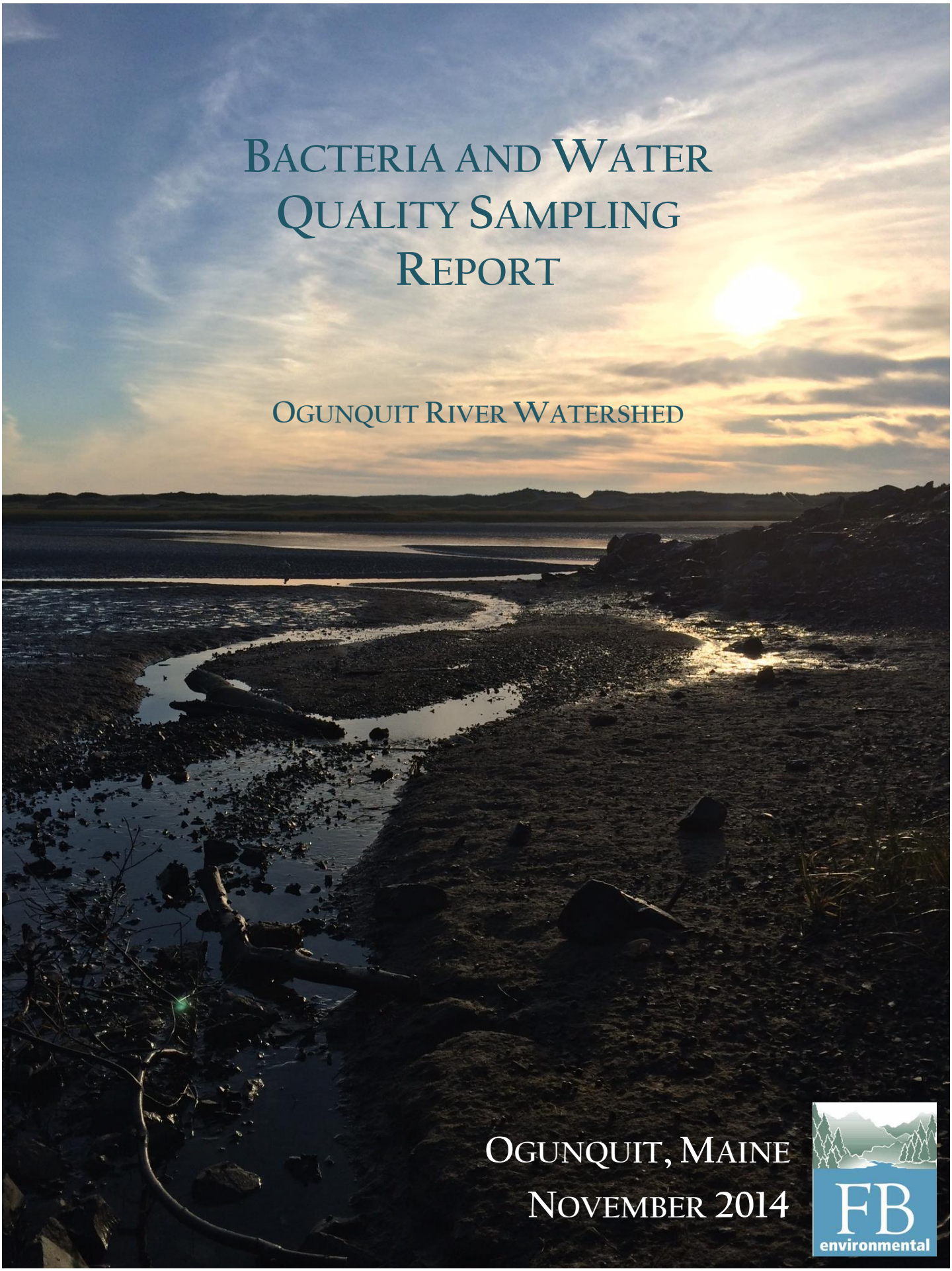

Bacteria and Water Quality Sampling Report

Ogunquit River Watershed

Ogunquit, Maine

November 2014

FB environmental

Bacteria and Water Quality Sampling Report

Ogunquit River Watershed

November 2014

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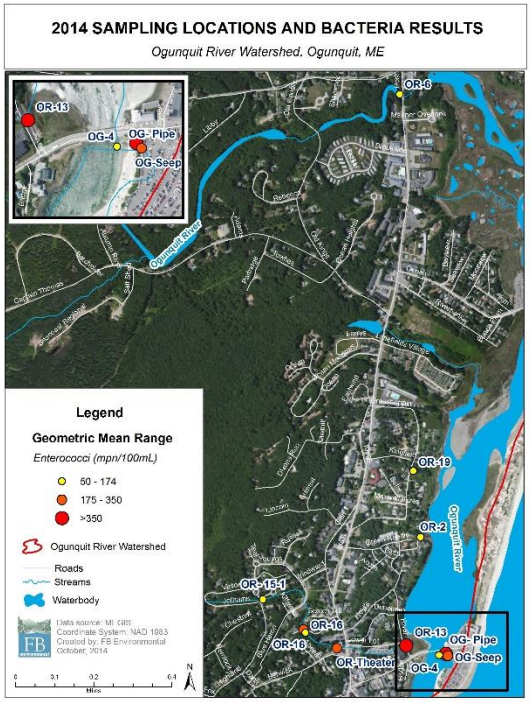
2014 REPORT SUMMARY

Ogunquit River Watershed Bacteria and Water Quality Sampling Report

Project Overview

The Ogunquit River and its estuary are impaired due to persistent bacterial contamination from unidentified sources that are largely attributed to nonpoint source pollution from the watershed. These high bacteria counts have led to seven beach closures over four summers from 2010 to 2014. In an effort to minimize beach closures, the Town of Ogunquit contracted FB Environmental Associates (FBE) to conduct bacteria sampling during two wet and two dry weather events at 11 previously-identified hotspots throughout the watershed, particularly near the coast (Figure 1). Other water quality data, including temperature, dissolved oxygen (DO), and salinity were also collected at each sampling location. This project included the development and implementation of a USEPA-approved Quality Assurance Project Plan (QAPP) for bacteria monitoring in the Ogunquit River watershed for 2014-2015.



The purpose of this monitoring program is to 1) help identify and bracket sources of high bacteria levels in the Ogunquit River watershed, and 2) maintain a baseline of bacteria data for hotspot sites to assess trajectory of changes as a result of remediation efforts.

Sampling Results

Enterococci **(mpn/100mL) results and geometric means for all sampling locations within the Ogunquit River Watershed from August-October 2014.**

Sample ID	Waterbody	*Enterococci* (mpn/100mL)				
		8/15/2014 WET	10/2/2014 WET	8/21/2014 DRY	9/26/2014 DRY	Geometric mean 2014
OR-6	Ogunquit R.	332	131	41	85	111
OR-19	Drainage to Ogunquit R.	52	246	85	30	76
OR-2	Drainage to Ogunquit R.	73	52	31	52	50
OR-15-1	Leavitt Stream (trib)	197	749	41	102	158
OR-15	Leavitt Stream (trib)	295	323	134	81	179
OR-16	Abenaki Stream (trib to Leavitt stream)	31	135	393	<10	64
OR-Theatre	Leavitt Stream (trib)	183	882	160	199	268
OR-13	Leavitt Stream (trib)	221	2,310	1,480	31	391
OG-4	Ogunquit R.	842	20	<10	41	51
OG-pipe	Stormwater outfall	227	>24,200	<10	n.f.	380
OG-seep	Beach seep	1,541	487	63	93	258

Gray cells indicate an exceedance of ME DEP water quality standard for Enterococci *= 104 colonies/100mL for single samples and 35 colonies/100mL for geometric means. "n.f." = no flow.*

Findings

Inlet culverts at OR-15-1. Impacted by sediment and rusty-red algae.

- Stormwater runoff from the Main Beach parking lot is contributing to the highest bacteria counts (likely from both gull and human waste, according to DNA analyses) in the watershed at **OG-pipe** and **OG-seep**.
- Sampling locations along or connected to the Leavitt Stream (**OR-Theatre, OR-15, OR-13, OR-15-1,** and **OR-16**) had high bacteria counts during both wet and dry weather conditions. Bacteria is likely from pet and wildlife waste during wet weather and human waste from malfunctioning septic and sewer systems during dry weather.
- **OR-2** and **OR-19** have consistently low bacteria compared to the rest of the watershed with fairly similar counts during both wet and dry weather. This suggests an equal and constant contribution of bacteria sources from stormwater runoff and groundwater inputs likely from malfunctioning septic/sewer systems.
- **OR-6** may also be impacted by malfunctioning septic and sewer systems since wet weather bacteria results were not much higher than dry weather, and canine results showed detection of human waste during dry weather.
- **OG-4** represents the majority of accumulated sources flowing from the Ogunquit River watershed. It appears that human waste from malfunctioning septic or sewer systems in the watershed may contribute to bacteria counts during dry weather, while pet waste may be a contributor during wet weather. The large storm on 8/15/2014 may have resulted in high water tables that flushed malfunctioning leachfields.

Next Steps

1. Continue to monitor bacteria levels annually within the Ogunquit River watershed.
2. Investigate the source of OG-seep south of the Beach Street bridge using dye testing in the stormwater and sewer systems.
3. Consider installing a catchbasin insert that filters for bacteria in 1-2 key catchbasins within the Main Beach parking lot.
4. Assess septic systems in priority neighborhoods (including OR-2, OR-19, and OR-15) in the watershed. Other areas of concern may be drawn from the currently-developing septic system database.
5. Address stormwater runoff throughout the watershed. The Town is currently implementing a grant from the ME DEP that includes the installation of Best Management Practices (BMPs) to treat stormwater. The Town is already planning to redo the parking lot draining to OR-13. Other recommendations include:
    a. Install BMPs to treat bacteria near OR-15.
    b. Install proper pet waste disposal signage near OR-13 and OR-15.
    c. Target the neighborhoods around OR-15 and OR-16 for "residential socials" on proper pet waste disposal and septic system maintenance.

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Project Overview

The Ogunquit River (Class B) and its estuary (Class SB) have experienced persistent bacterial contamination from unidentified sources attributed to nonpoint source pollution from the watershed. Because of this, the Ogunquit River estuary was listed in Maine's 2012 Integrated Water Quality Monitoring and Assessment Report (http://www.maine.gov/dep/water/monitoring/305b/) as impaired under Category 4-A: Estuarine and Marine Waters Impaired by Bacteria (fecal pollutants). The Maine DEP also listed the watershed as a Nonpoint Source Priority Coastal Watershed, the estuary as a Coastal Wetland Most at Risk from New Development, and a tributary (Stevens Brook) as impaired for aquatic life use under Category 5-A: Rivers and Streams Impaired by Pollutants.

Beach monitoring conducted by Maine Healthy Beaches, the Maine DEP, the Ogunquit Sewer District, and the Ogunquit Conservation Commission have shown elevated *Enterococci* levels exceeding USEPA's historical national bacteria recommendation of no more than 104 colony-forming units (cfu)/100mL for single samples collected in marine waters or beaches[1].

Enterococci bacteria are present in the intestinal tracts of warm-blooded animals and are used to indicate the presence of fecal contamination in waterbodies. Each gram of human feces contains approximately 12 billion bacteria, many associated with human health issues. Wastes from other warm-blooded animals, including pets, farm animals, and wildlife may also contribute bacteria and associated disease vectors to waterbodies. High concentrations of fecal indicator bacteria in waterbodies can lead to posted advisories at swimming beaches and closure of shellfish beds. These bacteria are used to signal human health risks such as gastrointestinal, respiratory, eye, ear, nose, throat, and skin infections transmissible to humans through the consumption of contaminated fish and shellfish, skin contact, and/or ingestion of water.

Dry and wet weather sampling by FB Environmental Associates (FBE) since 2012 show *Enterococci* ranges up to 2,481 col/100mL throughout the watershed with particularly high counts or "hotspots" along Leavitt Stream, a tributary to the Ogunquit River (>4,884 col/100mL). Canine detection methods used in 2012 and 2013 also detected human waste as a potentially significant source of bacteria at the outlet of and along Leavitt Stream. These high counts led to seven beach closures over four summers (2010-2014).

In conjunction with FBE, the Maine DEP, and the USEPA, the Town of Ogunquit funded the development of a USEPA-approved Quality Assurance Project Plan (QAPP) for their bacteria monitoring program in the Ogunquit River watershed. With this approved QAPP, the Town was able to receive matching Section 319 funds from the USEPA and the Maine DEP. This QAPP was approved for 2014-2015 bacteria monitoring.

[1] USEPA released a new Beach Action Value (BAV) of 60 cfu/100mL for beach advisories. This threshold is only a recommendation for States to adopt as a water quality criteria.

The watershed-scale bacteria monitoring project is designed to identify suspected illicit discharges and sources of fecal contamination and prioritize hotspots for remediation. The results will be used to assist future monitoring efforts and target areas for bacterial-source mitigation. Once remediation efforts are underway, the data may be used to assess trajectory of changes in bacterial counts and determine where further work may be needed to minimize beach closures. These efforts will likely help minimize beach closures during peak tourist season, which will have important economic and public health benefits for the communities within the Ogunquit River watershed. The public beaches in Ogunquit attract numerous tourists each year and provide a substantial stream of revenue for the Town.

Methodology

FBE conducted bacteria sampling during two wet weather and two dry weather sampling events at 11 locations throughout the Ogunquit River watershed within an hour of low tide between August and October 2014 (Figures 1 and 2). These locations were selected from priority "hotspot" sites identified in 2012 and 2013 bacteria sampling and canine detection efforts (FBE 2012, 2013). Two new locations were added in 2014 near OG-4 where the Ogunquit River estuary crosses under the Beach Street bridge. These sites are located at the stormwater pipe from the Main Beach parking lot that discharges directly to the beach (OG-Pipe) and at a large seep just to the south along the beach (OG-Seep). Dissolved oxygen, temperature, and salinity data were also collected during most sampling events at each location using an YSI ProODO meter and a refractometer. Bacteria collection was conducted in accordance with methods outlined in the QAPP. A more detailed discussion of QAPP deviations is discussed in Appendix A.

All bacteria samples were analyzed for *Enterococci* at Nelson Analytical Water Testing Laboratory in Kennebunk, Maine. *Enterococci* are used as an indicator of the presence of fecal material in saltwater by the Maine Healthy Beaches program. In Maine, the State water quality standard for *Enterococci* is 104 colonies/100mL for a single grab sample and 35 colonies/100mL for the geometric mean of multiple samples. Though the Ogunquit River is freshwater, the saltwater water quality standard was used to assess the impact of the Ogunquit River on potential beach closures in Ogunquit.

Two new sites were added: a stormwater pipe discharging from the Main Beach parking lot (OG-Pipe; left) and a large seep coming from the beach just south of the Beach Street bridge (OG- Seep; right).

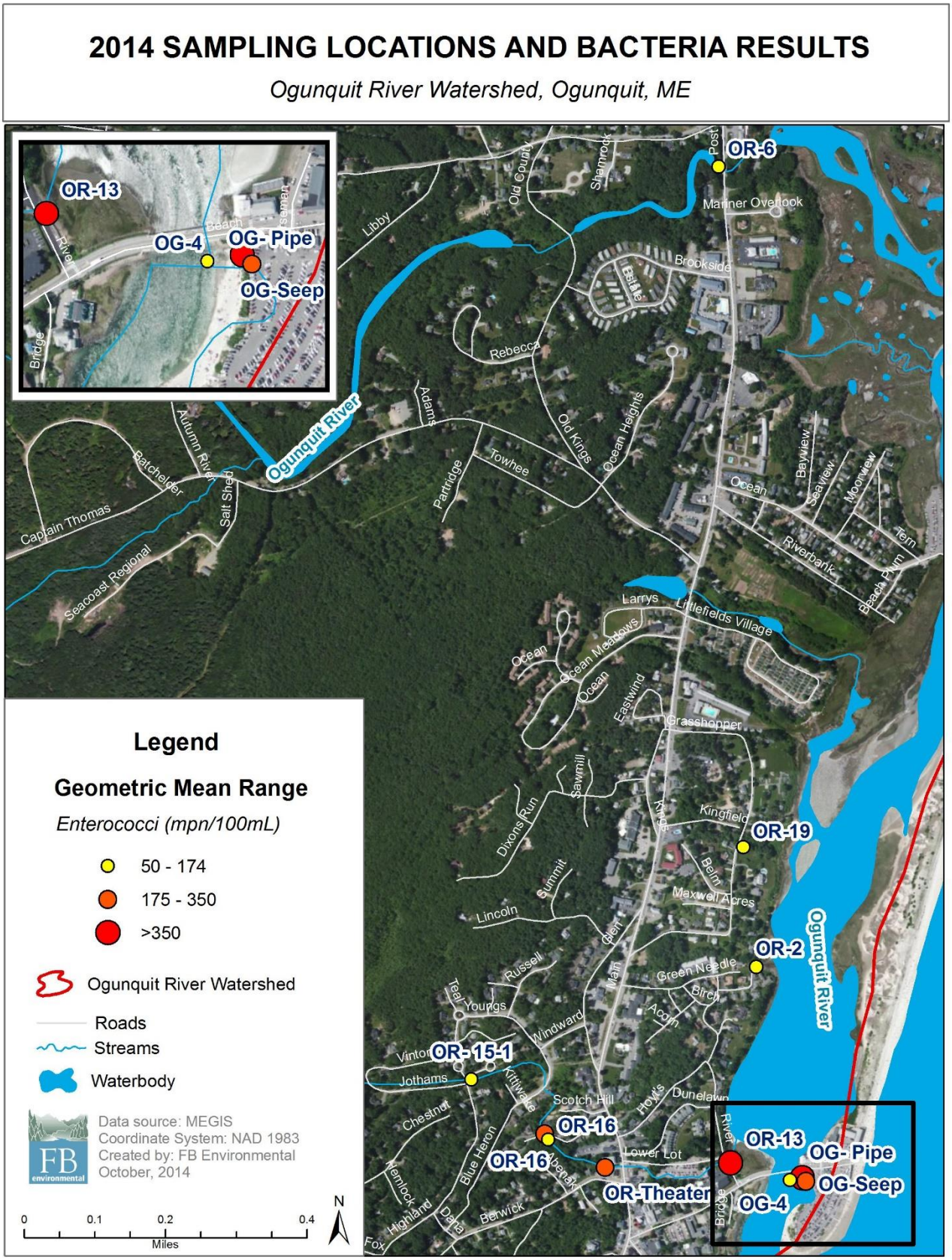


Figure 1. Sampling locations and bacteria concentrations (geometric means in mpn/100mL) for bacteria sampling in the Ogunquit River watershed from August-October 2014.

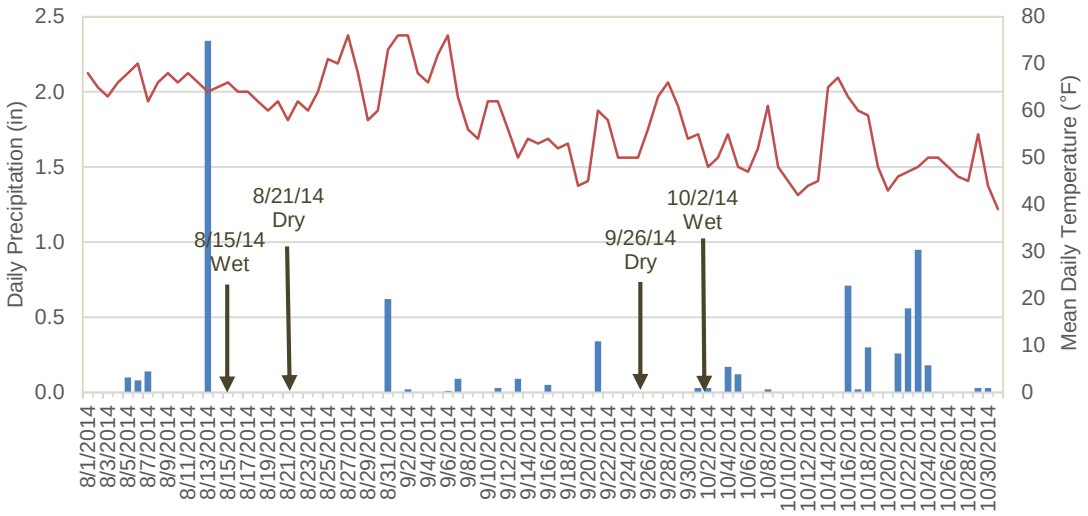


Figure 2. Mean daily temperature and precipitation data from August – October, 2014 with sampling dates highlighted. Data was retrieved from Weather Underground for Sanford, ME.

Results

For 2014 bacteria sampling in the Ogunquit River watershed, *Enterococci* concentrations ranged from <10 to over 24,200 mpn/100 mL, which span the range of the laboratory's detection limits for both high and low counts (Table 1). Bacteria exceeded the State water quality standard of 104 colonies or mpn/100mL[2] for single samples in the majority of samples, particularly during wet weather. The geometric mean ranged from 50 to 391 mpn/100 mL, exceeding the State water quality standard of 35 colonies or mpn/100mL[2] in all cases. Refer to Table 1 for the following results:

- OR-2 did not exceed the State standard of 104 mpn/100mL for any individual sampling event; however, the resulting geometric mean is above the State standard of 35 mpn/100mL. This geometric mean was the lowest of all sites at 50 mpn/100mL.
- OR-Theatre exceeded the State standard for both single sample and geometric mean for all samples in 2014.
- OR-13 had the highest geometric mean at 391 mpn/100mL, followed closely by OG-Pipe and OR-Theatre at 380 mpn/100mL and 268 mpn/100mL, respectively.
- Six of the 11 sites had elevated bacteria levels above the State standard on wet sampling events only.
- Four of the 11 sites had elevated bacteria levels above the State standard on both wet and dry sampling events.

[2] Although determined by slightly different methods (physical counts versus statistical inference), the units of mpn or col or cfu per 100mL are virtually interchangeable and the values comparable.

Table 1. *Enterococci* (mpn/100mL) results and geometric means for all sampling locations within the Ogunquit River Watershed from August- October 2014.

Sample ID	Waterbody	*Enterococci* (mpn/100mL)				Geometric mean 2014
		8/15/2014 WET	10/2/2014 WET	8/21/2014 DRY	9/26/2014 DRY	
OR-6	Ogunquit R.	332	131	41	85	111
OR-19	Drainage to Ogunquit R.	52	246	85	30	76
OR-2	Drainage to Ogunquit R.	73	52	31	52	50
OR-15-1	Leavitt Stream (trib)	197	749	41	102	158
OR-15	Leavitt Stream (trib)	295	323	134	81	179
OR-16	Abenaki Stream (trib to Leavitt stream)	31	135	393	<10	64
OR-Theatre	Leavitt Stream (trib)	183	882	160	199	268
OR-13	Leavitt Stream (trib)	221	2,310	1,480	31	391
OG-4	Ogunquit R.	842	20	<10	41	51
OG-pipe	Stormwater outfall	227	>24,200	<10	n.f.	380
OG-seep	Beach seep	1,541	487	63	93	258

Gray cells indicate an exceedance of ME DEP water quality standard for Enterococci *= 104 colonies/100mL for single samples and 35 colonies/100mL for geometric means. "n.f." = no flow.*

All data (2012-2014) were combined and the total geometric means for all data, wet weather, and dry weather were calculated (Table 2).

- Overall geometric means ranged from 46 to 380 mpn/100mL.
- Sample sites showed regular exceedances of the State standard for all data and during both wet and dry weather sampling events with the exception of OG-4 and OG-pipe that have geometric means for dry weather below the State standard of 35 mpn/100mL.
- Geometric means for wet weather were generally higher than dry weather with the exception of OR-16.
- Outlier analysis of all data (2012-2014) showed several statistically-significant outliers, including the following:
    - OG-4 at 842 mpn/100mL on 8/15/2014 during wet weather
    - OR-15 at 4,884 mpn/100mL on 8/10/2012 during dry weather
    - OR-15-1 at 2,460 mpn/100mL on 9/12/2013 during wet weather
    - OR-Theatre at 3,050 mpn/100mL on 9/12/2013 during wet weather

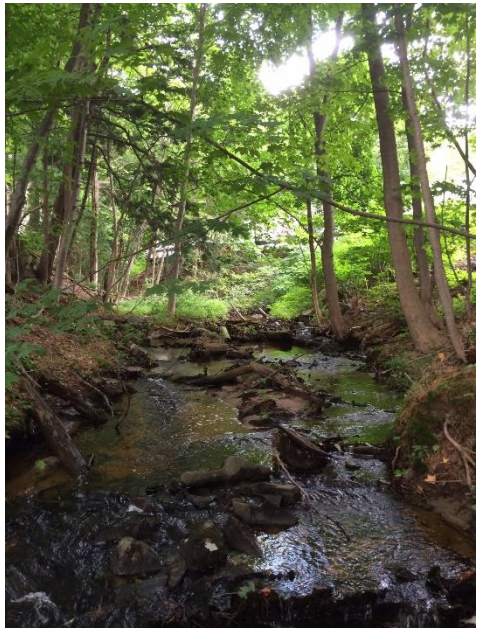
  Most of these outliers were high and occurred during wet weather, so are likely anomalies in the pollutants contributing to stormwater, the severity of the rain event, or the duration of dry weather preceding the wet weather event. Many sites do not yet have enough long term sampling to conduct an outlier analysis.

Table 2. *Enterococci* (mpn/100mL), canine detection, and DNA analyses results for sampling locations within the Ogunquit River Watershed from 2012-2014.

Sample ID	Enterococci (mpn/100mL)									Geomeans, Canine, and DNA Results				
	8/10/12 (dry)	7/30/13 (dry)	8/13/13 (dry)	9/12/13 (wet)	9/23/13 (wet)	8/15/14 (wet)	10/2/14 (wet)	8/21/14 (dry)	9/26/14 (dry)	Overall	Wet Weather	Dry Weather	2012-13 Canine Detection Results	2014 DNA Analyses
OR-6	554					332	131	41	85	153	209	125	Detected	Unknown
OR-19	231					52	246	85	30	94	113	84	Detected	Unknown
OR-2	86					73	52	31	52	55	62	52	Detected	Unknown
OR-15-1		474	272	2460	20	197	749	41	102	211	292	152	Not Detected	Unknown
OR-15	4884	63	109	836	41	295	323	134	81	220	239	205	Detected	Dog, Human
OR-16	337	431	183	41	10	31	135	393	10	83	36	160	Detected	Dog, No Human
OR-Theatre		109	75	3050	52	183	882	160	199	225	400	127	Not Detected	Unknown
OR-13	85	62	144	1500	41	221	2310	1480	31	218	421	128	Detected	Dog, No Human
OG-4	69	20				842	20	10	41	46	130	27	Detected	Dog, Gull, No Human
OG-pipe						227	24200	10		380	2344	10	Unknown	Human, Gull
OG-4 seep						1541	487	63	93	258	866	77	Unknown	Unknown

Gray cells indicate an exceedance of ME DEP water quality standard for enterococci = 104 colonies/100mL single sample and 35 colonies/100mL geometric mean

OR-16 (left) is located along Abenaki Stream just upstream of the convergence with the Leavitt Stream; OG-4 (middle) is located under the Beach Street bridge; OR-Theatre (right) is located along the Leavitt Stream just upstream of the Route 1 crossing behind the theatre.



A summary of water quality results taken during bacteria sampling is provided in Table 3. Temperatures were slightly cooler at locations along Leavitt Stream where the water was fresher and non-tidal. Dissolved oxygen (DO) is fairly good at all sites with the exception of OR-15-1, which is typically the lowest for DO compared to other sites. On 9/26/2014, OR-15-1 was at 3.33 mg/L and 31% saturation for DO. This low DO level threatens aquatic life within the Leavitt Stream. Significant algae and stagnant water were observed at this site, which may explain low DO levels.

Table 3. Summary of water quality data from 2013-2014 for sampling locations within the Ogunquit River watershed.

Sample ID	Waterbody	MEAN (2013-2014)			
		Temp (°C)	DO %	DO (mg/L)	Salinity (ppt)
OR-6	Ogunquit R.	15.8	86.8	8.6	1
OR-19	Drainage to Ogunquit R.	16.3	87.5	8.6	1
OR-2	Drainage to Ogunquit R.	16.7	100.9	9.8	2
OR-15-1	Leavitt Stream (trib)	15.1	74.9	7.5	0
OR-15	Leavitt Stream (trib)	14.8	92.8	9.4	0
OR-16	Abenaki Stream (trib to Leavitt stream)	14.6	93.6	9.5	0
OR-Theatre	Leavitt Stream (trib)	14.8	87.5	8.9	0
OR-13	Leavitt Stream (trib)	15.9	89.7	8.9	1
OG-4	Ogunquit R.	16.3	88.9	8.7	26
OG-pipe*	Stormwater outfall	--	--	--	6
OG-4 seep	Beach seep	16.5	81.1	7.9	25

**Flows too low to take water quality readings with YSI ProODO*

Discussion

Bacteria data from 2012-2014 at most sites showed exceedances during both wet and dry weather. This indicates that bacteria are coming from a variety of sources, including stormwater runoff, malfunctioning septic systems, pet waste, and wildlife. Overall, bacteria counts were generally higher under wet weather conditions than under dry weather conditions, suggesting that the majority of pollution may come from stormwater runoff. High counts in wet weather can indicate a connection to surface hydrology (street runoff, pet or wildlife waste, pipes or systems subject to overflow from rain) while high counts in dry weather suggest a source fed by a domestic water supply (leaking sewer pipes or septic systems). As rain water moves over the land and into a waterbody, it picks up bacteria from various sources (i.e. pet waste, dumpsters) as well as other pollutants (nutrients from lawn fertilizers and sediment). Large wet weather events can also raise the water table and lead to flushing of malfunctioning leachfields. High bacteria concentrations during dry weather sampling events suggest failing septic systems or leachfields nearby. Maine Healthy Beaches Program reported no beach closures and one advisory for severe flooding for the Ogunquit Beach in the summer of 2014. However, the number of posted beach advisories at Ogunquit Beach has shown an increasing trend since 2003 (Maine Healthy Beaches 2014).

Stormwater washout entering the Ogunquit River from OG-pipe.

The following provides a discussion of possible bacteria sources for each sampling location:

- The highest overall geometric means (2012-2014) for bacteria were found at **OG-pipe** and **OG-seep** near the Main Beach parking lot during wet weather, suggesting bacteria is largely sourced from stormwater runoff from the large parking area. OG-pipe showed low bacteria counts during dry weather, indicating that malfunctioning sewer lines are likely not the issue. This is further supported by results from a smoke test conducted in the area in 2014 showing all stormwater and sewer connections were good with no suspected illicit discharges. The Town of Ogunquit took a sample at OG-pipe and DNA analyses showed that gulls and humans were a major contributor of the bacteria present. The human waste component is likely within the stormwater, possibly coming from the outdoor wash station. The Town will be removing this wash station next year.

- High geometric means (2012-2014) for bacteria, particularly during wet weather, were also found at **OR-Theatre**, **OR-15**, **OR-13**, and **OR-15-1** along Leavitt Stream. This suggests an accumulation of bacteria sources largely from stormwater runoff leading to the Ogunquit River.
    - OR-15-1 was high during both wet and dry weather; canine results showed no detection of human waste during dry weather. Personal communication with a local resident indicated that a large rafter of turkeys has settled in the area and may be contributing to high bacteria counts during wet weather.
    - OR-15 shows high bacteria counts during both wet and dry weather sampling and was positive for human waste (by both canines and DNA testing), suggesting a potential contribution from nearby malfunctioning septic or sewer systems. DNA testing also showed dog waste as a potential contributor of bacteria. This may be a good location for proper pet waste disposal.
    - OR-Theatre routinely exceeds State standards, particularly during wet weather. Canine results show no detection of human waste during dry weather. This site may need to be re-investigated since sites upstream and downstream were positive for human waste during canine investigations.
    - OR-13 has particularly high bacteria counts during wet weather. Canines detected human waste during dry weather, while DNA testing did not detect human waste, but rather pet waste, during wet weather conditions. The parking lot area draining to OR-13 will be redone next year and BMPs that treat bacteria from stormwater runoff will be implemented. This may be a good location for proper pet waste disposal signage.

- **OR-16** is located on the Abenaki Stream just upstream of the convergence with the Leavitt Stream. Bacteria counts at this site are fairly low, particularly during wet weather. However, canine results show detection of human waste during dry weather when bacteria counts are highest. DNA testing during wet weather shows no detection of human waste, but was positive for pet waste. The Abenaki Stream may be impacted by malfunctioning septic, and possibly sewer, systems. The residential area would be ideal for a residential social that makes residents aware of proper pet waste disposal and maintenance of septic systems.

- **OR-2** and **OR-19** have consistently low bacteria compared to the rest of the watershed with fairly similar counts during both wet and dry weather conditions. This suggests an equal and constant contribution of bacteria sources split between stormwater runoff and groundwater inputs. Canine results show detection of human waste at both sites. Malfunctioning septic systems or leaky sewer lines may be causing the slightly elevated bacteria levels. Smoke tests in 2014 within these two stormwater drainages revealed no suspicious or malfunctioning connections to the stormwater or sewer systems. However, following-up with properties on septic systems to check for proper maintenance and function will be needed.

- **OR-6** may also be impacted by malfunctioning septic and sewer systems since wet weather bacteria results were not much higher than dry weather, and canine results showed detection of human waste during dry weather.

- **OG-4** represents the majority of accumulated sources flowing from the Ogunquit River watershed. Bacteria results are consistently low and only exceeded the State standard for a single sample once on 8/15/2014 after a major 6" storm event. Canine results were positive for human waste during dry weather, while DNA testing by the Town was negative for human waste, but positive for pet waste, during wet weather conditions. It appears that human waste from malfunctioning septic or sewer systems in the watershed may contribute to bacteria counts during dry weather, while pet waste is a potential source during wet weather. The large storm on 8/15/2014 may have resulted in high water tables that flushed malfunctioning leachfields.

Next Steps

1. Continue to monitor bacteria levels annually within the Ogunquit River watershed.
2. Investigate the source of OG-seep south of the Beach Street bridge using dye testing in the stormwater and sewer systems.
3. Consider installing a catchbasin insert that filters for bacteria in 1-2 key catchbasins within the Main Beach parking lot.
4. Assess septic systems in priority neighborhoods (including OR-2, OR-19, and OR-15) in the watershed. Other areas of concern may be drawn from the currently-developing septic system database.
5. Address stormwater runoff throughout the watershed. The Town is currently implementing a grant from the ME DEP that includes the installation of Best Management Practices (BMPs) to treat stormwater. The Town is already planning to redo the parking lot draining to OR-13. Other recommendations include:
    a. Install BMPs to treat bacteria near OR-15.
    b. Install proper pet waste disposal signage near OR-13 and OR-15.
    c. Target the neighborhoods around OR-15 and OR-16 for "residential socials" on proper pet waste disposal and septic system maintenance.

References

FB Environmental Associates (FBE). 2012. Bacteria Source Tracking with Canine Detection Report. Prepared for the Town of Ogunquit: August 2012.

FB Environmental Associates (FBE). 2013. Summary of Leavitt Stream Bacteria Sampling July-September 2013. Technical Memorandum to the Town of Ogunquit and the Ogunquit Conservation Commission: October 16, 2013.

FB Environmental Associates (FBE). 2014. Ogunquit River Watershed-Scale Bacteria Monitoring Quality Assurance Project Plan. Ogunquit River Watershed Management Plan Implementation: Water Quality Monitoring. Maine Department of Environmental Protection. 28 p.

Maine Healthy Beaches Program. 2014. http://www.mainehealthybeaches.org/

Appendix A: QAPP QA/QC Protocol Review

In 2014, an Ogunquit River Watershed-Scale Bacteria Monitoring Quality Assurance Project Plan (QAPP) was developed by FBE in cooperation with the Town of Ogunquit, ME and the Maine Department of Environmental Protection (Maine DEP). Bacteria samples were collected by FBE staff and analyzed by Nelson Analytical Laboratory in accordance with the specific Standard Operating Procedures (SOPs) outlined in the QAPP unless mentioned below. These deviations were minor and did not impact the quality of bacteria results.

1) Duplicate readings for temperature, DO, and salinity were taken for every 10 samples. One duplicate reading and sample was typically collected during each sampling event. Duplicates were not taken on the first sampling event (8/15/2014), so two duplicates were taken on the following sampling event (8/21/2014). YSI readings for temperature and DO were within acceptable values for difference between duplicate readings with the exception of OR-19 on 10/2/2014 (Table A1). This was noticed in the field and the duplicate reading was double-checked for accuracy. There may have been a pulse of water from upstream with different chemical composition. The meter had been calibrated that morning and there were no suspicious readings at other sites, so the deviation was deemed a natural phenomenon and not a mechanical failure of the equipment.

Table A1. Summary of field duplicate readings with the YSI meter and relative percent difference (RPD) between two duplicate field samples.

Site	Date	T (°C)	QA/QC ± 0.2 °C	DO %	QA/QC ± 2%	DO (mg/L)	QA/QC ± 0.3 mg/L	Salinity (ppt)	Entero (mpn/100mL)	RPD ± 20%
OR-13	8/21/14	16.9	-0.1	101.8	-0.2	9.9	0.0	1	1480	30%
OR-13DUP	8/21/14	16.8		101.6		9.9		1	1090	
OR-2	8/21/14	17.9	-0.1	103.1	0.1	9.8	0.0	2	31	43%
OR-2DUP	8/21/14	17.8		103.2		9.8		2	20	
OR-6	9/26/14	12.2	-0.1	76.7	0.2	8.2	0.0	0	85	0%
OR-6DUP	9/26/14	12.1		76.9		8.3		0	85	
OR-19	10/2/14	15.1	0.2	77.3	10.7	7.8	1.1	--	246	28%
OR-19DUP	10/2/14	15.3		88.0		8.8		--	185	

2) Field duplicates for bacteria should attempt to yield a relative percent difference (RPD) of < 20%; yet all duplicate samples resulted in RPD > 20% with the exception of the OR-6 duplicate on 9/26/2014 (Table A1). In most cases, RPD > 20% is acceptable given the inherent variability of collecting and measuring biological communities. Typically, higher bacteria counts will be less variable than lower bacteria counts < 200 mpn/100mL. In reality, this year's field duplicate RPDs ranging from 0-43% were ideal and reflect a consistent field sampling procedure by personnel.

3) Laboratory duplicates should also attempt to yield an RPD < 20%; laboratory duplicates for 2014 bacteria sampling in Ogunquit yielded RPDs ranging from 10-69% (Table A2). This also reflects a consistent laboratory analysis procedure by laboratory staff with greater RPDs generally associated with lower bacteria counts and vice versa. This is to be expected when measuring biological communities and the data are acceptable.

Table A2. Summary of relative percent difference (RPD) between field sample and laboratory duplicate results.

Site	Date	Field Sample *Entero* (mpn/100mL)	Lab Duplicate *Entero* (mpn/100mL)	RPD
OR-6	8/15/2014	332	243	31%
OR-6	8/21/2014	41	20	69%
OR-19	8/21/2014	85	75	13%
OR-13	9/26/2014	31	20	43%
OR-6	9/26/2014	85	97	13%
OR-13	10/2/2014	2310	2100	10%
OR-6	10/2/2014	131	86	41%

4) The last wet weather sampling on 10/2/2014 was impacted by malfunctioning weather data provided by Weather Underground (www.weatherunderground.com). The forecast for the Perkin's Cove station from 10/1 to 10/2 called for 0.24" of precipitation for the Ogunquit area. On the morning of 10/2, the rainfall count was only 0.05" within 24 hours. The site updated around 9:00am and showed rainfall at Perkin's Cove to be 0.22" within 24 hours. FBE staff took the opportunity to head out for a wet weather sample. Upon arrival back at the office, the station showed 0.05" inches within 24 hours again and has remained at that level since. This did not represent personal communication with Phil Pickering from the Wastewater Treatment Facility who said they had continuous light rain all day on 10/1 and a steady heavy rain the morning of 10/2. A look at another station just north of our study sites at the RAWS Rachel Carson station showed rainfall at 0.26" within 24 hours (Table A3). This seemed more representative of actual and forecasted predictions for the area. The sampling event on 10/2 qualifies as wet weather, but in the future, both stations at Perkin's Cove and Rachel Carson should be compared for more accurate area forecasts and actual totals for precipitation.

5) All bacteria samples were collected within a rough window of ±1 hour around dead low tide. The last sample taken on 9/26/2014 was collected nearly 2 hours after low tide, but this was due to logistical and safety reasons since low tide was early (6:58 AM) and FBE staff could not get out there until after sunrise (6:02 AM). All bacteria samples were delivered to the laboratory well within the 6 hour time limit (Table A3).

6) All bacteria samples were delivered to the laboratory at or below the recommended < 10 °C sample temperature with the exception of samples collected on 8/21/2014 (Table A3). This is reasonable since the water temperatures on that day were relatively high (~17 °C) and likely did not have enough time to cool down to 10 °C between field collection and laboratory delivery (< 2 hours). Personal communication with laboratory staff confirmed that this was not a concern for sample quality.

Table A3. Summary of QAPP protocol results for 2014 bacteria sampling.

Date	Precip 24 hrs prior (in)	Precip 48 hrs prior (in)	Precip 96 hrs prior (in)	Time of First Sample	Time of Last Sample	Time of Low Tide	Time Delivered to Lab	Temp Received (°C)
8/15/2014	0.01	6.44	6.44	8:05	10:15	9:22	11:05	5
8/21/2014	0.00	0.00	0.00	14:15	16:01	15:02	16:25	13
9/26/2014	0.00	0.00	0.00	7:00	8:51	6:58	9:20	--
10/2/2014	0.26	0.28	0.29	10:27	12:12	11:38	12:35	10

Date	Time Diff. First Sample (hh:mm)	Time Diff. Last Sample (hh:mm)	Time Diff. to Lab (hh:mm)
8/15/2014	1:17	0:53	3:00
8/21/2014	0:47	0:59	2:10
9/26/2014	0:02	1:53	2:20
10/2/2014	1:11	0:34	2:08

7) All field sheets and COC forms were complete. COC forms on 9/26/2014 and 10/2/2014 were not consistent with receiving lab personnel signatures and recording sample temperatures (missing temperature data on 9/26/2014). The correct protocols were followed upon sample delivery, but the information was not recorded on the COC forms.

8) The refractometer malfunctioned during the last half of sampling on 10/2/2014. These sites had historically been 0 for salinity, so the loss in data is likely not substantial.