2021 BROAD COVE WATER QUALITY SAMPLING | MEMORANDUM

TO: Melanie Pendleton, Town of Bremen and Boe Marsh, Community Shellfish
FROM: Maggie Kelly, FB Environmental Associates (FBE)
SUBJECT: 2021 Broad Cove Water Quality Sampling Memorandum
DATE: December 1, 2021
CC: Forrest Bell, FB Environmental Associates (FBE)

INTRODUCTION

Broad Cove is an approximately 830-acre cove in the Medomak River estuary and represents the most productive shellfish flats available to clammers in the Town of Bremen, Maine. In 2019, the main cove was listed as "Conditionally Approved" by the Maine Department of Marine Resources (DMR) with seasonal closures between July 1 and September 30 as a result of elevated fecal coliform at water quality station WS024.8. In 2020, the seasonal closure in Broad Cove was extended through November 30 due to elevated fecal coliform above state water quality criteria at a second station (WS026). Because shellfishing is an important resource for the community, the closures have prompted the Town of Bremen and Community Shellfish to investigate potential causes of fecal contamination in the surrounding waterways and landscapes.

FB Environmental Associates worked with the Town of Bremen and Community Shellfish in 2020 to conduct an in-depth review of possible threats to shellfish flats by completing a watershed survey, shoreline survey, and a historical water quality data analysis. One of the recommendations in the report was to perform water quality sampling in Broad Cove. The goal of this sampling was to conduct initial investigative baseline sampling at tributaries entering Broad Cove to provide the Town of Bremen and the Shellfish Committee with the best understanding of when, where, and under what circumstances fecal indicator bacteria sources may be affecting the tidal flats of Broad Cove.

In 2021, FB Environmental Associates (FBE) executed this baseline tributary sampling at five tributaries entering Broad Cove three times between August and September. The goal of this ongoing work is to improve water quality and the health of shellfish flats, with the ultimate goal of removing the seasonal closure of shellfishing areas in Broad Cove. **The results discussed in this report indicate high levels of fecal indicator bacteria (enterococci) at all tributary outlets sampled in 2021. The elevated levels of bacteria in Broad Cove across all three sampling events suggest that there are likely multiple pollution sources that are negatively impacting the water quality and shellfishing flats of Broad Cove.**

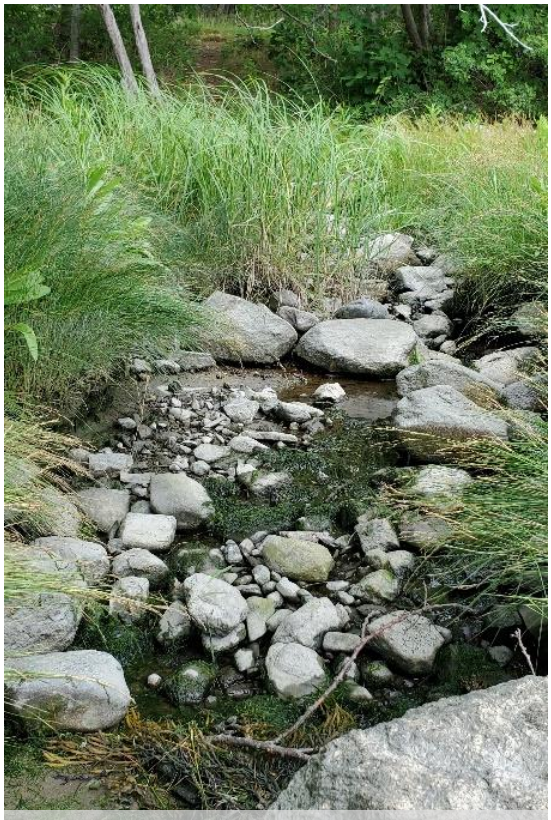
Site BC-1 on Crab Apple Creek during the 8/5/21 sampling event. Sampling occurred during low tide in an effort to capture pollutants entering Broad Cove from tributaries and the surrounding landscape, as opposed to pollutants in the incoming tide from Muscongus Bay. Photo: FBE

METHODOLOGY

FBE completed surface water sampling on August 5th, September 2nd, and September 10th, 2021. Baseline samples were originally intended to be collected under dry weather conditions, however project scientists from FBE visited the five tributary sites on July 8th to perform reconnaissance and found that only one of the five tributaries was running under dry weather conditions. FBE adjusted the methodology to sample under wet weather conditions instead to best understand how pollutants may be entering Broad Cove from the surrounding landscape. Wet weather often mobilizes fecal sources on the landscape and transports them to nearby rivers and streams. High in-stream fecal indicator bacteria levels during wet weather events can point to fecal sources on the landscape via stormwater runoff.

Samples were collected at five freshwater tributaries. This included Crab Apple Creek, three tributary outlets adjacent to DMR sampling station WS026, and one tributary outlet adjacent to station WS027 (Map 1). A sixth identified tributary at the top of Bug Tussle adjacent to WS028 was not sampled, as the access was off of a private driveway and access could not be obtained.

Fecal indicator bacteria (such as *Escherichia coli* or *E. coli*, Enterococci, and Fecal Coliform) are used to track a wide variety of potentially harmful pathogens such as viruses and bacteria found in mammalian fecal waste that would otherwise be too expensive to monitor comprehensively (see breakdown below). Enterococci is the most appropriate indicator bacteria for fecal source tracking in estuarine waters, or Class SB waters. The tributaries that enter Broad Cove are classified as Class B waters (or freshwater streams) where they are above head of tide. The sample locations were at the outlet of the streams and did have some estuarine influence (access above head of tide was not always feasible). Given that the sample points at the stream outlets have estuarine influence, enterococci was the best fecal indicator bacteria to use (*E. coli* does not survive in saltwater). In addition, several other parameters have been successfully used as "co-indicators" to fecal indicator bacteria; the combination of these parameters can help determine whether the contamination source is likely from humans. Nutrients (nitrate/nitrite and phosphorus) can indicate human sewage if in extremely high concentrations. Ammonia is used in illicit discharge detection screenings and high concentrations can indicate sewage contamination, however not all discharges have high concentrations, so it is best used in combination with other parameters. Optical brighteners are commonly used for wastewater detection. Optical brighteners are not naturally occurring and are typically added to laundry soaps, detergents, cleaning agents, and toilet papers to aid in the brightening of fabrics and/or surfaces. Testing positive for optical



Site BC-2 on 7/8/21 during dry weather conditions, above, was too low to sample. Below, after 0.6 inches of rain on 8/5/21, the stream was flowing enough to sample.

brighteners in groundwater strongly suggests greywater from leach fields is entering the groundwater without adequate filtration.

All samples were taken following 0.5 inches or greater of precipitation and within two hours of low tide to best capture the worst-case scenario of pollutants entering the estuary from runoff and tributary drainages. Sampling occurred at low tide to best avoid sampling water coming in from Muscongus Bay during tides. Surface water samples were collected and analyzed as follows:

- Field parameters included dissolved oxygen, temperature, salinity, and specific conductance and were recorded using a YSI ProSolo field meter.
- Enterococci bacteria samples, total phosphorus samples, and nitrate/nitrite samples were analyzed at Maine Environmental Laboratory (MEL) in Yarmouth, Maine.
- Ammonia was determined in the field using HACH ammonia test strips.
- Optical brighteners were measured using a handheld Aquaflor fluorometer, based on methods described in SOP 3.4.1.4 Measuring Optic Brighteners in Ambient Water Samples Using a Fluorometer, by Erick Burres, dated March 2011.

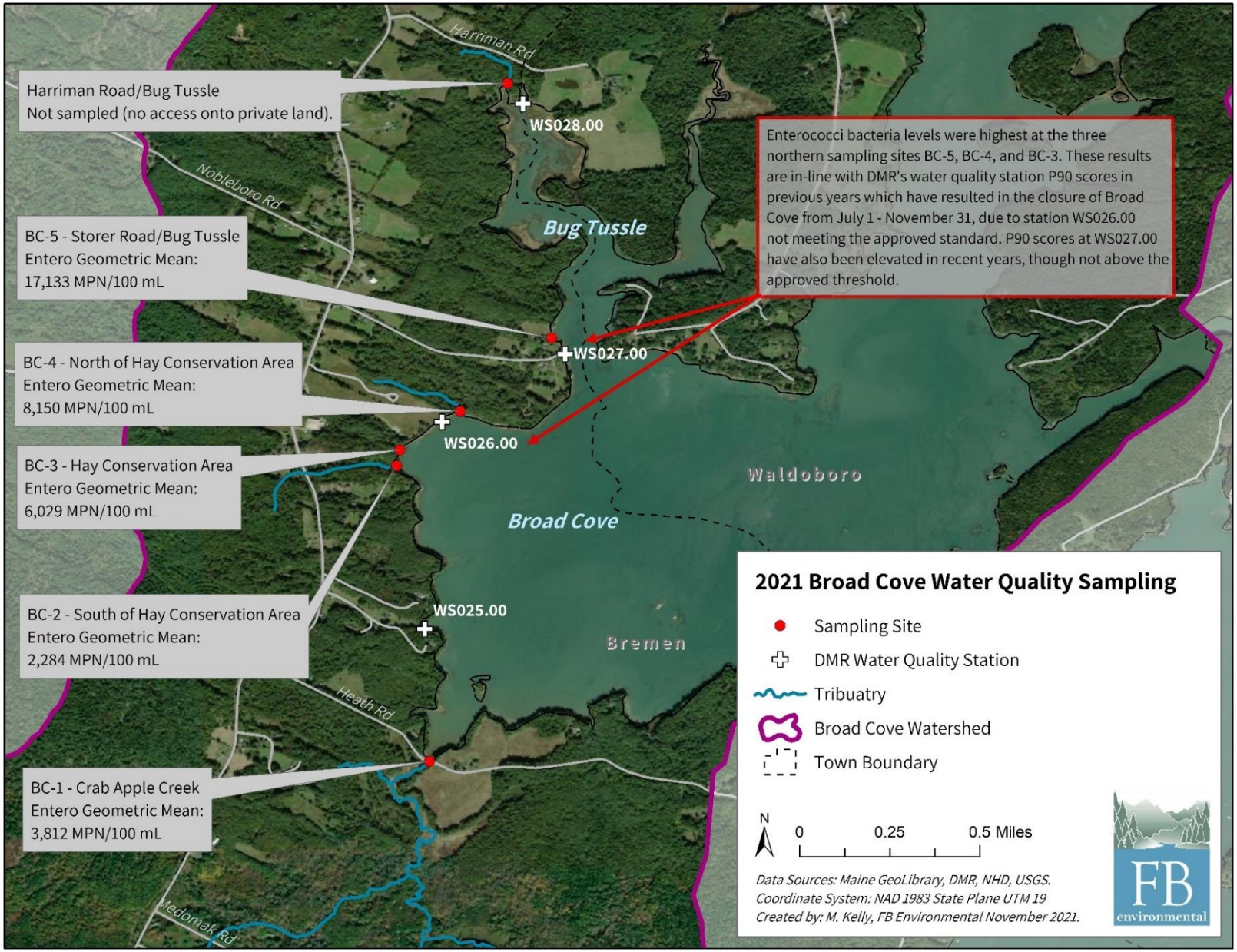
Fecal contamination is one of the most difficult pollutants to remediate. There are a few reasons for this:

(1) It is a nonpoint source pollutant, meaning that it can come from many different locations on the landscape.

(2) Human health concerns are caused by potentially harmful pathogens such as viruses and bacteria, that are present within fecal matter. However, it would be too expensive to track and monitor each harmful virus and bacteria individually. Because of this, we use indicator organisms (such as *Escherichia coli* or *E. coli*, Enterococci, and Fecal Coliform). These indicator organisms are chosen based on similarities to pathogens in behavior and transport in the environment.

(3) Synchronicity in behavior between fecal indicator bacteria and the pathogens-of-concern for public health risk (e.g., salmonella, campylobacter, rotavirus, giardia, norovirus, hepatitis, etc.) may break down under certain environmental conditions. Therefore, caution must be used when interpreting fecal indicator bacteria data in the context of risk management decisions.

(4) Fecal contamination tracking is an evolving science, with new technologies consistently making their way to the market. We do our best to use the tools at our disposal while recognizing their limitations.



Map 1. 2021 water quality sampling sites in Broad Cove. The geometric mean for all sites was above the state threshold for class SB marine waters of 8 MPN/100 mL.

RESULTS

The sampling results found high levels of fecal indicator bacteria (Enterococci) at all tributary outlets in Broad Cove across all three sampling events. Bacteria results were highest at the three northernmost sites. Results are displayed in Tables 1 & 2, and Map 1. Refer to Appendix 1 for applicable criteria for parameters. The sampled tributaries are classified as Class B waters (freshwater) by the State of Maine, though because sampling did not consistently occur above head of tide and thus there was saltwater influence, the samples were assessed using Class SB (estuarine waters) criteria for enterococci, dissolved oxygen, and specific conductivity. Field parameters were collected to serve as standard metrics of water quality that can help with data interpretation – including temperature, dissolved oxygen, specific conductance, and salinity. A brief explanation of each parameter and its applicability to this study are provided in the bullets below.

1. Temperature – Divergence of temperature from natural conditions can reflect changes in the dominant flowpath of water entering the stream. For example, unusually cold water could reflect higher than normal inputs of groundwater.
2. Dissolved Oxygen – Oxygen dissolved in the water is critical to aquatic life respiration. If there is an excessive source of nutrients to the stream (e.g., septic seepage), it can cause an abundance of algae to grow. The eventual decomposition of this algae by decomposing bacteria can consume the available oxygen and cause low dissolved oxygen readings.
3. Specific Conductance – This is a measure of ability of the water to conduct electricity. So basically, the more 'stuff' (e.g., ions) in the water will cause an increase in specific conductance. Sometimes this can be caused by inputs of pollution to the waterbody.
4. Salinity – Estuarine and marine waters have a higher salinity than freshwaters. The salinity reading lets us know if the sample collected is all freshwater or is a result of water mixing in from the estuary.

These metrics were all within the expected range based on Maine state criteria, with the exception of one dissolved oxygen reading at site BC-1 (Crab Apple Creek) on 8/5/21 which was below the state identified threshold of 85% dissolved oxygen for Class SB waters (estuarine waters). A low dissolved oxygen reading can indicate excessive algal growth and can be detrimental to aquatic life.

Laboratory results for enterococci showed extremely high bacteria at all five sites during each sampling event. Enterococci is one type of bacteria that is used as a fecal indicator bacteria to identify and track fecal contamination, as such, elevated bacteria levels during precipitation events indicate likely contamination from the surrounding landscape transported to surface waters via stormwater runoff. More specifically, results from the three sampling events showed Enterococci bacteria results at all five sites were elevated above Maine's EPA-approved instantaneous (one sample) threshold of 104 MPN/100 mL.[1] The geometric mean for each site averaged across the three samples exceeded the state threshold for enterococci set by the Maine Department of Environmental Protection of 8 MPN/100mL for Class SB waters.[2] A geometric mean is a form of average that suitably describes proportional growth (or loss) as a constant growth rate – this means a geometric mean is helpful when analyzing bacteria concentrations because levels may vary from 10 – 10,000 fold over a given period and the geometric mean tends to better account for the effect of very high or very low values.

Total phosphorus at each site were slightly elevated above the suggested natural levels set by the EPA. Nitrate + nitrite as nitrogen exceeded suggested natural levels at one site, BC-3. Neither ammonia nor optical brighteners were present at any site during sampling.

[1] Maine's EPA-approved instantaneous threshold for Enterococci in marine waters is 104 MPN/100 mL and is used to monitor recreational waters (https://www.maine.gov/dep/water/beaches/monitoring.html).
[2] https://legislature.maine.gov/statutes/38/title38sec465-B.html

DISCUSSION

Enterococci bacteria was high across all five sites during wet weather. These results are in-line with the historical data analysis FBE completed in 2020 that indicated runoff from precipitation may be impacting water quality during and directly after a storm. (The 2020 analysis assessed historical fecal bacteria levels from DMR sampling and rainfall and found that statistically significant higher fecal coliform scores occurred when there was a storm event in the 24 hours before or during sampling - refer to the 2020 Broad Cove Risk Assessment for more details). The precipitation event on 9/2/21 was the largest of the three storms sampled with 1.95 inches in the prior 24 hours; however, the enterococci bacteria levels were highest during the 9/10/21 storm with 1.5 inches in the prior 24 hours. The 9/2/21 samples were taken approximately 6 hours after the storm peak when it was no longer actively raining, while the 9/10/21 samples were taken at the end of a storm peak (i.e., during the highest flow and while it was still raining). The samples on 9/2/21 likely captured the "first flush" of pollutants entering the stream channel and traveling to the estuary. Figure 1 shows precipitation accumulation and sampling times for the three sampling dates (note: the low tide window dictated exactly when sampling could occur).

Bacteria levels were highest at the three northern sites, most notable at site BC-5 (adjacent to Storer Road and DMR water quality station WS027), followed by sites BC-3 and BC-4 (adjacent to the Hay Conservation area and DMR water quality station WS026). **These results are consistent with the Department of Marine Resource's elevated P90 scores at these stations in previous years which have resulted in the closure of Broad Cove from July 1 – November 31 due to station WS026 not meeting the approved standard.** Station WS027 has had elevated P90 scores but still meets the approved standard (refer to 2020 Broad Cove Risk Assessment report for more details).

Site BC-5 is located at the outlet of a small tributary that outlets into Bug Tussle approximately 300 feet north of DMR water quality station WS027. Station WS027 is located at the mouth of Bug Tussle at the end of Storer Road and has intermittently experienced elevated bacteria levels in the previous years. The bacteria sampling results from 2021 indicate that the small tributary outlet at Site BC-5 may be a contributing factor to the high bacteria results at the DMR water quality station. The area that drains to the small tributary flows through forested land then between several pastures that have previously (and may still) grazed horses. There is a moderate vegetated buffer present between the pasture and the small tributary.

Sites BC-3 and BC-4 are two tributaries located on either side of the Hay Conservation Area and adjacent field with residential homes. DMR water quality station WS026 is located between sites BC-3 and BC-4 and has elevated P90 scores resulting in the seasonal closure of Broad Cove. Site BC-4 is located at the tributary outlet north of WS026; the drainage area to this tributary includes fields bordering Broad Cove Road and along Route 32/Waldoboro Road. A DMR shoreline survey in July 2020 determined that there may be an incinerating or composing toilet approximately 150 feet from shore in the area of this tributary. Site BC-3 is located at the outlet of a small tributary that drains on the southern edge of Hay Conservation area. Elevated bacteria levels during wet weather experienced at both of these sites indicate that the pollution sources entering Broad Cove in this vicinity may be due to multiple factors. The 2020 Broad Cove Risk Assessment Report identified potential sources in this area as pet waste, wildlife (Canada Geese), human waste (lack of bathroom facilities and/or septic systems), and erosion. Further bracket sampling along these streams may be helpful to assist in pinpointing sources of bacteria entering the tributaries, done by sampling upgradient and downgradient of potential sources to isolate pollutant source locations.

Total phosphorus levels exceeded recommended natural background levels at all sites, however none were alarmingly high to indicated possible human sewage. The exceedance of Nitrate + Nitrite above recommended natural background levels at site BC-3, was not alarmingly high. The lack of presence of optical brighteners at all sites indicates there was no presence of wastewater during this specific sampling event; however a negative result for optical brighteners does not eliminate the possibility of a malfunctioning septic system as a cause of fecal contamination. Furthermore, sampling during wet weather increases the proportion of the water volume that is from surface runoff and overland flow, reducing the groundwater signal in the samples, which would be the route of transfer for wastewater.

Table 1. Field parameter and laboratory results for the five tributary sites sampled three times for water quality conditions during wet weather. Bold, italicized ***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). See Appendix I for details on the thresholds used to guide this analysis.

Site Name	Date	Temp (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Salinity (ppt)	Specific Conductance (µS/cm)	Ammonia (PPM)	Enterococci (MPN/100 mL)	Nitrate + Nitrite - N (mg/L)	Phosphorus (mg/L)	Optical Brighteners (positive/negative)
	Threshold	*<24 °C*	*NA*	*85%*	*NA*	*NA*	*0.3*	*104 MPN/100 mL*	*0.20 mg/L*	*0.02 mg/L*	*positive*
BC-1		19.6	6.04	***69.7***	9.81	16,664	0	***388***	ND	***0.034***	negative
BC-2		16.2	9.70	98.7	0.06	125	0	***359***	0.18 J	***0.021***	negative
BC-3	8/5/21	16.6	9.28	95.3	0.09	192	0	***4,352***	***0.26 J***	***0.040***	negative
BC-4		17.1	9.83	102.3	0.54	1,075	0	***2,282***	ND	***0.044***	negative
BC-5		19.4	7.44	84.8	8.06	13,898	0	***19,863***	ND	***0.093***	negative
BC-1		17.6	8.44	88.9	0.69	1,372	0	***9,208***	ND	***0.093***	negative
BC-2		16.3	9.71	99.1	0.03	67	0	***1,918***	ND	***0.033***	negative
BC-3	9/2/21	16.2	9.50	96.6	0.12	224	0	***3,873***	ND	***0.050***	negative
BC-4		16.9	9.56	98.8	0.11	227	0	***9,804***	ND	***0.067***	Undetermined**
BC-5		17.0	9.28	96.1	0.20	415	0	***10,462***	ND	***0.056***	negative
BC-1		17.4	8.48	88.9	0.89	1,741	0	***15,500***	ND	***0.072***	negative
BC-2		16.7	9.65	99.2	0.04	91	0	***17,300***	ND	***0.041***	negative
BC-3	9/10/21	16.5	9.57	98.0	0.08	173	0	***13,000***	ND	***0.056***	negative
BC-4		16.9	9.38	97.0	0.06	136	0	***24,200****	ND	***0.055***	negative
BC-5		17.2	9.10	94.6	0.05	112	0	***24,200****	ND	***0.050***	negative

J = Data reported between the Limit of Quantitation and Limit of Detection is J-flagged as "estimated".

** Enterococci levels were above the maximum detection limit, which is 24,200 MPN/100 mL.*

*** Samples are tested in triplicates; undetermined presence indicates the sample tested positive for optical brighteners in two of the triplicates and negative for optical brighteners in one triplicate. Resampling is recommended.*

Table 2. Average enterococci levels for the three sampling dates calculated using a geometric mean. Bold italicized red text indicates results exceeding state criteria.

Site Name	Enterococci All Data Geomean (MPN/100mL)
Threshold	*8 MPN/100mL (geomean)*
BC-1	***3,812***
BC-2	***2,284***
BC-3	***6,029***
BC-4	***8,150***
BC-5	***17,133***

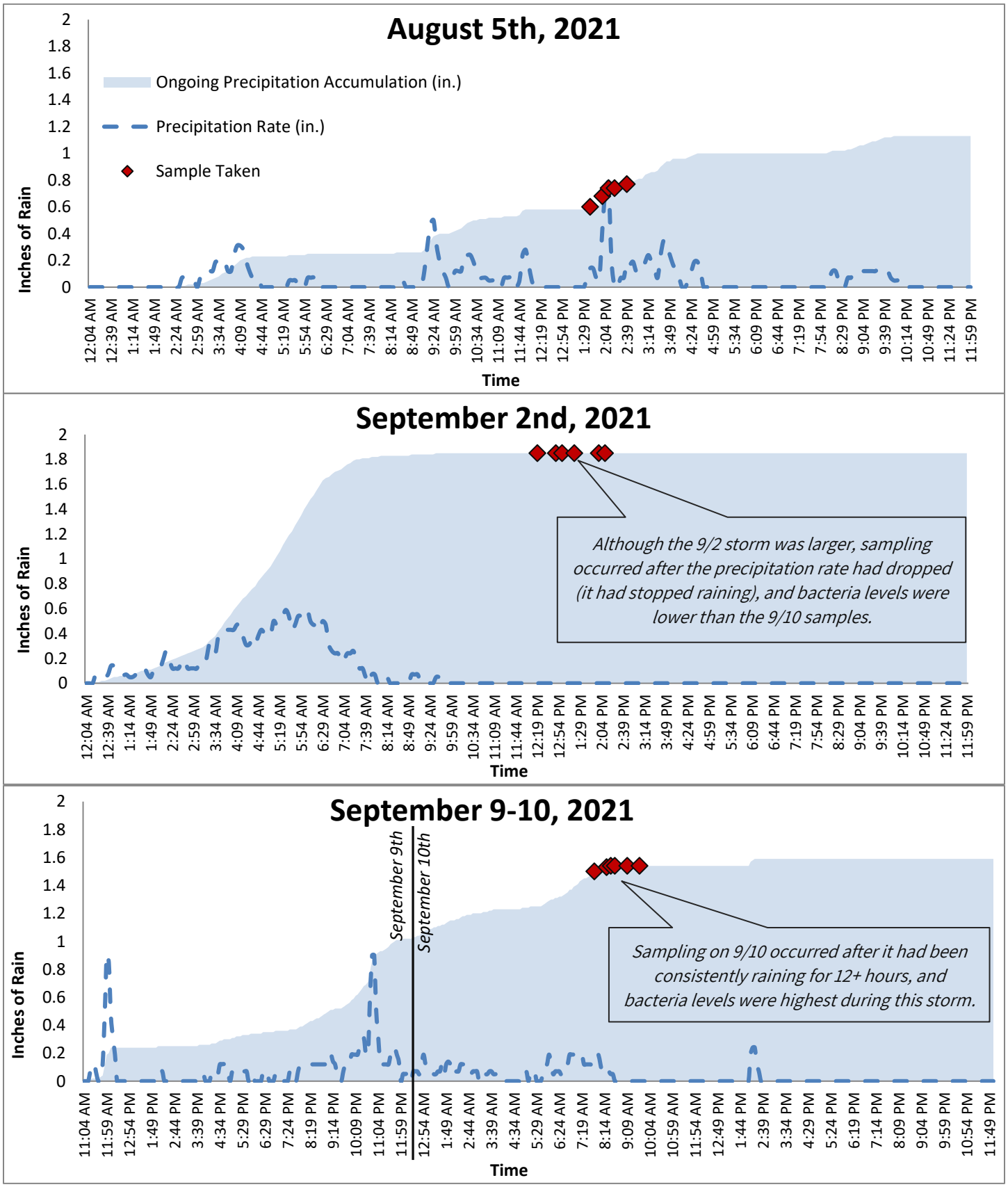


Figure 1. Precipitation accumulation during each sampling date is shown in light blue. Precipitation rate, measured in inches of rain per hour, is shown in dotted dark blue and indicates rainfall rate. Light rainfall is generally considered less than 0.10 inches per hour, while heavy rainfall is more than 0.30 inches per hour. The sampling times during the storm are denoted by red diamonds.

CONCLUSION AND RECOMMENDATIONS

Ultimately, the results from 2021 water quality sampling in Broad Cove found high levels of bacteria in the same vicinity as areas identified as hotspots by DMR water quality stations; namely around station WS026 and WS027. **The elevated levels of bacteria at all tributary outlets in Broad Cove across all three sampling events indicated that there are likely multiple pollution sources that are negatively impacting the water quality and shellfishing flats of Broad Cove.**

We recommend the Town of Bremen, Shellfish Committee, and Community Shellfish focus on future bacteria source tracking and remediation efforts in the northern areas of Broad Cove and Bug Tussle around DMR water quality stations WS026 and WS027. We recommend the following action items:

Follow up:

- If it has not already been done, follow up on the potential incinerating toilet or composting toilet within 150 feet of the shoreline in the vicinity of DMR water quality station WS026 (adjacent to Hay Conservation Area). This was identified in the DMR July 2020 shoreline survey. Incinerating toilets are not considered a threat to water quality, but DMR was not able to confirm what type of wastewater treatment is used at this residence. FBE can assist with this follow up during the completion of the Broad Cove Septic System Risk Assessment.
- Follow up with the landowners at the end of Storer Road regarding creating a nutrient management plan for their farm. It is important to note that (a) the Maine Department of Conservation and Forestry (DACF) visited this farm in 2016 and did not find any problems, and (b) if there are any pollution sources entering the estuary via the farm, it is unlikely that this is the only source causing elevated bacteria levels. A nutrient management plan helps farms minimize the transport of nutrients to ground and surface water, for example through proper manure storage. Assistance with nutrient management plans can come from local soil and water conservation districts or DACF.
- Contact the Natural Resources Conservation Service (NRCS) to identify possible funds to assist with a nutrient management plan and/or a site visit.
- Use the Broad Cove Septic System Risk Assessment, once completed, to assess for any vulnerabilities or risks in the vicinity of the BC-3, BC-4, and BC-5.

Recommendations:*

- Perform bracket sampling on the tributaries BC-4, BC-3, and potentially BC-2. Bracket sampling is a technique that assists in pinpointing sources of bacteria entering a tributary, done by sampling upgradient and downgradient of potential sources to isolate pollutant source locations. Bracket sampling will likely require landowner permission to access upstream reaches of these tributaries.
- Perform microbial source tracking sampling for human sources and wildlife sources (Canada Geese), and pet sources (dog) at BC-4, BC-3, or along the shoreline in the vicinity of DMR water quality station WS026 (adjacent to Hay Conservation Area).
- Perform microbial source tracking for human sources and/or farm animal sources (horse, ruminants, etc.) at the end of Storer Road or at BC-5. The Town of Bremen performed microbial source tracking in 2017 and further testing in targeted areas may be beneficial to help track and identify sources.

*FB Environmental is prepared to develop a scope of work and cost estimates to the Town of Bremen for these recommendations, if requested.

CITATIONS

Addendum to Sanitary Survey Report, Shellfish Growing Area WS, Pollution Area No. 26- Broad Cove, Bremen. 2020. Department of Marine Resources.

Broad Cove Risk Assessment Report. 2020. FB Environmental Associates.

Correspondence with Geoff Shook Regarding DMR 2020 Shoreline Survey. 2020. FB Environmental Associates.

Monitoring, Notifications, and Illness. 2021. Maine Department of Environmental Protection. https://www.maine.gov/dep/water/beaches/monitoring.html

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Standards for classification of estuarine and marine waters (§465-B). 2017. Maine Legislature. http://www.mainelegislature.org/legis/statutes/38/title38sec465-B.html

USEPA. 2001. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Rivers and Streams in Nutrient Ecoregion VIII. United States Environmental Protection Agency, Office of Water 4304, EPA 822-B-01-015. Retrieved online from http://www2.epa.gov/sites/production/files/documents/rivers8.pdf.

APPENDIX

Table 1. Applicable state thresholds and recommended background levels for all parameters applicable to the Broad Cove sampling. The samples were assessed using Class SB (estuarine waters) criteria for enterococci, dissolved oxygen, and specific conductivity. For Enterococci, the state thresholds are set in colony forming units (CFU) per 100 mL; this is equal to most probable number (MPN) per 100 mL for all intents and purposes in this report.

PARAMETER	TYPE	CLASSIFICATION	THRESHOLD JUSTIFICATION	THRESHOLD	APPLICABLE TO
Enterococci	Estuarine	Class SB	Maine DEP	**8 CFU/100mL** (geometric mean in any 90-day interval)	Broad Cove
			EPA	**104 CFU/100mL** (instantaneous)	
Dissolved Oxygen	Freshwater	Class A/B	Maine DEP	**7 ppm** and **75% saturation***	Freshwater tributaries to Broad Cove above head of tide
	Estuarine	Class SB	Maine DEP	**85% saturation**	All estuarine waters and below head of tide on tributaries
Temperature	Freshwater	None	Maine DEP	Recommended **<24°C** for cold water fish survival	All fresh waters
Specific Conductance	Freshwater	None	Maine DEP	Recommended **<854 µS/cm**	All fresh waters (not applicable to estuarine waters)
Ammonia	Freshwater	None	Center for Watershed Protection and US EPA "IDDE Guidance Manual"; A concentration of 1 mg/L Ammonia is generally assumed raw waste and 0.3 mg/L is an indicator of a potential problem and worth exploring other parameters.	0.3 mg/L	All fresh waters
Nitrate/Nitrite-N	Freshwater	None	US EPA Ecoregion VIII Ambient Water Quality Criteria; threshold set higher than reference condition (0.03 mg/L for nitrate + nitrite, 0.38 mg/L for total nitrogen).	0.20 mg/L	All fresh waters
Total Phosphorus	Freshwater	None	US EPA Ecoregion VIII Ambient Water Quality Criteria; threshold set higher than reference criteria for total phosphorus concentration (0.01 mg/L).	.02 mg/L	All fresh waters

**Except for Oct 1 – May 14 during spawning and egg incubation. 7-day mean dissolved oxygen not less than 9.5 ppm and 1-day minimum not less than 8.0 ppm in identified fish spawning areas.*