

2020 WATER QUALITY MONITORING REPORT FOR

SPRUCE CREEK

FOR THE TOWN OF KITTERY, ME

[December 2020]

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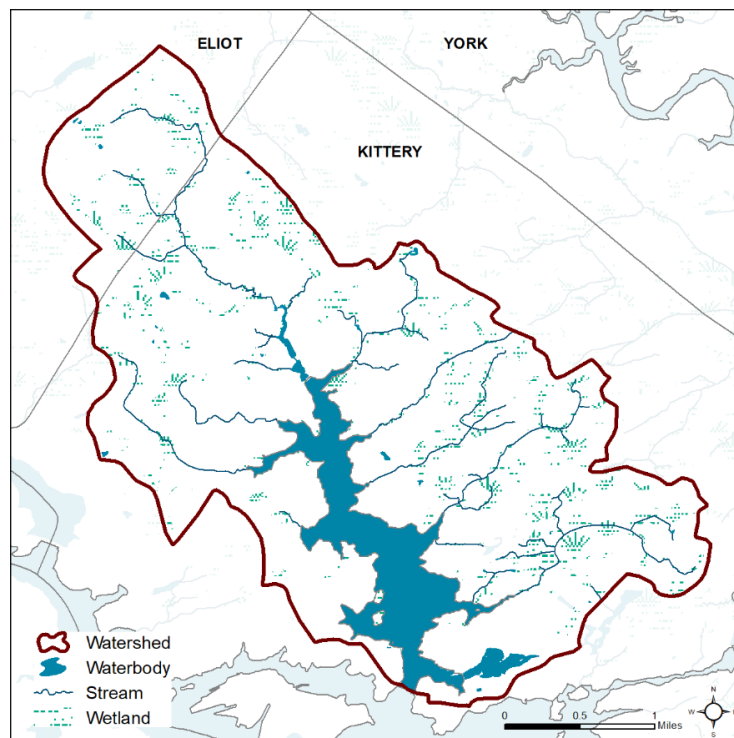
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PICOTT DS at low tide in August 2020. Credit: Jessa Kellogg.

BACKGROUND

The Spruce Creek watershed covers 9.5 square miles in the Towns of Kittery (90%) and Eliot (10%), Maine (Map 1). Drained by seven major freshwater streams (Barter's 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.



MAP 1. Spruce Creek watershed in Kittery, ME.

Fecal contamination (as evidenced through elevated fecal indicator bacteria or FIB) is 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. On 1/3/2020, the City of Portsmouth, NH announced the Pierce Island Wastewater Treatment Facility Upgrade project has been largely completed. This upgrade included the completion of the Biological Aerated Filter (BAF), a secondary treatment that targets the removal of organic matter and disinfection of bacteria in wastewater prior to the discharge to a surface water. The upgrade is still in progress as additional components of the treatment facility upgrade are underway. 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 Maine Department of Marine Resources (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 US Environmental Protection Agency's (US EPA) recommendations and Maine state criteria. Dry and wet weather sampling from 2008 through 2019 has 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 US EPA-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.

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 QAPP for the Spruce Creek Watershed Restoration Project, Phase V (dated July 26, 2018). The 2018 grab sampling and continuous logger monitoring data were presented in the 2018 Spruce Creek Water Quality Monitoring Report. The 2019 continuous logger monitoring data were presented in the 2019 Spruce Creek Water Quality Monitoring Report. The Town of Kittery and volunteers were unable to collect grab samples due to scheduling constraints in 2019, so this effort was moved to 2020. The following report summarizes 2020 grab sampling results and details next step recommendations. The analysis and presentation of 2020 continuous logger monitoring data will be funded at a later date.

WATER QUALITY MONITORING

In 2020, FBE completed the second of two years collecting water quality data per 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). Jessa Kellogg, the Town of Kittery's Shoreland Resource Officer, collected samples from nine sites that bracket the Rustlewood Farm buffer planting project (completed in May 2019) in the upper portion of the Creek. Volunteers did not assist due to the COVID-19 pandemic.

TARGETED SAMPLING (GRAB SAMPLES)

METHODS

The Town of Kittery collected water quality samples at nine sites in the upper portion of Spruce Creek to better track possible fecal sources upstream of the known "hotspot" site at Picott Road (PICOTT) and to assess water quality improvements following implementation of the stream buffer planting between sites RUSWOODFARM-3 and RUSWOODFARM-2 (Map 2). Six sets of samples were collected, along with field meter readings, at low tide (± 2 hours) during both wet and dry weather from July to October 2020 (Figure 1). Samples were delivered on ice to Absolute Resource Associates and were analyzed for Enterococci, nitrate, nitrite, orthophosphate, total Kjeldahl nitrogen, and total phosphorus. Water temperature, dissolved oxygen, salinity, conductivity, total dissolved solids (TDS), ammonia, and pH field readings were also collected. Three sets of samples, along with field meter readings, were collected at a site in the middle estuary, MIDEST, during low tide from August to October. Samples at MIDEST were analyzed at Absolute Resource Associates for Enterococci, nitrate, nitrite, total Kjeldahl nitrogen (TKN), total phosphorus, total suspended solids, and total organic carbon.

GEOMETRIC MEAN

The annual geometric mean is a form of average using the n^{th} root of the product of a set of numbers. This more accurately portrays serial correlation and is a measure of central tendency. A geometric mean suitably describes proportional growth (or loss) as a constant growth rate.

The 2020 sampling season experienced less than average rainfall, and the extent of drought within the Spruce Creek watershed during the sampling period was moderate in July and became severe in August (National Drought Mitigation Center, 2020; Figure 1). Due to the drought, three sites, **OLFARMLN**, **RUSWOODFARM-3**, and **RUSWOODFARM-2**, remained dry during each of the sampling visits and no measurements or samples were collected. OLFARMLN, the most upstream site, has historically been found dry in August and September; however, RUSWOODFARM-3 and RUSWOODFARM-2 have historically contained water in late summer.

RESULTS

Refer to Table 1 for a summary of sample results. Additional figures can be found in Appendix B. The following summarizes general observations from 2020 sample results:

- **RUSWOODFARM-1**, downstream of the Rustlewood Farm buffer planting, met the state criteria for Enterococci for the annual **geometric mean** and for all single samples except for one (683 mpn/100mL on 8/11/20). RUSWOODFARM-1 was also found to have an elevated total Kjeldahl nitrogen concentration on 10/8/20 (0.70

mg/L) and elevated total phosphorus concentrations ranging from 0.05-0.10 mg/L on all sample days.

- **UPSC-PRDRIVE** met the state criteria for Enterococci for the annual geometric mean and for all single samples except for two (141 mpn/100mL on 8/11/20 during dry weather and 345 mpn/100mL on 8/20/20 during wet weather). UPSC-PRDRIVE was also found to have an elevated total Kjeldahl nitrogen concentration on 9/23/20 (0.70 mg/L) and elevated total phosphorus concentrations ranging from 0.04-0.20 mg/L on all sample days. Dissolved oxygen was consistently low and not meeting state criteria on all sample days.
- **WR Cul** met the state criteria for Enterococci for the annual geometric mean and for all single samples except for one (187 mpn/100mL on 8/11/20). WR Cul was also found to have elevated total Kjeldahl nitrogen concentrations on four out of six sample days (0.6-0.9 mg/L) and elevated total phosphorus concentrations ranging from 0.07-0.14 mg/L on all sample days. Dissolved oxygen was consistently low and not meeting state criteria in July and August. pH was generally low but reflected brackish waters mixing with marine and freshwater.
- **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 concluded that the upper estuary at PICOTT showed evidence of nutrient and organic enrichment during both wet and dry weather events. In 2020, PICOTT met the state criteria for Enterococci for all single samples and the annual geometric mean, but dissolved oxygen percent saturation and concentration were regularly low and not meeting state criteria and total Kjeldahl nitrogen and total phosphorus concentrations were regularly elevated (0.6-1.2 mg/L and 0.07-0.13 mg/L, respectively). Enterococci at PICOTT showed a significant improvement compared to previous years, likely due to the drought conditions and lack of landscape flushing during the summer months. pH was generally low but reflected brackish waters mixing with marine and freshwater.
- **PICOTT CULVERT** met the state criteria for Enterococci for the annual geometric mean and for all single samples except for one (131 mpn/100mL on 8/11/20). PICOTT CULVERT was also found to have elevated total Kjeldahl nitrogen concentrations on four out of six sample days (0.7-2.7 mg/L) and elevated total phosphorus concentrations ranging from 0.06-0.25 mg/L on five out of six sample days. PICOTT CULVERT had the highest mean total Kjeldahl nitrogen concentration when compared to all other sites, with the highest single-day result over four times the natural background level for tidal environments (0.57 mg/L). Dissolved oxygen did not meet state criteria on two sample days. pH was generally low but reflected brackish waters mixing with marine and freshwater.
- **PICOTT DS** met the state criteria for Enterococci for the annual geometric mean and for all single samples except for one (389 mpn/100mL on 8/11/20). PICOTT DS was also found to have elevated total Kjeldahl nitrogen concentrations on two sample days (1.0-1.2 mg/L) and elevated total phosphorus concentrations ranging from 0.06-0.24 mg/L on all sample days. Dissolved oxygen did not meet state criteria on any of the sample days. pH was generally low but reflected brackish waters mixing with marine and freshwater.
- **MIDEST** generally met state criteria and natural background conditions in 2020 with some exceptions. One Enterococci sample exceeded the instantaneous state criterion on 10/7/20 at 167 mpn/100mL. Total phosphorus concentrations were elevated at 0.05 mg/L compared to natural background conditions.

Due to the region’s severe drought, the 2020 sampling season was a challenging period to ascertain sources of fecal contamination entering Spruce Creek, for the following key reasons:

1. **Reduced transport of fecal sources.** During a normal water year, surface runoff and groundwater flow connect the Creek to the surrounding landscape and watershed. During a drought, there is less surface runoff and groundwater flow, which can result in a decrease of terrestrial fecal sources transported from the landscape to the Creek.

2. **Inactivation of fecal indicator bacteria.** Many factors affect the survival of fecal indicator bacteria in aquatic environments such as salinity, flow, UV radiation, and temperature. Fecal indicator bacteria can die off when exposed to high salinity and high UV radiation caused by low flow conditions that concentrate solutes in surface waters and allow greater UV radiative penetration in shallower and clearer (from settling) waters, respectively (Byappanahalli et al., 2012). Infrequent storm events prevent flushing and mechanical mixing of bottom sediments into the water column; thus, low and slow flows allow fecal indicator bacteria to settle to the bottom and become unaccounted for in surface grab sampling. Low and slow flows can also warm waters quickly and stimulate bacterial growth within a certain threshold (between 10°C and 45°C) beyond which fecal indicator bacteria die off at extreme temperatures. The last two sampling days (9/23/20 and 10/8/20) were reaching the lower temperature limit for Enterococci to survive as water temperatures ranged from 9.8 to 15.2 °C, with a mean of 12.5 °C at all sites at the time of measurement on those two days.

TABLE 1. Average 2020 field measurements and laboratory analysis results for Spruce Creek. Bold, red or orange text indicates results exceeding state criteria and natural background or suggested levels, respectively (as indicated by the grey highlighted values for freshwater and tidal sites). DO = dissolved oxygen. Sal = salinity. Cond = specific conductance. TDS = total dissolved solids. Amm. = Ammonia. TKN = total Kjeldahl nitrogen. TP = total phosphorus. TOC = total organic carbon. TSS = total suspended solids. No samples were collected in 2020 for OLFARMLN, RUSWOODFARM-3, and RUSWOODFARM-2 due to no flow conditions.

Site ID	Temp (°C)	DO (%)	DO (mg/L)	Sal. (ppt)	Cond. (µS/cm)	TDS (ppt)	pH	Amm. (mg/L)	Entero (mpn/ 100mL)	TKN (mg/L)	TP (mg/L)	TOC (mg/L)	TSS (mg/L)
Freshwater	24-28	75.0	7.0	0.5	854	NA	6.5-8	0.5	35	0.20	0.02	NA	30.0
OLFARMLN													
RUSWOODFARM-3													
RUSWOODFARM-2													
RUSWOODFARM-1	13.0	90.6	9.8	2.1	442	3.15	7.6	0	13	0.33	0.07		
UPSC-PRDRIVE	15.7	21.5	2.2	2.1	454	3.23	7.2	0	23	0.33	0.12		
Tidal	24-28	85.0	NA	NA	NA	NA	8-8.5	0.5	35	0.57	0.02	NA	30.0
WR Cul	18.8	70.1	6.9	9.6	1,672	3.32	7.1	0	10	0.60	0.11		
PICOTT	19.5	62.8	6.0				7.2	0	9	0.72	0.10	3.2	7.7
PICOTT CULVERT	19.5	90.8	8.5				6.7	0	11	1.17	0.10		
PICOTT DS	19.5	71.5	6.8				6.9	0	12	0.62	0.11		
MIDEST	19.2	96.7	7.9		47,824				16	0.33	0.05	0.8	3.7

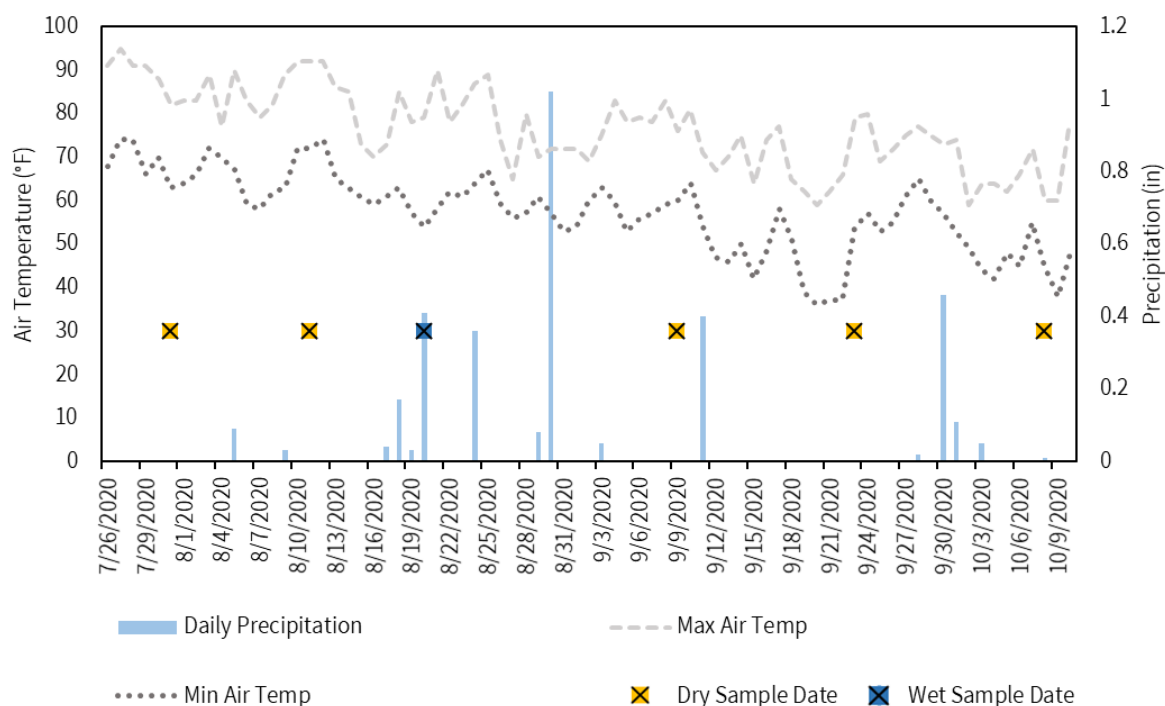


FIGURE 1. Daily precipitation, maximum temperature, and minimum temperature for the 2020 sampling season. Data were collected from the Pease International Tradeport weather station at weatherunderground.com.

RUSTLEWOOD FARM BUFFER PLANTING

Funded by a Maine DEP-administered 319 Watershed Assistance Grant in May 2019, the Town of Kittery, FBE, and 40 local volunteers gathered at Rustlewood Farm to plant 600 native trees along 400-foot stretch of Spruce Creek’s headwaters between two established sampling sites (RUSWOODFARM-2, upstream, and RUSWOODFARM-1, downstream; Map 2). A riparian buffer is a vegetated area along a stream that reduces erosion and flooding, provides shade, and minimizes the amount of pollutants entering the stream by absorbing and filtering animal waste, sediments, nutrients, and pesticides from nearby lands. The owners of Rustlewood Farm apply manure on adjacent hayfields according to a USDA-approved Comprehensive Nutrient Management Plan, which sets the timing and rate of manure application to reduce nutrient runoff to nearby surface waters. The goal of the buffer planting was to further reduce any possible untreated surface runoff from the manured hayfields to the Creek.

Ideally, water quality data from before and after the buffer planting at the upstream control sites (OLFARMLN, RUSWOODFARM-3, and RUSWOODFARM-2) and the closest downstream site to the buffer planting (RUSWOODFARM-1) would be used to determine the success of the buffer planting in improving water quality. Due to the drought¹ and resulting no flow conditions in the upper reaches of the Creek during the 2020 sampling season, the Town of Kittery was unable to collect water quality samples from the three upstream control sites. Until more data are collected over multiple years with near normal precipitation, no significant conclusions can be made on the limited data set. Here, we present general patterns and observations.

In general, water quality at RUSWOODFARM-1 in 2020 (after the buffer planting) compared to 2018 (before the buffer planting) showed higher dissolved oxygen concentration, lower salinity and conductivity, higher pH, lower Enterococci,

¹ During the 2018 sampling season, a total of 12 inches of precipitation fell from the first sample collected in July through the last sample in September, and five separate rainfall events produced over 1 inch of precipitation. By contrast, 3.3 inches of precipitation fell during the 2020 sampling season with only one storm over 1 inch (Figure 1).

lower total Kjeldahl nitrogen, and similar total phosphorus and total dissolved solids (Table 2; Figure 2). These seemingly improved water quality conditions in 2020 are confounded by drought conditions. Continued water quality monitoring in 2021 and beyond is strongly recommended to determine to what extent the buffer planting has improved the water quality of Spruce Creek.

TABLE 2. Average 2018 and 2020 field measurements and laboratory analysis results for RUSWOODFARM-1 (downstream of the Rustlewood Farm buffer planting). Bold, **red** or **orange** text indicate results exceeding state criteria and natural background or suggested levels, respectively (as indicated by the grey highlighted values for freshwater sites). DO = dissolved oxygen. Sal = salinity. Cond = specific conductance. TDS = total dissolved solids. Amm. = Ammonia. TKN = total Kjeldahl nitrogen. TP = total phosphorus.

Site ID	Temp (°C)	DO (%)	DO (mg/L)	Sal. (ppt)	Cond. (µS/cm)	TDS (ppt)	pH	Amm. (mg/L)	Entero (mpn/100mL)	TKN (mg/L)	TP (mg/L)
Freshwater	24-28	75.0	7.0	0.5	854	NA	6.5-8	0.5	35	0.20	0.02
2018	17.0	51.0	5.1	3.2	680	3.00	7.1	0	135	0.79	0.07
2020	13.0	90.6	9.8	2.1	442	3.15	7.6	0	13	0.33	0.07



Rustlewood Farm buffer planting in 2020, one year post installation. Credit: FBE

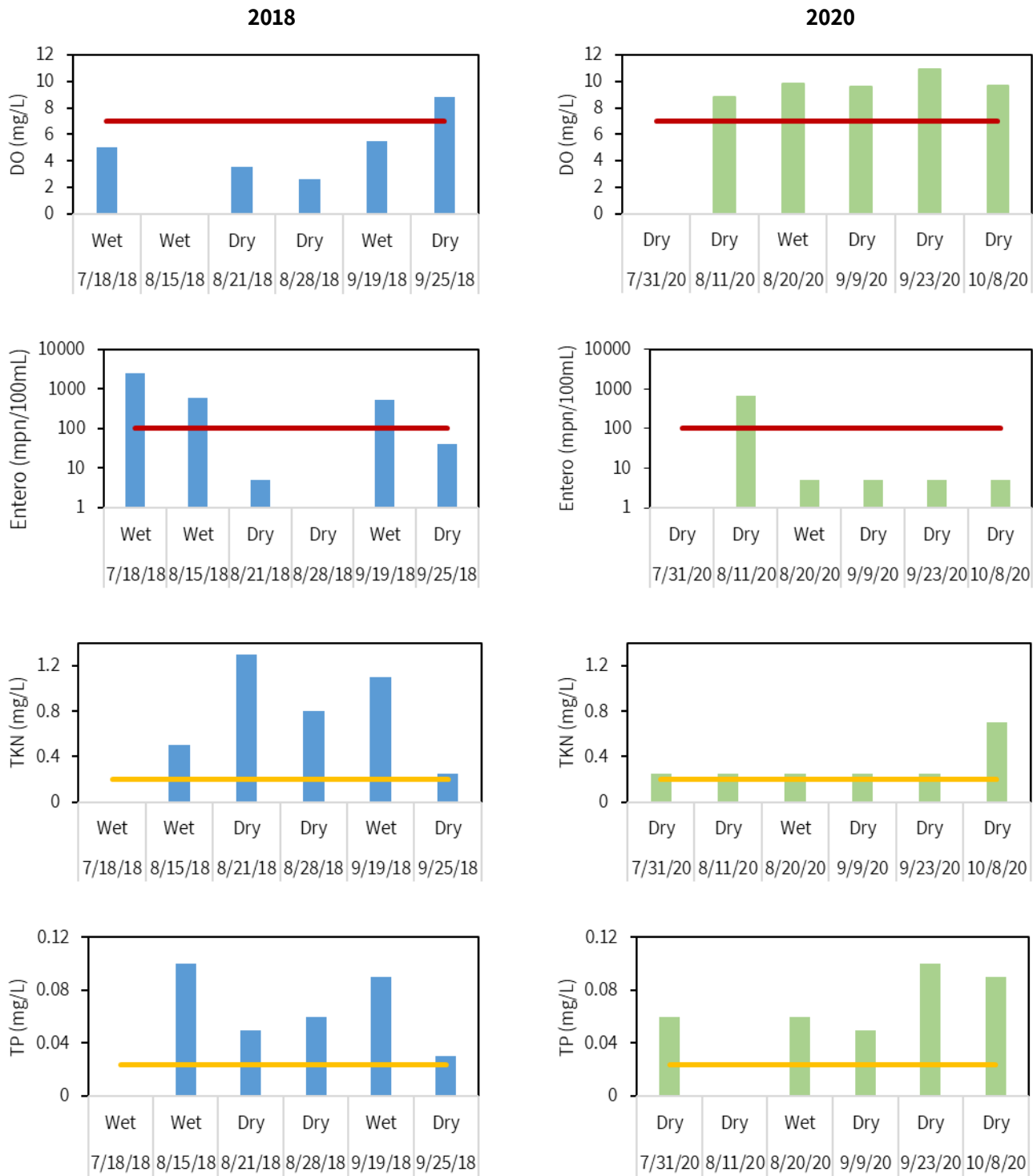


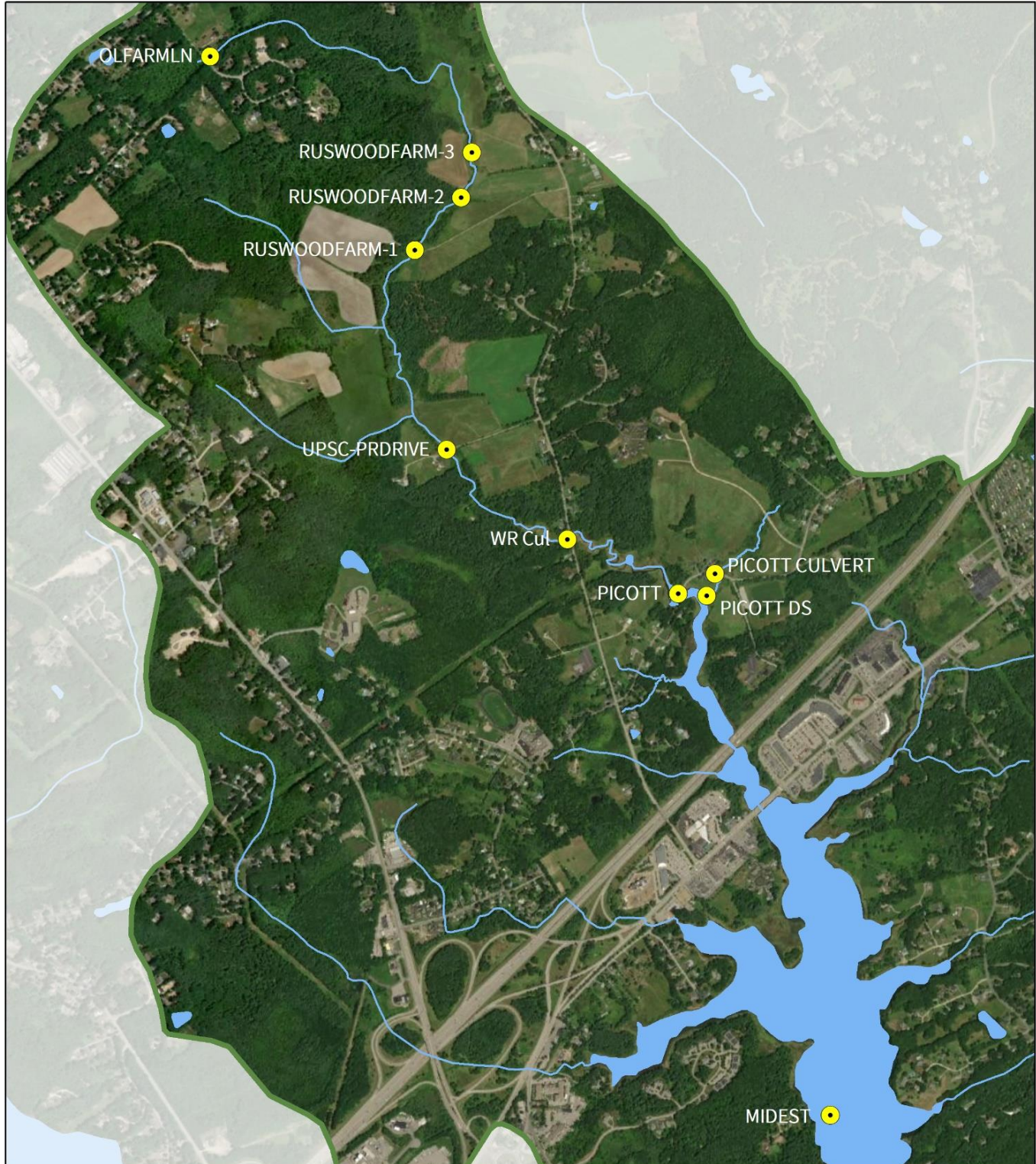
FIGURE 2. Comparison of data collected at RUSWOODFARM-1 in 2018 (left, blue) and 2020 (right, green) for DO concentration, Enterococci, total Kjeldahl nitrogen (TKN), and total phosphorus (TP). Red or orange horizontal lines indicate the state criteria and natural background or suggested levels, respectively.

Spruce Creek, Kittery, Maine Sampling Sites 2020

Data Source: ME GIS, NHD
Projection: NAD 19183 UTM Zone 19N
Created by: FBE November 2020

 Watershed
 Stream
 Sampling Site
 Waterbody

0 0.125 0.25 0.5 Miles



MAP 2. Location of 2020 sampling sites in the Spruce Creek watershed.

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 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.).

CONCLUSIONS

- The upper headwaters were extremely susceptible to drought conditions and did not contain enough water to sample for the entire 2020 sampling season.
- Sites generally showed water quality improvement in 2020 when compared to historic records, most likely due to drought conditions that reduced pollutant delivery to the Creek. Additional monitoring under several normal precipitation years will be needed to assess the impact of the Rustlewood Farm buffer planting and the Pierce Island Wastewater Treatment Facility upgrades.
- Numerous Canada geese have been observed at or near PICOTT DS and are likely a significant source of fecal indicator bacteria and nutrients to this site. It is likely that PICOTT CULVERT and PICOTT are also impacted by fecal sources at PICOTT DS due to tidal inundation.

NEXT STEPS

- Secure funds to analyze the continuous logger data collected in 2020 at PICOTT and MIDEST.
- 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 efforts is essential to detecting long-term trends in water quality.
 - Redeploy data loggers at the upper and middle estuary annually in August-September.
 - Continue collection of samples at hotspot sites, particularly those sites 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 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 SpruceCreek.
 - 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.
 - Investigate possible sources of excess nitrogen between WR Cul and PICOTT and at PICOTT CULVERT.

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APPENDIX A: Quality Assurance-Quality Control Review

Sampling conducted in 2020 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 are described below.

- 1) A mix of weather conditions (5 dry and 1 wet weather events) from July through October were sampled. The sampling events were not split evenly between wet and dry weather due to the lack of wet weather in 2020. Precipitation values were collected from Weather Underground's Pease International Airport at Pease Station, approximately five miles southwest of Spruce Creek.
- 2) Dissolved oxygen measurements were not collected on 7/31/20 due to a malfunctioning YSI 55 meter. Any field measurements collected by the YSI 55 for dissolved oxygen (mg/L and % saturation) with salinities greater than 9 PSU were not corrected due to over range Oakton PCSTestr 35 salinity readings (>10 PSU). It is likely that corrections were needed for most sites so dissolved oxygen concentrations were likely slightly (5-10%) lower than reported. Field measurements at MIDEST for dissolved oxygen were automatically corrected using a YSI Pro Solo meter except for readings collected on 8/11/20 by the YSI 55.
- 3) Many readings by the Oakton PCSTestr 35 in 2020 were recorded as "OR" or over range because salinities were greater than the detectable limit by the unit (>10 ppt). This was due to highly concentrated chloride concentrations in low flow conditions throughout the summer. Chloride concentrations at these sites in 2020 were one or two magnitudes higher than observed in 2018. Absolute Resource Associates provided the following table summarizing chloride concentration (mg/L) differences between two batch sample runs:

Sample ID	45514 (8/15/2018)	54178 (8/11/2020)
RUSWOODFARM-1	58	29
UPSC-PRDRIVE	52	31
WR CUL	~160	~6,000
PICOTT	~500	~12,000
PICOTT DS	~700	~13,000
PICOTT CULVERT	~550	~10,000

- 4) Samples from tidal sites on 7/31/20 were collected up to 4 hours and 50 minutes before the 2-hour window surrounding the head of low tide (within 2 hours and 22 minutes of the head of high tide). Samples were accepted because they were collected in the window of slack tide. This sampler error likely did not greatly impact results since these tidal sites were already highly impacted by concentrated chloride concentrations.
- 5) Fecal indicator bacteria were not analyzed from samples collected on 7/31/20 due to laboratory policies for not receiving bacteria samples on Fridays.
- 6) All fecal indicator bacteria samples were delivered to Absolute Resource Associates within the 6-hour holding time limit. All samples were delivered to the laboratory at or below 10°C with two exceptions. One set of samples collected on 8/11/20 was delivered at 16.6°C. These samples were accepted because the water temperatures taken at these sample sites were above 16.6°C, indicating that the samples were put on ice but were delivered to the laboratory before they had a chance to cool to below 10°C. Refer to Table A1. Another sample collected from MIDEST on 10/7/20 was delivered to the laboratory at 16.0°C, around but slightly warmer than the 14.3°C at collection. There was no known sampler error, and the sample was delivered on ice within 2 hours to the laboratory. It may have been an error with the laboratory temperature method. Results were deemed acceptable.

- 7) All COC forms and field forms were complete. One entry error for WR Cul on 8/20/20 was entered by the lab as “WR wl” due to a misread of a handwritten COC form. The COC and lab results also misprinted TOC results for PICOTT as PICOTT DS for 8/11/20 samples.
- 8) Grab samples and field meter readings were not collected at RUSWOODFARM-2, RUSWOODFARM-3, or OLFARMLN in 2020 due to prolonged dry weather generating no flow conditions. Overall and including all sites (whether flowing or not flowing), 56% of all measurements were collected and/or analyzed in 2020.
- 9) Field duplicates for fecal indicator bacteria should attempt to yield a relative percent difference (RPD) <30%, but one out of five duplicate samples resulted in RPD >30% (Table A2). RPDs >30% can be deemed acceptable given the inherent variability of collecting and measuring biological communities. Typically, higher bacteria counts will be less variable than lower bacteria counts of <200 mpn/100mL. As such, 2020 RPDs ranging from 0-67% were acceptable and reflected a consistent field sampling procedure by personnel.
- 10) Field duplicates for all other laboratory parameters should attempt to yield an RPD <20% (Table A2). RPD values greater than that limit were flagged, including TKN on 8/11/20 at PICOTT DS and on 10/8/20 at RUSWOODFARM-1, as well as orthophosphate on 8/20/20 at WR Cul and on 10/8/20 at RUSWOODFARM-1. In these cases, the results were less than the reporting limit; low values generate higher RPDs even with relatively small differences. Data were deemed acceptable and reflected a consistent field sampling procedure by personnel.
- 11) Matrix interference was a significant issue for most samples collected in 2020 for orthophosphate, nitrate, and nitrite. Dilutions were required due to matrix interference on multiple sample dates and at multiple sites. The dilutions extended the analysis process outside the recommended holding time for some samples. These factors led to high reporting limits of 5 and 10 mg/L. The matrix interference was the result of high chloride concentrations, over one to two magnitudes above those observed in previous years, which reflected the severe drought conditions in the region.

TABLE A1. Summary of adherence to quality assurance and quality control protocols. Deviations are highlighted in red. Precipitation data collected from Pease International Airport at Pease Station (Weather Underground). LT = low tide. COC = chain of custody.

Date	Precip 24 hrs prior (in)	Precip 48 hrs prior (in)	Precip 96 hrs prior (in)	Time of First Sample	Time of First Tidal Sample	Time of Last Tidal Sample	Time of Low Tide	Time Delivered to Lab	Temp Received (°C)	COC
7/31/2020	0.00	0.00	0.00	9:45	10:15	11:25	15:05	12:18	6.0	signed
8/11/2020	0.00	0.00	0.03	9:30	9:50	12:10	11:06	14:05	16.6	signed
8/20/2020	0.41	0.44	0.65	8:10	8:10	8:45	6:32	11:20	1.0	signed
9/9/2020	0.00	0.00	0.00	10:30	10:30	10:30	10:22	12:40	4.0	signed
9/9/2020	0.00	0.00	0.00	9:00	9:55	11:40	10:22	12:40	10.0	signed
9/23/2020	0.00	0.00	0.00	9:15	10:10	10:50	10:22	12:15	9.0	signed
10/7/2020	0.00	0.00	0.05	9:30	9:30	9:30	9:00	11:20	16.0	signed
10/8/2020	0.01	0.01	0.01	9:00	9:50	10:35	9:44	11:25	3.0	signed

Date	Time Diff - Lab (hh:mm)	Time Diff - LT (hh:mm)	Time Diff - LT (hh:mm)
7/31/2020	2:33	4:50	3:40
8/11/2020	4:35	1:16	1:04
8/20/2020	3:10	1:38	2:13
9/9/2020	2:10	0:08	0:08
9/9/2020	3:40	0:27	1:18
9/23/2020	3:00	0:12	0:28
10/7/2020	1:50	0:30	0:30
10/8/2020	2:25	0:06	0:51

TABLE A2. Summary of relative percent difference (RPD) between duplicate field samples. Blue text indicates the result was less than the laboratory detection limit of 10 mpn/100mL for Enterococci and 0.5 mg/L for total Kjeldahl nitrogen; therefore, values were changed to half the detection limit for analyses. RPD values greater than 30% for Enterococci and 20% for all others are highlighted in light orange for further investigation. All data were accepted.

Date	Wet/ Dry	Sample ID	Enterococci (mpn/100mL)	RPD (%)	Total Kjeldahl Nitrogen (mg/L)	RPD (%)	Orthophosphate (mg/L)	RPD (%)
7/31/2020	Dry	PICOTT			0.25 0.25	0	0.11 0.13	17
8/11/2020	Dry	PICOTT DS	389 441	13	0.50 0.25	67		
8/20/2020	Wet	WR Cul	5 5	0	0.25 0.25	0	0.10 0.07	35
9/9/2020	Dry	PICOTT CULVERT	10 5	67	2.70 2.90	7	0.25 0.24	4
9/23/2020	Dry	UPSC-PRDRIVE	5 5	0	0.70 0.60	15	0.11 0.12	9
10/8/2020	Dry	RUSWOODFARM-1	5 5	0	0.70 0.25	95	0.09 0.03	100

APPENDIX B: Data Figures by Weather for Spruce Creek Sites in 2020

