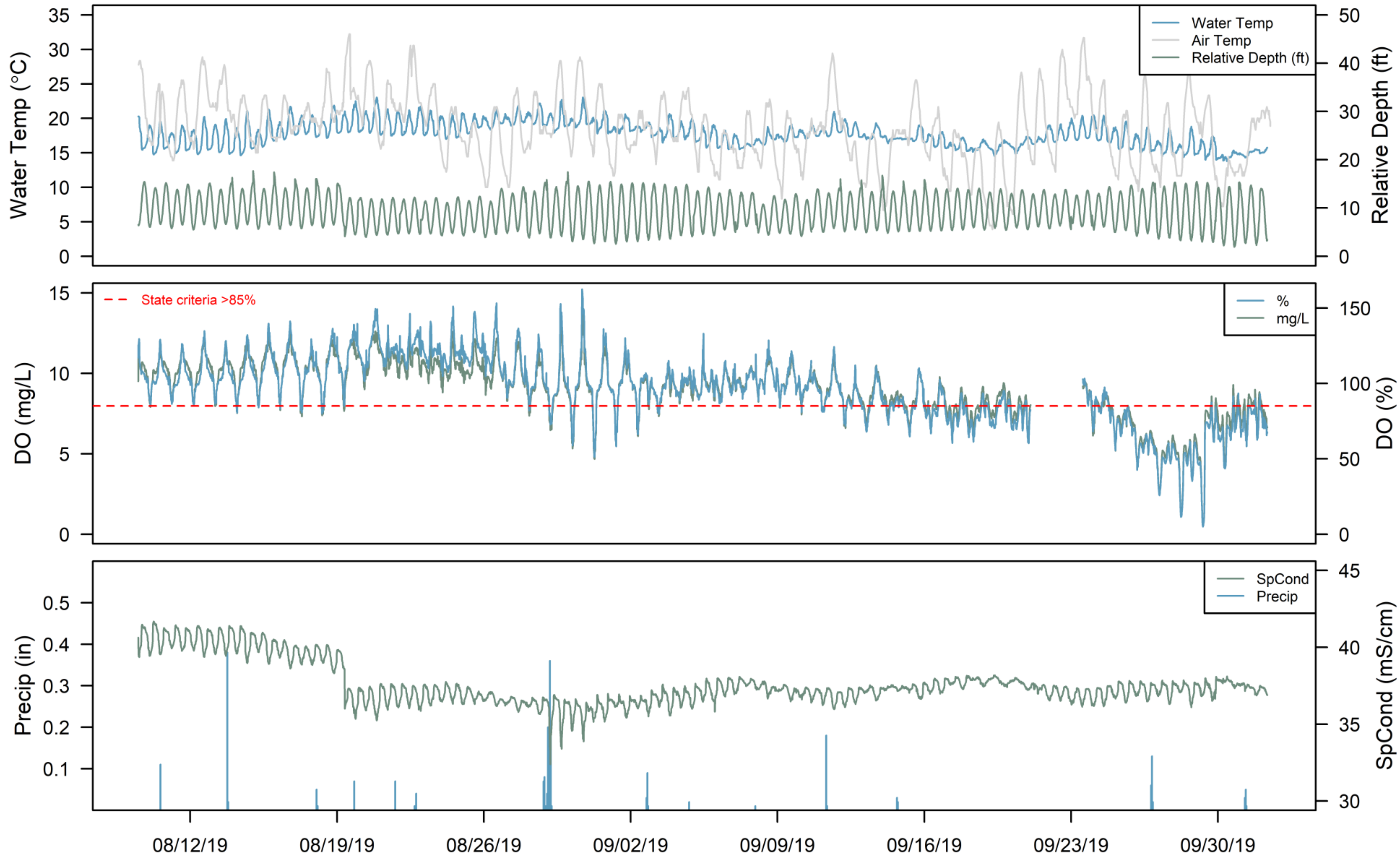


FIGURE 2. Continuous data collected in the middle estuary of Spruce Creek (MIDEST). The drop in specific conductivity on 8/19/19 was due to logger repositioning following maintenance.

TABLE 1. 2019 laboratory analysis results for Spruce Creek. Bold, italicized red or orange text indicates results exceeding state criteria and natural background or suggested levels, respectively. Green text indicates the lab reporting limit was higher than the state criteria or suggested levels. TKN = total Kjeldahl nitrogen. TP = total phosphorus. OP = orthophosphate, phosphorus. TOC = total organic carbon. TSS = total suspended solids. AA = Alpha Analytics. AR = Absolute Resources.

Site ID	Date	Time	Wet/ Dry	Entero (mpn/100mL)	TKN (mg/L)	Nitrate-Nitrite (mg/L)	TP (mg/L)	OP (mg/L)	TSS (mg/L)	TOC (mg/L)	Lab
Tidal State Criteria/ Suggested Levels				104	0.57	0.31	0.24	0.24	30	NA	
MIDEST	8/9/19	12:35	Wet	10	0.317	<0.10	0.035	0.018	8.2	1.17	AA
MIDEST	9/10/19	15:05	Dry	<10	<0.500	<1.00	0.090	<1.000	6.4	1.80	AR
MIDEST	10/2/19	8:40	Dry	60	**0.651**	<0.11	0.057	0.011	22.0	2.07	AA
PICOTT	8/9/19	15:35	Wet	**580**	**1.080**	<0.10	0.094	0.040	10.0	9.46	AA
PICOTT	9/10/19	16:15	Dry	**122**	**0.700**	**<5.00**	0.080	<5.000	8.3	3.70	AR
PICOTT	10/2/19	10:10	Dry	**390**	0.412	0.066	0.062	0.017	1.0	4.97	AA

CONCLUSIONS AND NEXT STEPS

The water quality monitoring dataset for Spruce Creek becomes more robust for every year that monitoring is continued. As the data record expands, water quality analysis will provide better insights to the long-term trends and allow better understanding of interannual changes in water quality that may be related to specific conditions within a given year (e.g., weather patterns, land use changes, remediation efforts, etc.).

However, given the limited number of targeted grab sampling in 2019, we are limited in conclusions. The upper and middle estuary showed evidence of nutrient and organic enrichment as a persistent source on nonpoint source pollution, possibly from agricultural, residential, or wetland areas upstream.

NEXT STEPS

- Continue to monitor sites for changes in water quality in Spruce Creek. This will provide valuable information and allow the Town of Kittery to track progress toward improving water quality in Spruce Creek. Consistency and continuity of monitoring effort is essential to detecting long term trends in water quality.
  - → Re-deploy data loggers at the upper and middle estuary annually in August-September.
  - → Re-start collection of samples at major tributary sites, particularly those with consistently high fecal indicator bacteria counts and/or with future changes to land use. This could be aided by the reactivation and expansion of the Spruce Creek Association (SCA) Volunteer Monitoring Program.
  - → Re-sample sites bracketing the buffer planting in the upper portion of Spruce Creek to assess the success of the buffer planting project.
- Assess and remediate potential sources of nonpoint source pollution to Spruce Creek.
  - → Investigate locations along Picott Road and Old Farm Lane to install stormwater BMPs that treat road runoff.
  - → Work with property owners adjacent to Spruce Creek to enhance buffers and/or install other practices that help treat runoff before entering the Creek.
  - → Install geese deterrents at or near PICOTT DS.

REFERENCES

FBE. (2018). Spruce Creek Watershed-Scale Water Quality Monitoring: Spruce Creek Watershed Restoration Project, Phase V Quality Assurance Project Plan (QAPP). Prepared by FB Environmental Associates on behalf of the Town of Kittery for the Maine Department of Environmental Protection, July 26, 2018.

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Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A. (2006). Guidelines and standard procedures for continuous water-quality monitors-Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed at http://pubs.water.usgs.gov/tm1d3

APPENDIX A: QUALITY ASSURANCE-QUALITY CONTROL REVIEW

Sampling conducted in 2019 followed protocols detailed in the Spruce Creek Watershed-Scale Water Quality Monitoring QAPP for the Spruce Creek Watershed Restoration Project, Phase V (dated July 26, 2018). A summary of those protocols and any deviations relevant to the 2019 sampling are described below.

1) All COC forms and field forms were complete.
2) YSI 55 conductivity meter was not working on 8/9/19, so we were unable to compare field conductivity measurements with logger measurements at both sites. The ProODO meter was not working properly on 8/9/19 at MIDEST, so we were unable to compare field dissolved oxygen measurements with logger measurements.
3) Fecal indicator bacteria samples were delivered to Absolute Resource Associates within the 6-hour holding time limit and all other grab samples were delivered to Alpha Analytics on the sample day. All samples were delivered to the labs at or below 10°C. Refer to Table A1.
4) Beginning on 8/26/19, the YSI 55 temperature probe was not working properly, thus impacting specific conductivity measurements. Specific conductivity measurements from the YSI 55 were converted to conductivity using the ProODO temperature reading and then converted back to specific conductivity using ProODO temperature for comparison with specific conductivity measurements from the logger. Beginning on 9/10/19, only conductivity measurements were taken, and these were converted to specific conductivity using the ProODO temperature measurements.
5) Dissolved oxygen measurements recorded at MIDEST between September 21 and September 23 were removed due to extreme biofouling.
6) The PICOTT conductivity meter was buried in sediment from 9/10/19 – 10/2/19; therefore, all conductivity measurements from this time period have been removed.
7) Matrix interference was an issue for grab samples collected at both sites. Nitrate-nitrite for PICOTT on 9/10/19 received a "J" or estimate qualifier; nitrate-nitrite for MIDEST on 9/10/19 received a "J" or estimate qualifier; TOC for MIDEST on 10/2/19 received a "J" or estimate qualifier; nitrate-nitrite for PICOTT on 10/2/19 received a "J" or estimate qualifier; ortho-phosphate for PICOTT on 9/10/19 received a "J" or estimate qualifier; ortho-phosphate for MIDEST on 9/10/19 received a "J" or estimate qualifier.

TABLE A1. Summary of adherence to quality assurance and quality control protocols. No deviations are noted.

Date	Precip 24 hrs prior (in)	Precip 48 hrs prior (in)	Precip 96 hrs prior (in)	Time of PICOTT Sample	Time of MIDEST Sample	Time of Low Tide	Time Delivered to Lab	Temp Received (°C)	Time to Lab (All Samples) (hh:mm)
8/9/2019	0.1	1.52	1.52	13:15	12:35	12:58	14:20	2.6	1:45
9/10/2019	0	0	0.01	16:15	15:05	15:32	17:04	2	1:59
10/2/2019	0	0.09	0.09	8:40	10:10	8:16	12:10	4.6	2:00

APPENDIX B: CORRELATION MATRICES FOR CONTINUOUS DATA AT PICOTT AND MIDEST

The correlation matrices shown below for PICOTT (top) and MIDEST (bottom) were generated in R statistical programming using the package *PerformanceAnalytics*. The distribution of each variable is shown on the diagonal. The bivariate scatterplots with fitted lines are shown below the diagonal. SpCond = Specific Conductivity; TempC = Water Temperature in Celsius. DOConc = Dissolved Oxygen concentration in mg/L. The value and significance of the correlation are shown above the diagonal. Significance levels by symbol are as follows: "***" = <0.001, "**" = 0.001, "*" = 0.01, "-" = 0.05, " " = >0.05.