

BACTERIA SOURCE TRACKING IN KITTERY, MAINE

FINAL REPORT

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1. PROJECT SUMMARY

1.1 PROJECT BACKGROUND

Spruce Creek is listed in Maine's Integrated Water Quality Monitoring and Assessment Report (303d) as impaired under Category 5-B-1: Estuarine & Marine Water Impaired by Bacteria (TMDL required) for nonpoint source pollutant sources. Efforts to reduce the bacteria load to Spruce Creek have increased in the past few years. The Town of Kittery, the Spruce Creek Association, and FB Environmental (FBE) have partnered to identify sources of bacteria to the creek in an effort to guide remediation efforts.

In 2009, FBE conducted a study of nine stormwater outfalls in the Spruce Creek watershed and another fourteen in 2011 (**Figure 2-1**). From this work, two outfalls (Culvert on Picott and Culvert at Haley and Trafton) were identified as “primary hotspots” of bacterial contamination. Reducing the bacteria loading to these outfalls has become a high priority. The 2009 and 2011 surveys also indicated the need to identify other outfalls with high bacteria concentrations in the watershed.

1.2 BACTERIA SOURCE TRACKING ON PICOTT ROAD AND TRAFTON LANE

In response to high bacteria levels found at the culverts on Picott Road and Trafton Lane during the 2011 outfall sampling project, a more detailed analysis of the drainage areas and upstream land uses was conducted. The drainage areas to these two outfalls were accurately mapped and bracket sampling was used to “bracket” or isolate the sources of bacteria by sampling upstream and downstream of the culverts where high concentrations of bacteria were found (**Figure 3-1 and 3-2**).

Bracket sampling was conducted during four dry weather days and two wet weather days at six locations on the stream draining to Picott culvert and at three locations along Fuller Brook (Trafton Lane). Sources of bacteria likely include stormwater runoff and malfunctioning septic systems (Picott and Trafton) and agricultural runoff (Picott only). A detailed plan for addressing these sources can be found in **Section 3**.

1.3 OUTFALL SAMPLING IN SPRUCE CREEK

In an effort to continue the work of the 2009 and 2011 outfall sampling projects, 40 more stormwater outfalls or tributaries to Spruce Creek were identified and 20 outfalls were sampled for bacteria throughout the watershed (**Figure 4-1**). This sampling was conducted during four wet and four dry weather events during the summer and early fall of 2012. Canine scent trackers trained specifically to identify human sources of fecal pollution were also utilized in conjunction with water analyses for *E. coli* to identify possible sources of bacterial contamination at the outfalls.

Of the 20 outfalls sampled, two outfalls had overall bacteria levels greater than ten times the water quality standard for *E. coli* (64 colonies/100 mL). Seven outfalls had wet-weather bacteria levels greater than ten times the water quality standard, and two outfalls had dry-weather bacteria levels at this high level. Specific remediation efforts are outlined in **Section 4.2**.

1.4 CANINE DETECTION THROUGHOUT KITTERY

Other locations throughout Kittery have been identified as bacterial hotspots in previous studies. Canine detection was used at three of these locations, Admiralty Village, a small stream behind the Orvis outlet on Route 1, and the beach at Fort Foster to identify specific sources of bacteria to each site. Human wastewater was detected at all sites. In Admiralty Village, human sources of bacteria were found to be concentrated to the storm drain system on Philbrick Avenue. At Fort Foster, high bacteria concentrations found in seepages along the beach are thought to be from an abandoned outhouse near a marsh that drains to the beach. Remediation efforts are outlined in [Section 5](#).

What is Canine Detection?

Sable and Logan, the dogs from Environmental Canine Services, are trained to detect, through scent, the presence of human wastewater in storm drain systems and waterbodies. When paired with water quality data and other background information, canine detection is a useful tool to identify human sources of bacteria.



Sable at work in Admiralty Village



Logan at work at Fort Foster

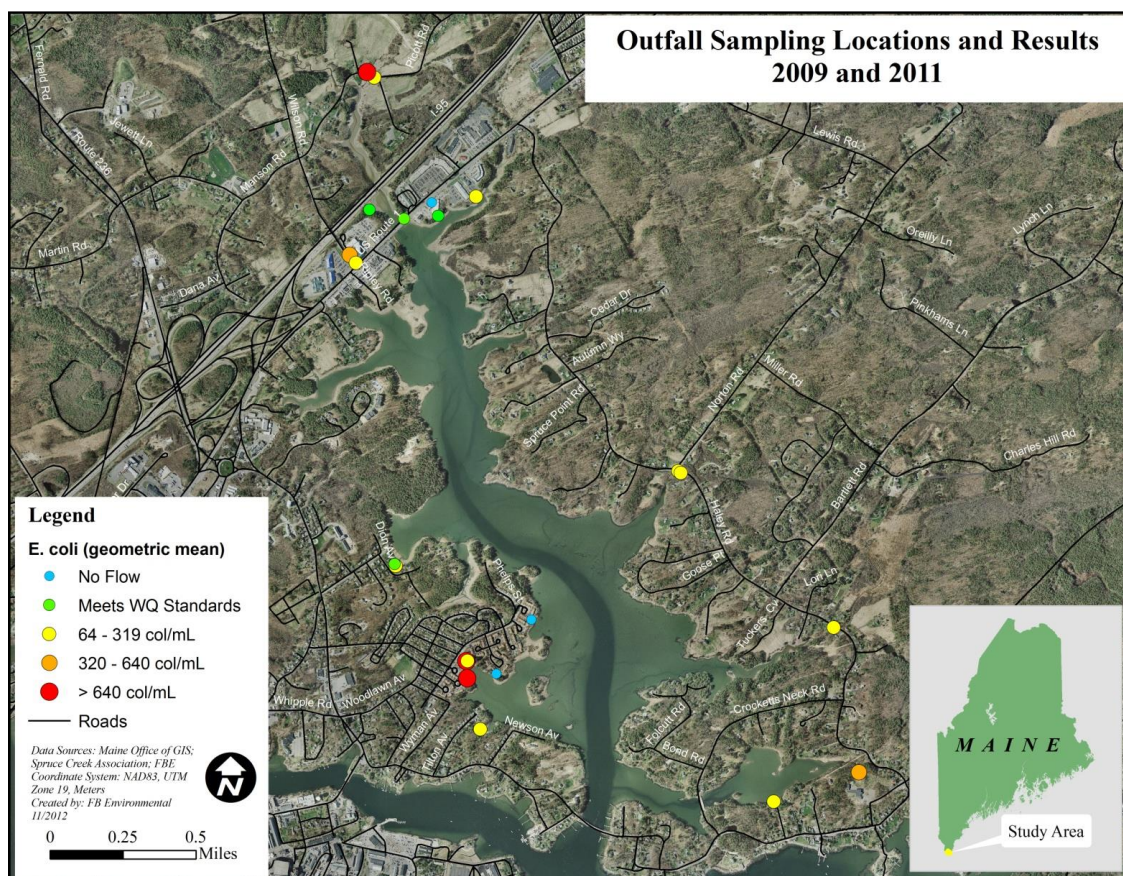
2. INTRODUCTION

2.1 BACKGROUND

Due to poor water quality, Spruce Creek is listed in Maine's Integrated Water Quality Monitoring and Assessment Report (303d) as impaired under Category 5-B-1: Estuarine & Marine Water Impaired by Bacteria (TMDL required) for nonpoint source pollutant sources. This body of water is also identified by the Maine DEP as one of 17 Nonpoint Source Priority Coastal Watersheds due to bacterial contamination, low dissolved oxygen, toxic contamination, and a compromised ability to support commercial marine fisheries. Additionally, the Spruce Creek watershed is listed by the DEP as one of seven coastal watersheds most at risk from development in the state. A detailed description of the Spruce Creek watershed can be found in [Appendix A](#).

Historically, there has been little data collected to determine areas of bacterial contamination in the watershed. In order to augment the available data, the Spruce Creek Association (SCA), the Town of Kittery, and FB Environmental Associates (FBE) began conducting studies of stormwater outfalls to the creek in 2009, with follow-up projects in subsequent years ([Figure 2-1](#)). These studies have provided a starting point to identify bacteria hotspots in the creek to allow the project partners to better focus future investigations and implementation efforts.

Figure 2-1: Outfall Sampling Bacteria Results in the Spruce Creek Watershed (2009 and 2011)



2.2 PROJECT GOALS

The overall goals of this project are to identify specific sources of bacteria to known hotspots of bacterial contamination to Spruce Creek and to identify new hotspots. Specific goals include:

1. Conduct a bacteria source tracking investigation at two sites identified as hotspots in the 2011 outfall sampling project (Picott Road and Trafton Lane). Specific tasks include:
 - Map the drainage area to each outfall.
 - Conduct an upstream land use investigation to identify potential sources on the ground.
 - Identify sampling locations to conduct bracket sampling. Bracket sampling consists of sampling upgradient and downgradient of locations with high bacteria concentrations to “bracket” (or isolate) pollutant source locations.
 - Conduct bracket sampling on four dates during dry weather and two dates during wet weather. Sampling in different weather conditions provides insight into the sources of bacteria. High bacteria concentrations in wet weather events is often linked to stormwater runoff while high concentrations during dry weather events may be from leaking sewer lines, malfunctioning septic systems, or other illicit discharges.
 - Use canine detection to identify human sources of bacteria to these outfalls. Canine detection is a rapid, cost efficient method of detecting illicit discharges in storm drain systems and in waterbodies.
2. Identify other hotspots of bacterial contamination to Spruce Creek. Specific tasks include:
 - Identify 40 – 50 additional outfalls in the Spruce Creek watershed.
 - Conduct outfall sampling at approximately 12 outfalls on three dates during dry weather and three dates during wet weather.
 - Use canine detection to identify human sources of bacteria to these outfalls and other known hotspot locations in Kittery.



Sable and Logan from Environmental Canine Services

3. BACTERIA SOURCE TRACKING ON PICOTT ROAD AND TRAFTON LANE

From the 2011 outfall study, the culverts on Picott Road and Trafton Lane were identified as hotspots of bacterial contamination to Spruce Creek (**Figure 2-1**). In this project, the drainage areas to each of these culverts were mapped (**Figure 3-1 and 3-2**), and investigated for potential sources. Additional sampling sites within the drainage area were identified and sampled on four dates during dry weather and two dates during wet weather to more precisely locate the actual sources of bacteria to these culverts. A specific range of weather conditions and flow conditions are necessary to identify bacteria sources in stormwater. High levels of bacteria during dry conditions may indicate the presence of leaking sewer pipes or illicit connections to storm drains (Clary et al., 2008).

All samples were analyzed for *E. coli* bacteria and, temperature, salinity, and dissolved oxygen, and flow conditions were noted. All sites were sampled during low tide to ensure the samples were capturing the downstream flow and not tidal backwash. Samples were analyzed for *E. coli* bacteria at the Nelson Analytical Lab in Kennebunk, ME.

In addition to water quality sampling, canine detection was also used to determine sources of bacteria to these culverts on one date during the sampling period.

3.1 PICOTT ROAD

Sampling Locations

The drainage area to the culvert on Picott Road was mapped using GIS and field investigation (**Figure 3-1**). The drainage area to this culvert is 120 acres. Once mapped, an on-the-ground field investigation of the watershed allowed for the selection of five sites for further bacteria source tracking investigation. Pictures and further descriptions of these sites can be found in **Appendix B**.

- Picott Upstream: This site is located at the headwaters of the stream, just downstream of its outlet from a small pond. This site is located upstream of the house on 9 Kelsey Lane in the woods behind the house. The area around this site is undeveloped and forested, with an intact riparian buffer zone.

The stream continues through the forested area, passes in front of the house on Kelsey Lane (#9), and flows under the driveway leading to the house in two culverts.

- Picott Driveway Up: This site is located at the outlet of the culvert closest to the house at 9 Kelsey Lane.
- Picott Driveway Down: This site is located at the outlet of the culvert closest to the road at 9 Kelsey Lane.

The stream converges in a forested area downstream of 9 Kelsey Lane and continues southeasterly where it is joined by another small stream just upstream of Seward Farm Lane.

- Picott Farm: This site is located at the culvert on Seward Farm Lane. A large agricultural field is located directly adjacent to the sampling location.

The stream continues through an agricultural area and crosses Picott Road.

- Picott Culvert: This site is located at the culvert on Picott Road.

The stream then continues through a marsh behind residential homes on Picott Road before it empties into Spruce Creek.

- Picott Downstream: This site is located at the outlet of the stream to Spruce Creek. A small animal farm including goats, geese, and chickens is located directly adjacent to this sampling location.



Picott Farm

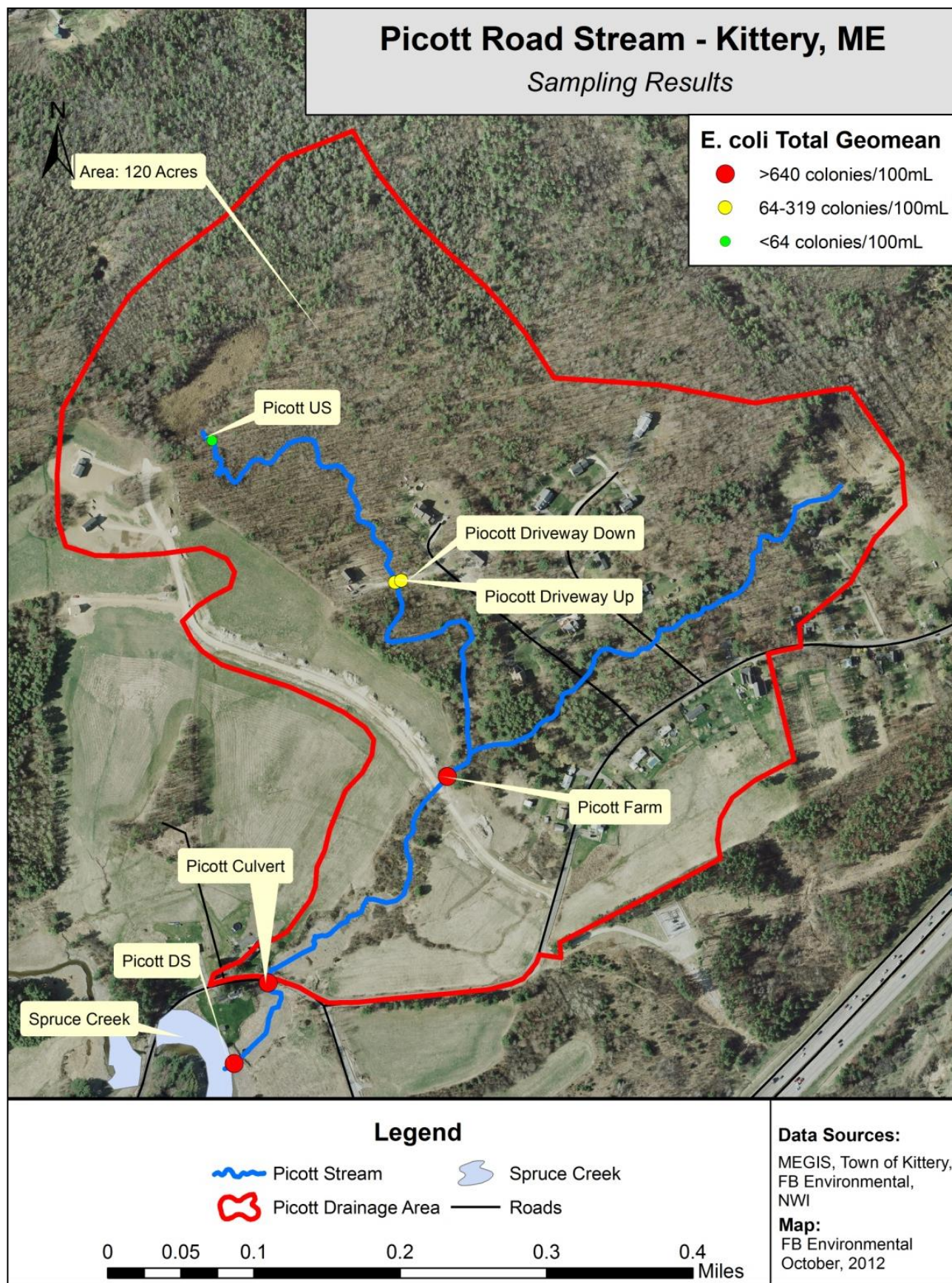


Picott Culvert



Picott Downstream

Figure 3-1: Piccott Road Drainage Area, Sampling Locations, and Bacteria Results



Bacteria Results

E. coli bacteria are important indicators of potential fecal contamination from warm blooded animals. In general, elevated levels of *E. coli* in surface waters correspond with an increased likelihood of human illness from mammalian fecal contamination.

Maine's freshwater *E. coli* water quality standards (WQS) for Class B streams are

- 236 colonies/100 mL for instantaneous samples
- 64 colonies/100 mL for a geometric mean of multiple samples.

Sample results indicate that five of the six sampling sites on the Picott Road stream exceeded Maine's geometric mean WQS for *E. coli* bacteria (**Table 3-1 and Figure 3-1**). Of those sites, three sites had a geometric mean above 640 colonies/100 mL (greater than ten times the water quality standard) and two sites had a geometric mean between 64 and 319 colonies/100 mL (up to five times the water quality standard). In addition to the samples collected for analysis for bacteria, FBE measured dissolved oxygen (DO), temperature, and salinity and estimated flow conditions (**Appendix D**).

Table 3-1: *E. coli* results (colonies/100 mL) for bracket sampling conducted at Picott from June to September 2012

Sampling Location	6/27/2012 (Wet)	7/10/2012 (Dry)	7/19/2012 (Dry)	7/23/2012 (Dry)	8/7/2012 (Dry)	8/9/2012 (Dry)	9/5/2012 (Wet)	Geometric Mean
Picott US	60	9	13	9	29	--	73	23
Picott Driveway Down	115	49	205	81	99	--	336	121
Picott Driveway Up	179	43	83	73	--	--	--	83
Picott Farm	238	>2420	1553	>2420	727	921	4106^	1290
Picott Culvert	461	>2420	>2420	>2420	308	107	1565	856
Picott DS	365	1203	1413	1120	1986	534	728	915

- Gray cells indicate an exceedance of instantaneous WQS for *E. coli* (236 colonies/100 mL)
 - Red cells indicate a geometric mean > 640 colonies/100 mL (greater than 10 times the WQS of 64 colonies/100 mL)
 - Orange cells indicate a geometric mean of 320 – 640 colonies/100 mL (between 5 and 10 times the WQS of 64 colonies/100 mL)
 - Yellow cells indicate a geometric mean of 64- 319 colonies/100 mL (up to 5 times the WQS of 64 colonies/100 mL)
 - Green cells indicate a geometric mean of < 64 colonies/100 mL (does not exceed the WQS)
 > 2420 is the maximum number that the analytical method can measure before being cited as too numerous to count
 ^ Indicates that a sample was assumed to have a high bacteria concentration and therefore was diluted prior to analysis
 -- Indicates that no sample was taken on that date.

The geometric mean was also calculated for wet-weather and dry-weather samples in an effort to identify potential bacteria sources (**Table 3-2**). All sampling sites that had enough data to calculate a wet-weather geometric mean exceeded Maine's WQS for *E. coli* bacteria. Five of the six sampling sites that had

enough data to calculate a dry-weather geometric mean exceeded Maine's WQS for *E. coli* bacteria. Canine detection indicated the presence of human wastewater at one location (Picott DS).

Table 3-2: Total, Wet, and Dry-Weather *E. coli* (colonies/100 mL) geometric means and canine response to the presence of human fecal contamination for outfall sampling conducted at Picott from June to September 2012

Sampling Location	<i>E. coli</i> Geometric Mean			Canine Response to the presence of human fecal contamination
	Total	Wet	Dry	
Picott US	23	66	13	No
Picott Driveway Down	121	197	95	--
Picott Driveway Up	83	--	64	No
Picott Farm	1290	989	1435	No
Picott Culvert	856	849	859	No
Picott DS	915	515	1151	Yes
- Red cells indicate a geometric mean > 640 colonies/100 mL (greater than 10 times the WQS of 64 colonies/100 mL) - Orange cells indicate a geometric mean of 320 – 640 colonies/100 mL (between 5 and 10 times the WQS of 64 colonies/100 mL) - Yellow cells indicate a geometric mean of 64- 319 colonies/100 mL (up to 5 times the WQS of 64 colonies/100 mL) - Green cells indicate a geometric mean of < 64 colonies/100 mL (does not exceed the WQS) -- Indicates that no geometric mean could be calculated due to lack of data OR canines were not used				

Potential Sources

Picott Farm, Picott Culvert, and Picott DS had geometric means greater than ten times the water quality standard for bacteria (**Figure 3-1 and Table 3-1**). The wet weather and dry weather geometric means also exceeded the water quality standard. However, canine detection indicated that human wastewater was only present at the downstream location (Picott DS). As such, sources of bacteria to this section of the small tributary to Spruce Creek are likely from:

- Runoff from the agricultural field at the farm on Seward Farm Road. The field was treated with manure in preparation for the season's crop.
- Stormwater runoff from Picott Road.
- Runoff from the small animal farm near the outlet of the stream.
- Malfunctioning septic systems near the downstream sampling location.

Recommended Next Steps

The goal of the bracket sampling at the Picott Road stream was to identify the source(s) of bacteria in the drainage area. Further investigation of these sources is necessary to determine the origin of bacteria within the drainage area and to work towards reducing the bacteria load. A list of next steps is presented below:

1. Determine the actual source of bacteria using microbial source tracking. This type of test would allow for more targeted remediation efforts.
2. Work with the owners of Picott Farm to install agricultural BMPs including increasing the width of vegetative stream buffer and minimizing use of manure.
3. Investigate locations along Picott Road near the Picott Culvert to install stormwater BMPs to treat road runoff.
4. Work with the owners of the small animal farm adjacent to the Picott Downstream location to install agricultural BMPs including a vegetative stream buffer.
5. Investigate the possibility of septic system malfunctioning in the residential neighborhood along Picott Road. This may be accomplished through canine detection along the stream corridor, dye testing of individual homes, or through a survey of the neighborhood to determine age and pumping frequency of each septic system.

3.2 TRAFTON LANE (FULLER BROOK)

Sampling Locations

The drainage area to the culvert on Trafton Lane was mapped using GIS and field investigation (**Figure 3-2**). The drainage area to this culvert is 150 acres. Once mapped, an on-the-ground field investigation of the watershed allowed for the selection of three sites for further bacteria source tracking investigation. Pictures and further descriptions of these sites can be found in **Appendix B**.

- Trafton Upstream: This site is located near the headwaters of Fuller Brook behind the residential development on Parsonage Way. Above this site, Fuller Brook is an intermittent stream draining a wetland.

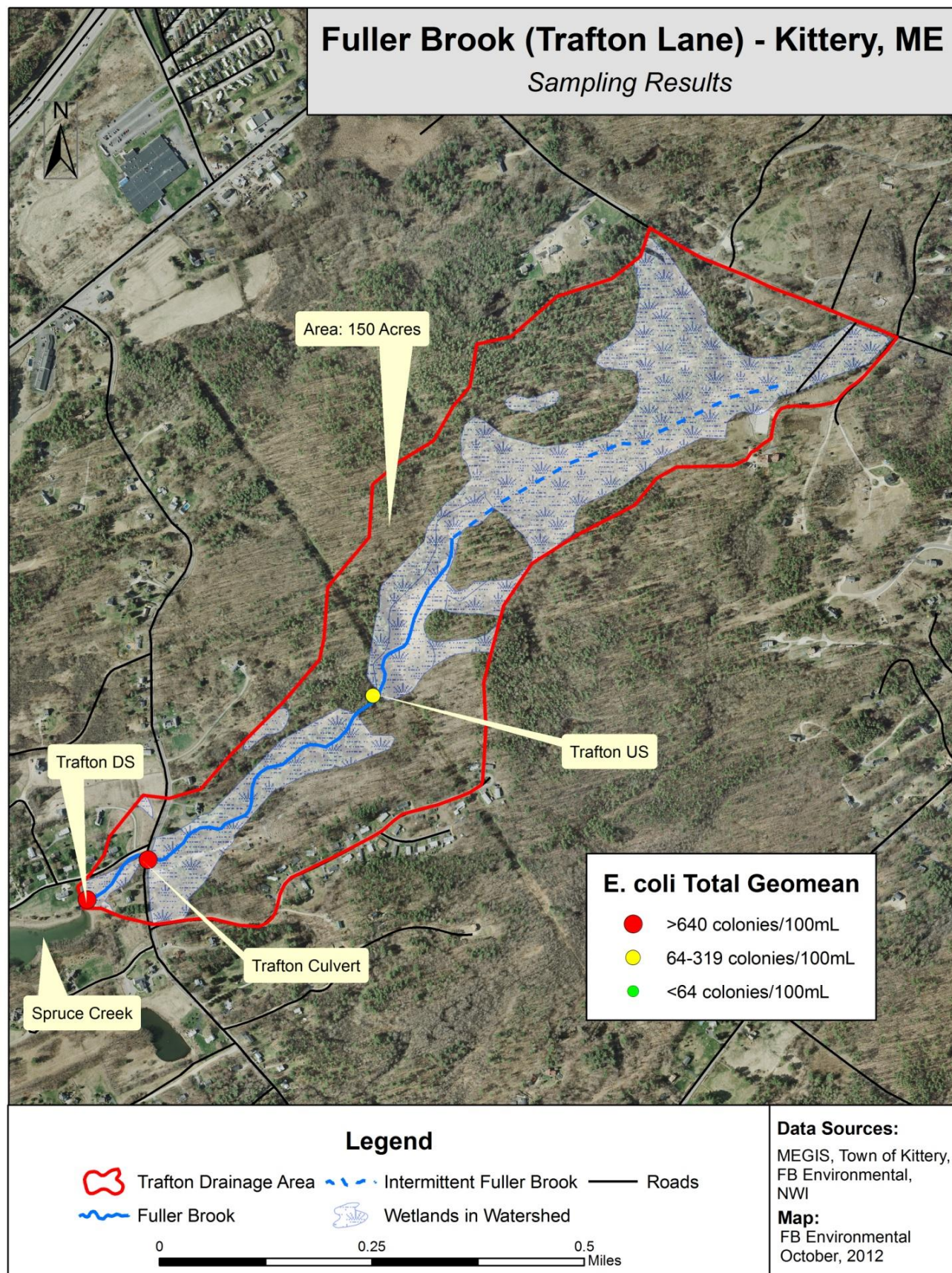
Fuller Brook continues southwesterly through the forested area behind the residential development and crosses Haley Road through a culvert on Trafton Lane.

- Trafton Culvert: This site is located at the culvert on Trafton Lane.

The brook continues behind the residential neighborhoods on Trafton Lane and enters Spruce Creek behind the house located at 11 Trafton Lane.

- Trafton Downstream: This site is located at the outlet to Spruce Creek. The yard for the house at 11 Trafton Lane is located adjacent to this site.

Figure 3-2: Fuller Brook (Trafton Lane) Drainage Area, Sampling Locations, and Bacteria Results



Bacteria Results

All sample sites on Fuller Brook exceeded Maine's WQS for bacteria (**Table 3-3**). Of those sites, two sites had a geometric mean above 640 colonies/100 mL (greater than ten times the water quality standard) and one site had a geometric mean between 64 and 319 colonies/100 mL (up to five times the water quality standard). In addition to the samples collected for analysis for bacteria, FBE measured dissolved oxygen (DO), temperature, and salinity and estimated flow conditions (**Appendix D**).

Table 3-3: *E. coli* results (colonies/100 mL) for bracket sampling conducted on Fuller Brook

Sampling Location	6/27/2012 (Wet)	7/10/2012 (Dry)	7/19/2012 (Dry)	7/23/2012 (Dry)	8/7/2012 (Dry)	8/9/2012 (Dry)	9/5/2012 (Wet)	Geometric Mean
Trafton US	68	96	--	--	--	--	435	142
Trafton Culvert	157	435	387	687	980	921	2755^	642
Trafton DS	345	235	261	--	>2420	--	2909^	683

- Gray cells indicate an exceedance of instantaneous WQS for *E. coli* (236 colonies/100 mL)
 - Red cells indicate a geometric mean > 640 colonies/100 mL (greater than 10 times the WQS)
 - Orange cells indicate a geometric mean of 320 – 640 colonies/100 mL (between 5 and 10 times the WQS)
 - Yellow cells indicate a geometric mean of 64- 319 colonies/100 mL (up to 5 times the WQS)
 > 2420 is the maximum number that the analytical method can measure before being cited as too numerous to count
 ^ Indicates that a sample was assumed to have a high bacteria concentration and therefore was diluted prior to analysis
 -- Indicates that no sample was taken on that sample date

The geometric mean was also calculated for wet-weather and dry-weather samples in an effort to identify potential bacteria sources (**Table 3-4**). All sampling sites that had enough data to calculate a wet-weather geometric mean exceeded Maine's WQS for *E. coli* bacteria. Both sampling sites that had enough data to calculate a dry-weather geometric mean exceeded Maine's WQS for *E. coli* bacteria. Canine detection indicated the presence of human wastewater at one site.

Table 3-4: Total, Wet, and Dry-Weather *E. coli* (colonies/100 mL) geometric means and canine response to the presence of human fecal contamination

Sampling Location	<i>E. coli</i> Geometric Mean			Canine Response to the presence of human fecal contamination
	Total	Wet	Dry	
Trafton US	142	172	--	--
Trafton Culvert	642	658	636	No
Trafton DS	683	1002	529	Yes

- Red cells indicate a geometric mean > 640 colonies/100 mL (greater than 10 times the WQS)
 - Orange cells indicate a geometric mean of 320 – 640 colonies/100 mL (between 5 and 10 times the WQS)
 - Yellow cells indicate a geometric mean of 64- 319 colonies/100 mL (up to 5 times the WQS)
 -- Indicates that no geometric mean could be calculated due to lack of data OR canines were not used due to flow conditions

Potential Sources

Trafton Culvert and Trafton DS had geometric means greater than ten times the water quality standard for bacteria (**Figure 3-2 and Table 3-3**). The wet-weather and dry-weather geometric means also exceeded the water quality standard. Canine detection indicated the presence of human wastewater at the downstream site (**Table 3-4**). As such, sources of bacteria to this section of the tributary to Spruce Creek are likely from:

- Stormwater runoff from Haley Road and Trafton Lane.
- Malfunctioning septic systems in the neighborhood downstream of the culvert.

Recommended Next Steps

1. Investigate locations at Trafton Culvert and along Trafton Lane to install stormwater BMPs to treat road runoff.
2. Investigate the possibility of septic system malfunctioning in the residential neighborhood of Trafton Lane and the immediate Haley Road properties. This may be accomplished through canine detection along the stream corridor, dye testing of individual homes, or through a survey of the neighborhood to determine age and pumping frequency of each septic system.



Trafton Culvert

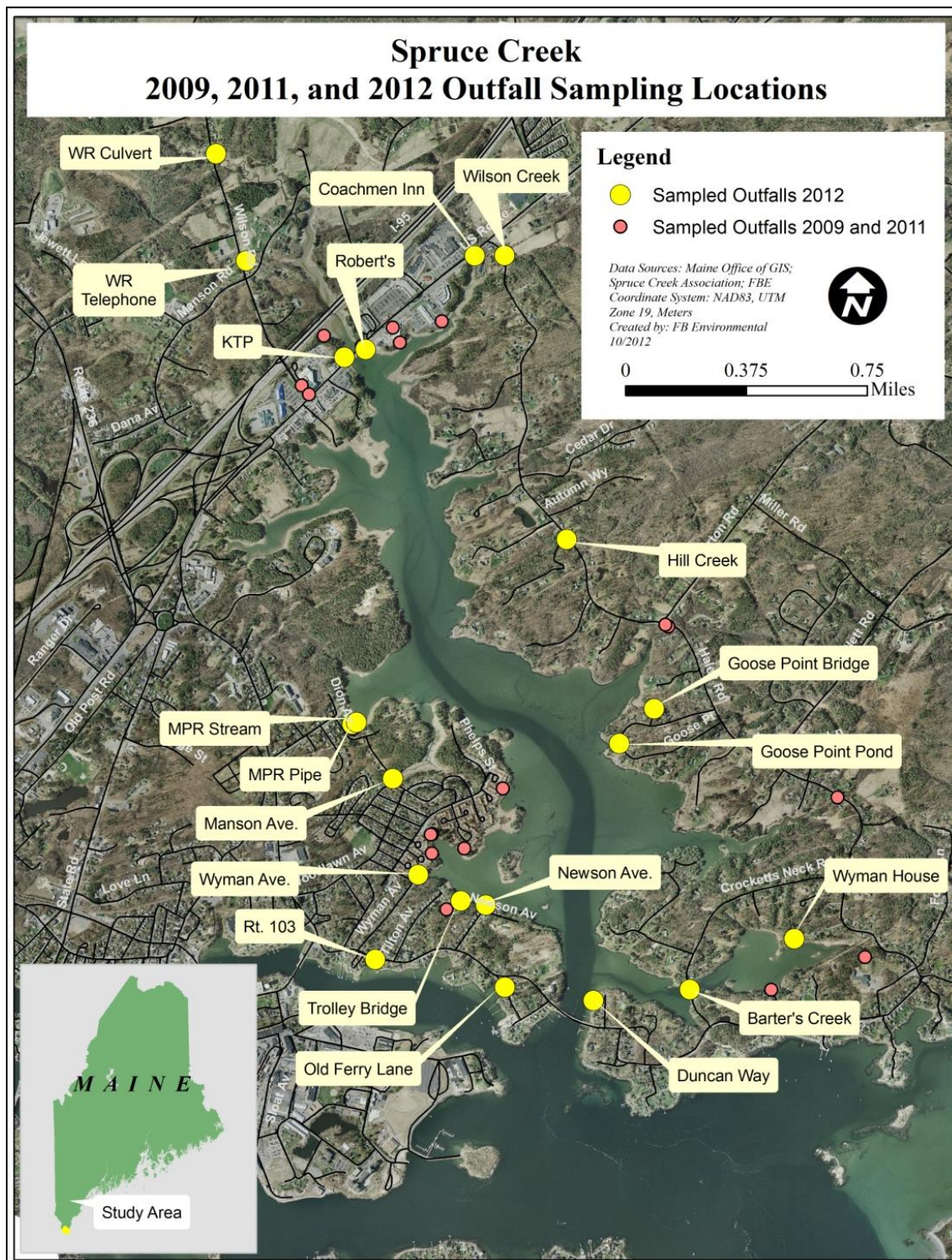


Trafton Downstream

4. OUTFALL SAMPLING THROUGHOUT THE SPRUCE CREEK WATERSHED

In addition to the bacteria source tracking on Picott Road and Trafton Lane, 40 additional stormwater outfalls and tributaries to Spruce Creek were identified ([Appendix C](#)). From these 40 sites, 20 sites were chosen for sampling ([Figure 4-1](#)). A detailed description of each site is also provided in [Appendix C](#).

Figure 4-1: 2009, 2011, and 2012 Kittery Outfall Sampling Locations



4.1 BACTERIA RESULTS

The project sites were sampled on four wet and four dry-weather days from August to October 2012. A range of weather conditions is helpful in identifying potential bacteria sources in stormwater and minimal flow conditions (Clary et al., 2011). All samples were analyzed for *E. coli* bacteria at the Nelson Analytical Lab in Kennebunk, ME. As indicated previously, *E. coli* bacteria are important indicators of potential fecal contamination from warm blooded animals. In general, elevated levels of *E. coli* in surface waters correspond with an increased likelihood of human illness from mammalian fecal contamination.

Maine's freshwater *E. coli* water quality standards (WQS) for Class B streams are

- 236 colonies/100 mL for instantaneous samples
- 64 colonies/100 mL for a geometric mean of multiple samples.

Sample results indicate that 13 of the 15 sampling sites exceeded Maine's WQS for *E. coli* bacteria (**Table 4-1 and Figure 4-2**). At all sites that could be sampled, the instantaneous results exceeded Maine's WQS for *E. coli* bacteria of 236 colonies/100 mL on at least one sample date throughout the study (**Table 4-1**). Two sites, Goose Point Bridge and Manson Avenue, exceeded the instantaneous sample criteria on every date sampled and had a geometric mean greater than 640 colonies/100 mL (greater than ten times the WQS) six sites had a geometric mean between 320 and 640 colonies/100 mL (between five and ten times the WQS), and five sites had a geometric mean between 64 and 319 colonies/100 mL (up to five times the WQS). Two sites did not exceed the water quality standard (Robert's and Rt. 103). Five sites did not have flow on any sample date.

In addition to the samples collected for analysis for bacteria, FBE measured dissolved oxygen (DO), temperature, and salinity and estimated flow conditions (**Appendix E**).

Figure 4-2: 2012 Outfall Sampling Results

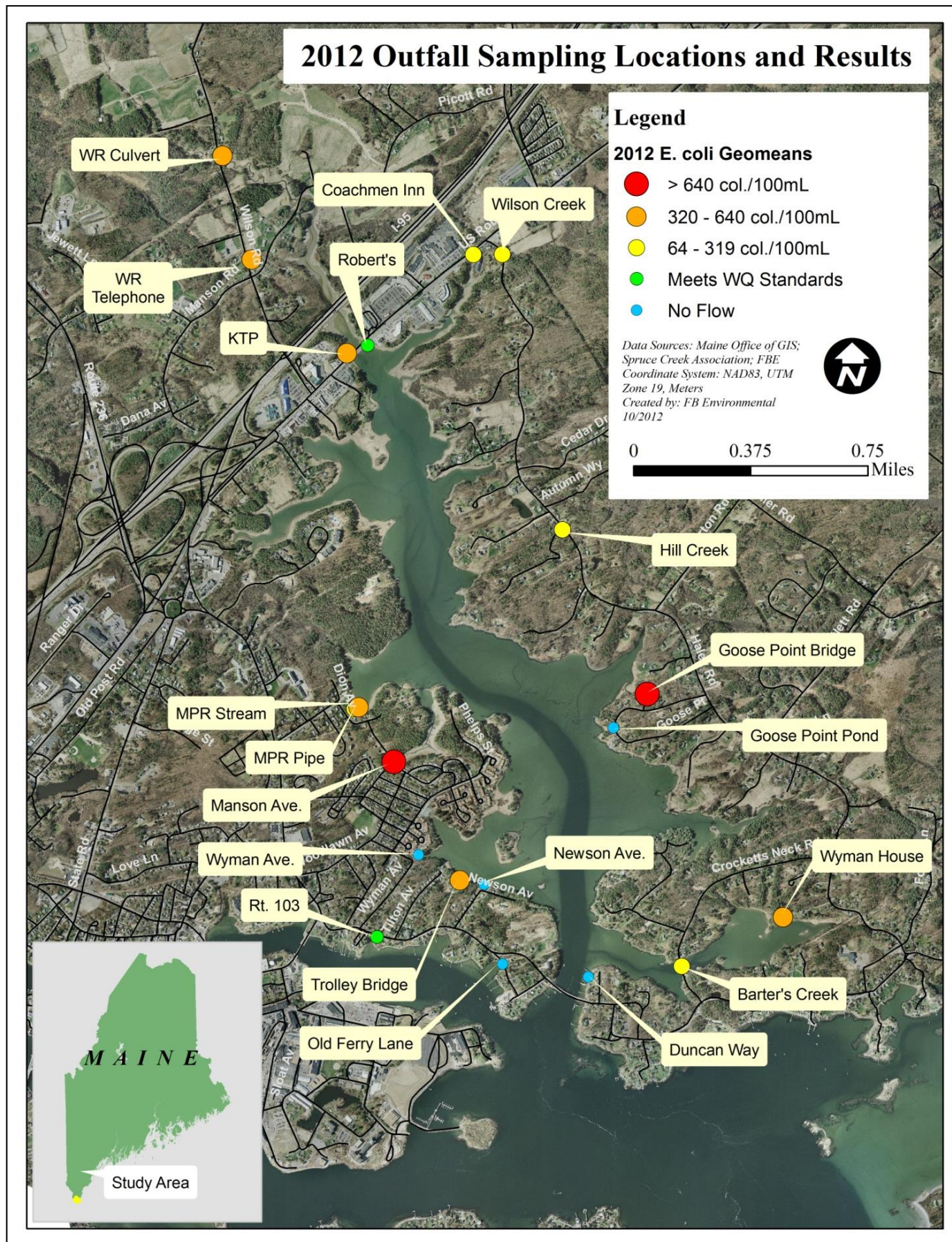


Table 4-1: *E. coli* results (colonies/100 mL) for outfall sampling conducted throughout the Spruce Creek Watershed

Outfall ID	Outfall Location	8/7/2012 (Dry)	8/9/2012 (Dry)	8/23/2012 (Dry)	9/4/2012 (Wet)*	9/5/2012 (Wet)	9/20/2012 (Wet)	10/4/2012 (Wet)	10/22/2012 (Dry)	Geometric Mean
Manson Avenue	Stream on Manson Ave	>2420	>2420	1553	>2420	3130^	2420	1414	>2420	2182
Goose Point Bridge	Culvert under bridge at 12 Goose Point Road	>2420		488	>2420	3255^	>2420	548	291	1068
MPR Stream	Mill Pond DS of pipe	>2420	816	121	--	1086	248	1300	461	628
WR Cul	Wilson Road culvert	272	980	1046	2420	2064	1414	93	74	477
Trolley Bridge	Stream underneath old trolley bridge at end of Tilton	>2420	36	961	--	169	>2420	2420	24	411
WR Telephone	Wilson Road telephone house	517	548	291	>2420	1723	1414	365	24	404
KTP	Drainage ditch behind KTP			68	1300	5172^	461	105	579	397
Wyman House	Outfall behind 578 Haley Road	115	231	411	1550	3255^	1046	411	62	370
Barter's Creek	Outlet of Barter's Creek	594	>2420	167	1300	10	>2420	1733	33	318
Wilson Creek	Wilson Creek outfall on Haley	435	1120	157	>2420	677	210	105	27	227
Hill Creek	At Spruce Creek Point Rd	--		68	210	1483	>2420	68	25	211
Coachmen Inn	Culvert on Route 1	62	36	58	>2420	414	194	84	49	89

Outfall ID	Outfall Location	8/7/2012 (Dry)	8/9/2012 (Dry)	8/23/2012 (Dry)	9/4/2012 (Wet)*	9/5/2012 (Wet)	9/20/2012 (Wet)	10/4/2012 (Wet)	10/22/2012 (Dry)	Geometric Mean
MPR Pipe	Outfall pipe behind house on Mill Pond Road	921	124	6	649	1450	86	32	12	85
Rt 103	Outfall across Rt 103 from pump station	39	>2420	17	225	63	73	13	11	52
Robert's	Outfall Pipe next to Robert's			15	579	697	25	285	4	50
Duncan Way	Pipe behind house	--	--	--	--	--	--	--	--	--
Goose Point Pond	Area where Goose Point Pond drains	--	--	--	--	--	--	--	--	--
Newson Ave	Pipe behind house at end of street	--	--	--	--	--	--	--	--	--
Old Ferry Lane	Outfall pipe on Old Ferry Lane	--	--	--	--	--	--	--	--	--
Wyman Outfall	Outfall in Admiralty Village by playground	--	--	--	--	--	--	--	--	--

* Sample taken at the beginning of a rain event and was not used to calculate geometric mean

- Gray cells indicate an exceedance of instantaneous WQS for *E. coli* (236 colonies/100 mL)

- Red cells indicate a geometric mean > 640 colonies/100 mL (greater than 10 times the WQS of 64 colonies/100 mL)

- Orange cells indicate a geometric mean of 320 – 640 colonies/100 mL (between 5 and 10 times the WQS of 64 colonies/100 mL)

- Yellow cells indicate a geometric mean of 64- 319 colonies/100 mL (up to 5 times the WQS of 64 colonies/100 mL)

- Green cells indicate a geometric mean of < 64 colonies/100 mL (does not exceed the WQS)

> 2420 is the maximum number that the analytical method can measure before being cited as too numerous to count

^ Indicates that a sample was assumed to have a high bacteria concentration and therefore was diluted prior to analysis

-- Indicates that no sample was taken due to no flow conditions or inaccessibility or not enough data to calculate a geometric mean

The geometric mean was also calculated for wet-weather and dry-weather samples in an effort to identify potential bacteria sources (**Table 4-2**). All sampling sites that had enough data to calculate a wet-weather geometric mean exceeded Maine's WQS for *E. coli* bacteria. Twelve of the 15 sampling sites that had enough data to calculate a dry-weather geometric mean exceeded Maine's WQS for *E. coli* bacteria of 64 colonies/100 mL for a geometric mean of multiple samples (**Table 4-2**). Canine detection was used at 12 of the outfalls using bucket sampling on one date. Overall, results from canine detection indicated that human wastewater may be present at seven of these sites.

Table 4-2: Total, Wet, and Dry-Weather *E. coli* (colonies/100 mL) geometric means and canine response to the presence of human fecal contamination for outfall sampling conducted throughout the Spruce Creek Watershed

Outfall ID	Outfall Location	<i>E. coli</i> Geometric Mean			Canine Response to the presence of human fecal contamination*
		Total	Wet	Dry	
Manson Avenue	Stream on Manson Ave	2182	2204	2166	Yes/No
Goose Point Bridge	Culvert under bridge at 12 Goose Point Road	1068	1628	700	No/No
MPR Stream	Mill Pond downstream of pipe	628	705	576	Yes/Yes
WR Cul	Wilson Road culvert	477	647	379	No/No
Trolley Bridge	Stream underneath old trolley bridge at end of Tilton	411	997	212	Yes/No
WR Telephone	Wilson Road telephone house	404	962	211	No/Yes
KTP	Drainage ditch behind Kittery Trading Post	397	630	198	--
Wyman House	Outfall behind 578 Haley Road (Wyman House)	370	1119	161	Yes/No
Barter's Creek	Culvert on Crockett Brook Road	318	347	298	No/No
Wilson Creek	Wilson Creek outfall on Haley	227	246	213	No/Yes
Hill Creek	At Spruce Creek Point Rd	211	625	41	--
Coachmen Inn	Culvert on Route 1	89	189	50	No/No
MPR Pipe	Outfall pipe behind house on Mill Pond Road	85	159	54	Yes/No
Rt 103	Outfall across Rt 103 from pump station	52	39	65	No/No
Robert's	Outfall Pipe next to Robert's	50	171	8	--
- Red cells indicate a geometric mean > 640 colonies/100 mL (greater than 10 times the WQS) - Orange cells indicate a geometric mean of 320 – 640 colonies/100 mL (between 5 and 10 times the WQS) - Yellow cells indicate a geometric mean of 64- 319 colonies/100 mL (up to 5 times the WQS) - Green cells indicate a geometric mean of < 64 colonies/100 mL (does not exceed the WQS) -- Indicates that no geometric mean could be calculated due to lack of data OR canines were not used *The “Yes/No” response indicates the response of each dog (Sable/Logan) to the presence of human fecal contamination.					

High Priority Areas

The following areas had geometric means greater than ten times the water quality standard for bacteria and should be prioritized for remediation. The wet weather and dry weather geometric means were also greater than ten times the water quality standard indicating a variety of potential sources including stormwater runoff, leaking sewer lines, and malfunctioning septic systems.

Manson Avenue: This site is a small tributary in Admiralty Village off of Manson Avenue. Sampling took place just downstream of two outfalls whose sources are unknown. The water from this stream flows through a marsh and into Spruce Creek. The area upstream of this site is residential and sewered. Both wet and dry geometric means were very high indicating that various sources are contributing bacteria to these outfalls. Canine detection indicated human wastewater may be present at this site.

Goose Point Bridge: This site is a small tributary to the main stem of Spruce Creek. The sample location is underneath a private, gravel driveway off of Goose Point Road. This tributary appears to drain a small wetland area just upstream across Haley Road. The area upstream of the Goose Point Bridge outfall is residential with homes relying on septic systems for waste removal. Both wet and dry geometric means were very high indicating that various sources are contributing bacteria to this stream.

Medium Priority Areas

The following areas had geometric means between five and ten times the water quality standard for bacteria. For these sites, the wet weather geometric means were greater than ten times the water quality standard indicating the exceeded the water quality standard. Sources to these sites are possibly stormwater runoff, leaking sewer lines, and malfunctioning septic systems.

MPR Stream: Mill Pond Road Stream is a small tributary to Spruce Creek. This site is located within a marsh, just downstream of three outfalls. The sources of these outfalls are unknown, but all are in backyards of houses along Mill Pond Road. The wet-weather geometric mean of MPR Stream was more than ten times the water quality standard, indicating wet-weather sources such as stormwater runoff from Mill Pond Road may be contributing bacteria to this site. However, the dry-weather geometric mean was between five and ten times the water quality standard, indicating dry-weather sources such as malfunctioning septic systems may also be contributing bacteria to the site. Canine detection indicated that human wastewater is likely present at this site.

WR Culvert: This site is on the upstream portion of Spruce Creek as the creek flows under Wilson Road through a large concrete box culvert. The sampling site is located just downstream of the culvert within a grassy meadow. The wet-weather geometric mean was more than ten times the water quality standard, indicating wet-weather sources such as stormwater runoff may be contributing bacteria to this site. However, the dry-weather geometric mean was still relatively high, indicating dry-weather sources such as malfunctioning septic systems or illicit discharges may also be contributing bacteria to the site. A small trailer home compound is located directly on the banks of the creek just upstream of the culvert. This home has a known septic failure which is currently being addressed with the assistance of the town. The

location where Wilson Road crosses over the creek is also a low point along a fairly busy road and may experience heavy stormwater collection and runoff.

Trolley Bridge: This site is located at the end of Tilton Avenue, at the outlet of a tidal pond and marsh that flows into Spruce Creek. The wet-weather geometric mean was more than ten times the water quality standard, indicating wet-weather sources such as stormwater runoff may be contributing bacteria to this site. However, the dry-weather geometric mean was still relatively high, indicating dry-weather sources such as malfunctioning septic systems or other illicit discharges may also be contributing bacteria to the site. The areas surrounding this tidal pond and marsh are developed, although fairly well buffered, and may be contributing large volumes of stormwater runoff. Canine detection indicated human wastewater may be present at this site.

WR Telephone: The Wilson Road Telephone House (WR Telephone) is a sampling site in a small, upstream tributary to Spruce Creek. The wet-weather geometric mean is more than ten times the water quality standard, indicating wet-weather sources such as stormwater runoff may be contributing bacteria to the site. However, the dry-weather geometric mean was still up to five times the water quality standard, indicating that dry-weather sources such as malfunctioning septic systems or illicit discharges may also be contributing bacteria to the site. This sampling site is adjacent to agricultural fields and very close to Wilson Road, both which may be contributing stormwater runoff. Canine detection indicated human wastewater may be present at this site.

KTP: The Kittery Trading Post outfall is the outlet of an old drainage ditch that begins near the Kittery Trading Post parking lot and flows through a fringe marsh and into Spruce Creek just upstream of Route 1. The wet-weather geometric mean was between five and ten times the water quality standard, indicating wet-weather sources such as stormwater runoff may be contributing bacteria to this site.

Wyman House: Wyman House is a sampling site located directly on Barter's Creek and receives flow primarily through groundwater infiltration from the surrounding upland areas. The wet-weather geometric mean was much higher than the dry-weather geometric mean, at more than ten times the water quality standard, indicating wet-weather sources such as stormwater runoff may be contributing bacteria to the site. Recent construction, clear-cutting and vegetation mowing has taken place within the upland area surrounding the sampling site, which may be contributing to stormwater runoff. Furthermore, a maintained lawn is adjacent to the sampling site with no intact buffer. Canine detection indicated human wastewater may be present at this site.

Low Priority Areas

Five sites had geometric means up to five times the water quality standard for bacteria. For these sites, the wet weather geometric means were higher than the dry weather geometric means indicating that stormwater runoff is the likely source of bacteria to these outfalls. The five sites are Barter's Creek, Wilson Creek, Hill Creek, Coachmen Inn, and MPR Pipe.

4.2 RECOMMENDED NEXT STEPS

The goal of this outfall sampling in Spruce Creek was to identify hotspots of bacterial contamination in the watershed. Further investigation of potentially significant hotspots is necessary to determine more precisely the location and extent of bacteria at each site and the probable cause of bacteria. A list of prioritized next steps is presented in **Table 4-3**.

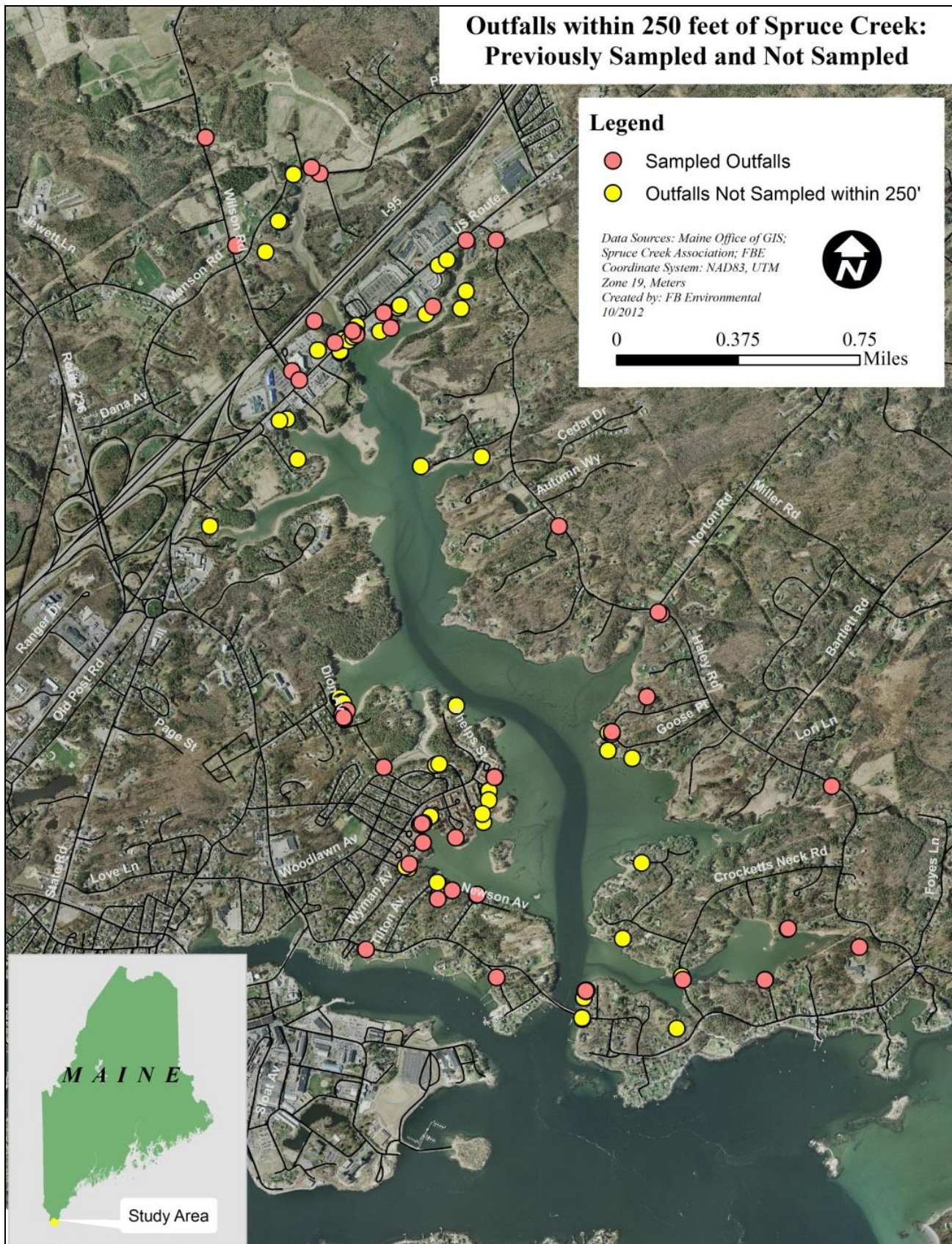
Table 4-3: Prioritized List of Next Steps for each Outfall

Sample ID	Sample Location	Priority	Wet/Dry Weather Issues	Next Steps
Manson Avenue	Stream on Manson Avenue in Admiralty Village	High	Wet and Dry	1). Map the drainage area to the outfall. 2). Determine source of three outfall pipes. 3). Use canine detection to determine location of illicit discharges along stream corridor.
Goose Point Bridge	Culvert under bridge at 12 Goose Point Road	High	Wet and Dry	1). Map the drainage area to the outfall. 2). Conduct an upstream land use investigation to determine potential sources. 3). Use canine detection to determine location of illicit discharges along stream corridor.
MPR Stream	Mill Pond downstream of pipes	Medium	Wet	1). Map the drainage area to the outfall. 2). Determine source of outfall pipes. 3). Investigate locations in Mill Pond Road neighborhood to install stormwater BMPs.
Trolley Bridge	Stream underneath old trolley bridge at end of Tilton	Medium	Wet	1). Map the drainage area to the outfall. 2). Determine source of outfall pipes. 3). Investigate locations in Mill Pond Road neighborhood to install stormwater BMPs.
WR Cul	Wilson Road culvert	Medium	Wet	1). Ensure complete upgrade of the failing septic system on Wilson Road. 2). Upstream land use investigation including mapping the drainage area to the outfall. 3). Use canine detection to determine location of illicit discharges along stream corridor. 4). Investigate locations along Wilson Road to install stormwater BMPs.
WR Telephone	Stream next to telephone house on Wilson Road	Medium	Wet	Investigate locations along Wilson Road to install stormwater BMPs.
KTP	Drainage ditch behind Kittery Trading Post	Medium	Wet	Investigate locations in the KTP parking lot and at the outfall to install stormwater BMPs.
Wyman House	Outfall behind 578 Haley Road (Wyman House)	Medium	Wet	1). Upstream land use investigation including mapping the drainage area to the outfall. 2). Investigate locations on property near outfall to install stormwater BMPs.
Barter's Creek	Culvert at outlet of Barter's Creek	Low	Wet	Investigate locations on Crockett's Neck Road to install stormwater BMPs.

Sample ID	Sample Location	Priority	Wet/Dry Weather Issues	Next Steps
Wilson Creek	Wilson Creek Outfall on Haley Rd.	Low	Wet/Dry	Investigate locations near outfall to install stormwater BMPs
Hill Creek	At Spruce Creek Point Road	Low	Wet	Investigate locations on Haley Rd. to install stormwater BMPs.
Coachmen Inn	Culvert underneath Rt. 1 near Coachmen Inn	Low	Wet	Investigate locations on Rt.1 to install stormwater BMPs.
MPR Pipe	Outfall Pipe behind house on Mill Pond Rd.	Low	Wet	1). Upstream land use investigation including mapping the drainage area to the outfall. 2). Investigate locations at outfall to install stormwater BMPs.

We also recommend extending the search for other bacteria hotspots in the watershed, as the majority of outfalls have yet to be sampled. As shown in **Figure 4-3**, 42 stormwater outfalls have been sampled by FB Environmental in 2009, 2011, and 2012. The current investigation was successful in identifying a few high priority outfalls, and continued sampling would enable the top source areas on a watershed basis to be moved to the top of the list for action. Improving the water quality of Spruce Creek will benefit the area economically, create healthy aquatic habitats, improve the safety of recreational uses, and serve as an example for other at-risk watersheds in the State of Maine.

Figure 4-3: All outfalls within 250 feet of Spruce Creek. Outfalls highlighted in red have been sampled by FBE in 2009, 2011, and 2012.



5. USE OF BACTERIA SCENT-TRACKING CANINES THROUGHOUT KITTERY

Three other areas in Kittery have been previously identified as potential hotspots of bacteria to Spruce Creek and other waterbodies in Kittery. These sites include:

1. The catch basin system on Philbrick Avenue in Admiralty Village
2. A small stream behind the Orvis outlet on Route 1
3. Beach seepages at Fort Foster.

To further identify sources of bacteria to these three sites, a thorough investigation using canine detection was conducted on one date in August 2012.

5.1 ADMIRALTY VILLAGE

In a previous project, one outfall (AV2) on Philbrick Avenue in Admiralty Village in Kittery was identified as sources of bacteria to Spruce Creek. In a subsequent project, an investigation of the catch basins draining to this outfall identified potential sources to AV2 (**Figure 5-1**), including two inflow pipes to CB3 (3-Lower and 3-NH). A follow-up investigation led to the discovery of a system of catch basins in private backyards along Goodrich Avenue (**Figure 5-2**).

Figure 5-1: Results of 2011 Bracket Sampling in Admiralty Village on Philbrick Avenue

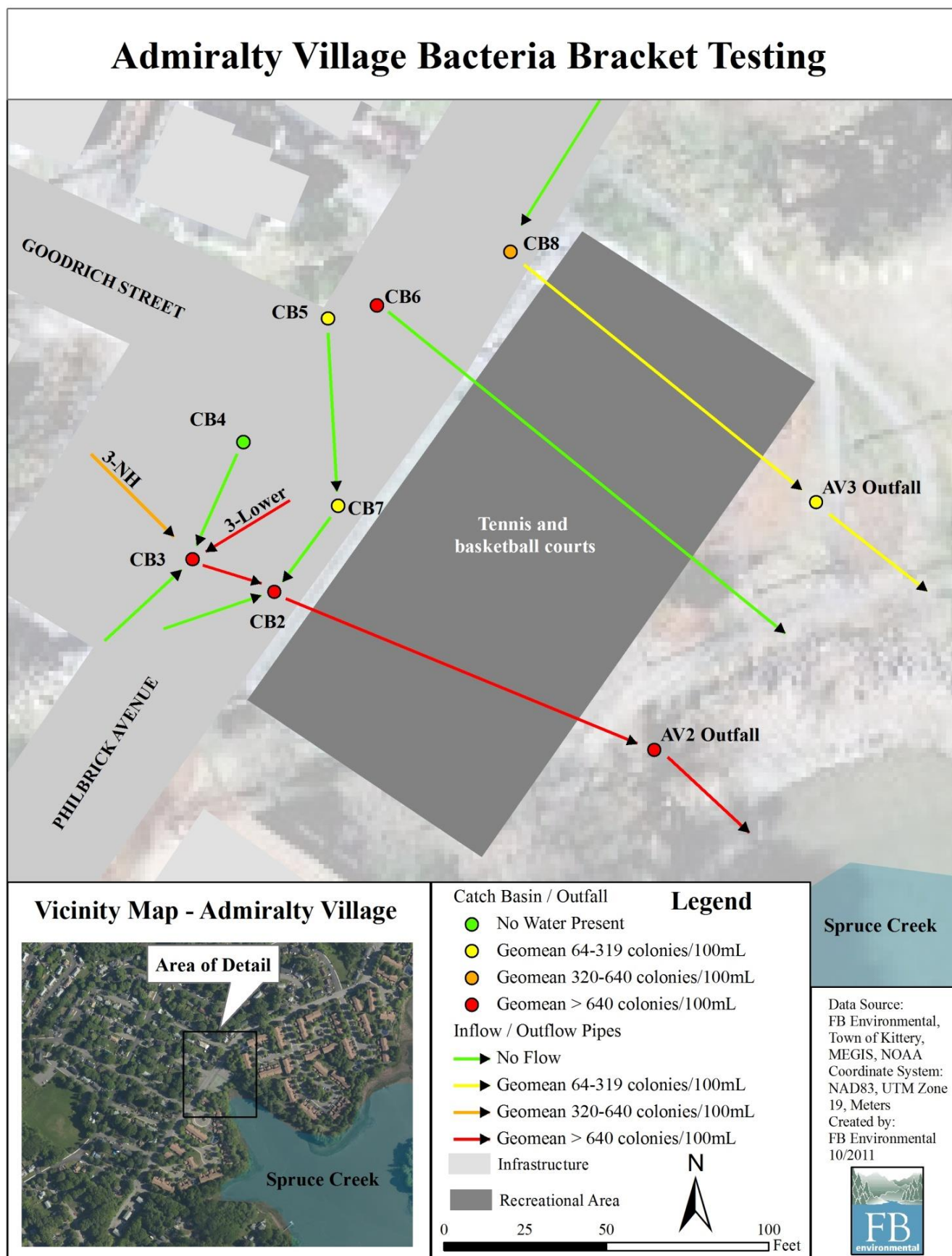
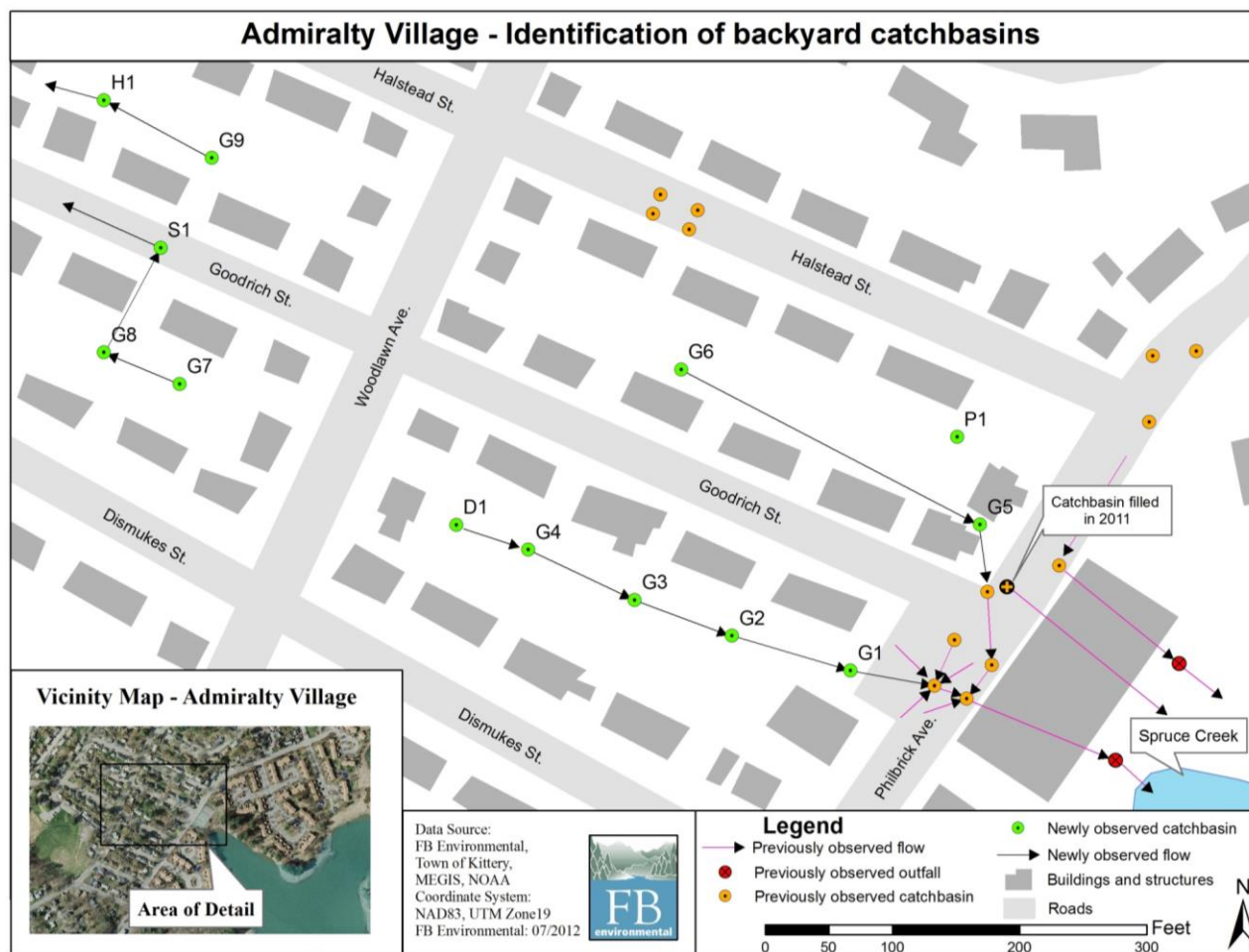
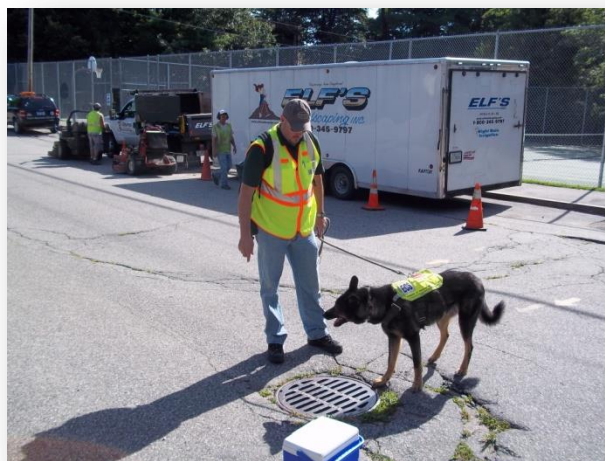


Figure 5-2: Backyard catch basins draining to the storm drain system on Philbrick Avenue



The use of canine detection at these catch basins and outfalls provided further information about the sources of bacteria to these sites. As shown in [Table 5-1](#), canine detection identified four sites as positive for human wastewater. This wastewater was found to be isolated to the catch basins and outfalls on Philbrick Avenue and was not found in the private catch basin system on Goodrich Avenue.



Sable in Admiralty Village

Table 5-1: Results of canine detection in the storm drain system on Philbrick Avenue in Admiralty Village on 8/7/2012 (gray cells indicate an exceedance of water quality criteria)

Outfall ID (Admiralty Village)	Outfall Location	Date	Time	<i>E.coli</i> (colonies/100 mL)	Canine Response to the presence of human fecal contamination
AV2	Outfall	8/7/2012	9:15	461	Yes
AV3	Outfall	8/7/2012	9:20	277	Yes
CB3	Catch Basin on Philbrick	8/7/2012	9:30	--	Yes
G1	Goodrich Ave Private CBs	8/7/2012	9:40	--	No
G2	Goodrich Ave Private CBs	8/7/2012	9:45	--	No
G3	Goodrich Ave Private CBs	8/7/2012	11:15	--	No
D1	Goodrich Ave Private CBs	8/7/2012	10:00	--	No
GS1	Goodrich St CB	8/7/2012	9:50	--	No
GS2	Goodrich St CB	8/7/2012	10:30	--	No
CB5	Philbrick Ave CB	8/7/2012	10:10	--	No
G5	Goodrich Ave Private CBs	8/7/2012	10:40	--	No
G6	Goodrich Ave Private CBs	8/7/2012	11:00	--	No
CB8	Philbrick Ave CB	8/7/2012	11:25	--	Yes (slight response)
PS1	Upper Philbrick Ave CBs	8/7/2012	11:30	--	No
PS2	Upper Philbrick Ave CBs	8/7/2012	11:30	--	No
PS3	Upper Philbrick Ave CBs	8/7/2012	11:35	--	No
HS1	Halsted Ave CBs	8/7/2012	11:40	--	No
HS2	Halsted Ave CBs	8/7/2012	11:40	--	No
HS3	Halsted Ave CBs	8/7/2012	11:40	--	No
HS4	Halsted Ave CBs	8/7/2012	11:40	--	No

The priority area continues to be the catch basins draining to outfall AV2. Recommended next steps include:

- Removal of pipe 3-Lower. Though a camera inspection revealed no obvious sources to the pipe 3-Lower, bacteria sampling from this pipe has shown extremely high concentrations of bacteria. It is recommended that this pipe be removed as the source of this pipe is unknown.
- Education of homeowners along Goodrich and Halstead Avenues. Most of these residents were unaware of the presence of catch basins in their backyards. As such, an education program would provide residents with the information necessary to properly use these catch basins and prevent future contamination.
- Camera inspection of AV3.

5.2 ORVIS OUTLET STREAM

In a previous project, the small stream behind the Orvis outlet on Route 1 was shown to have high bacteria concentrations. Sources to this site were thought to be stormwater runoff from Route 1 and surrounding neighborhoods. In this project, canine detection indicated the presence of human wastewater. This wastewater may be from leaking sewer lines or malfunctioning septic systems in the neighborhood on Ox Point Road. Recommended next steps include:

- Map the drainage area to this stream.
- Conduct an upstream land use investigation to determine the location of sewer lines and septic systems.
- Investigate locations in the Ox Point neighborhood and Orvis parking lot to install stormwater BMPs.

5.3 FORT FOSTER

Recent sampling by the Town of Kittery revealed high concentrations of bacteria in seepage coming out of the beach at Fort Foster. Canine detection of these seepages, the surf zone, and the marsh draining to the beach are presented in **Table 5-2**. Water quality samples were taken where there was enough water available. Maine's enterococci water quality standards (WQS) for determining beach closures are:

- 104 colonies/100 mL for instantaneous samples
- 35 colonies/100 mL for a geometric mean of multiple samples.

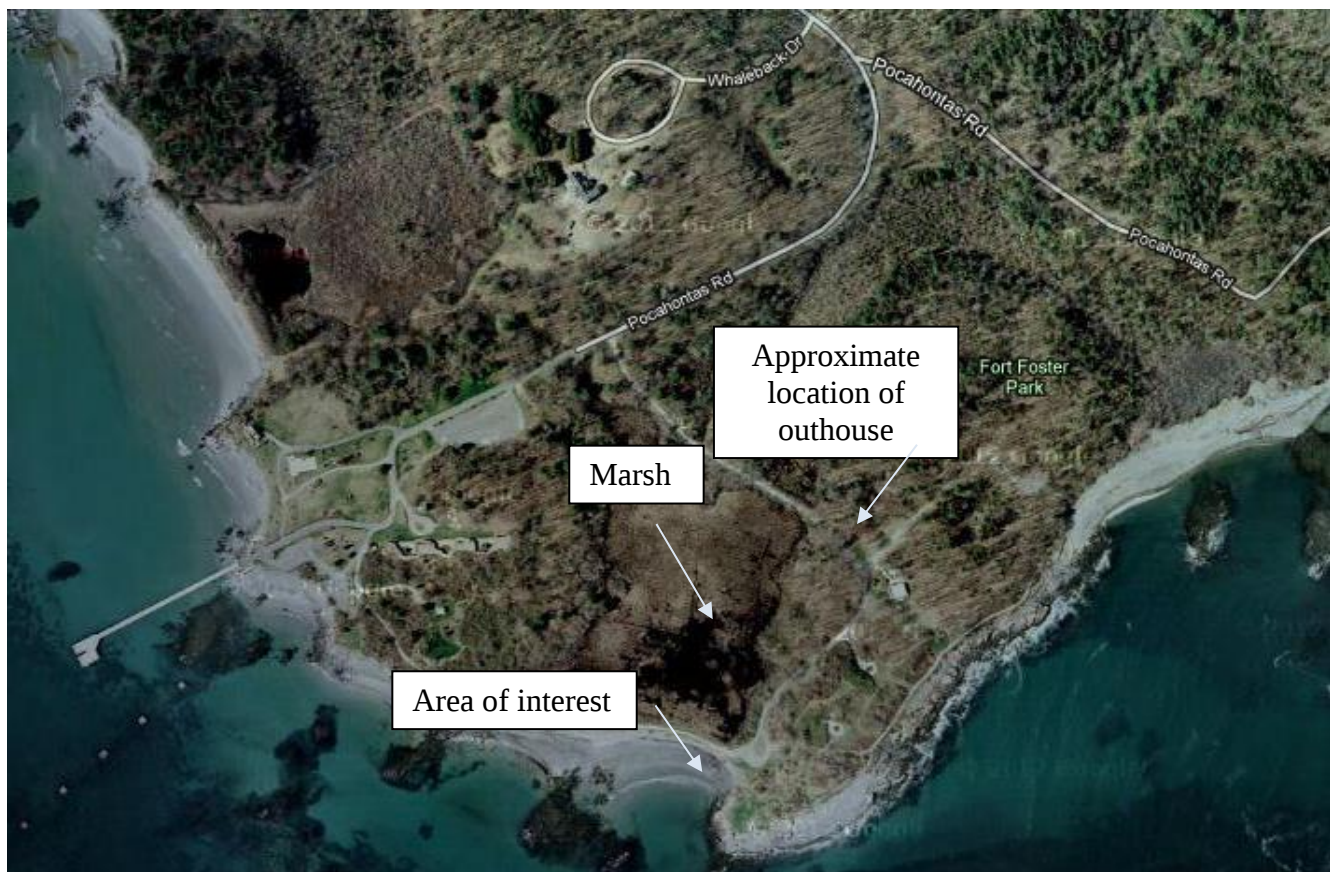
Table 5-2: Sampling Results from Canine Detection and Water Quality Sampling at Fort Foster on 8/7/2012 (gray cells indicate an exceedance of WQS for enterococci)

Sampling Sites	Site Description	Enterococci (colonies/100mL)	Canine Response
Beach Seepage K5	Dry area where original seep was found	--	Yes
Fort Foster K5	Surf Zone	40	Yes
Beach Seepage K4.5	Wet seep	146	Yes
Beach Seepage K4.2.5	Tidal pool	41	Yes
Beach Seepage K4	Wet seep	--	Yes
Fort Foster K4	Eastern Surf Zone	112	Yes
Fort Foster Culvert	culvert draining marsh (dry)	--	Yes
Fort Foster Coffe Dam	Downstream edge of marsh	109	Yes
Outhouse Pipe	no flow	--	Yes
Fort Foster Upper Marsh	Upstream portion of marsh near road	569	Yes

As shown in the table above, four sites exceeded the WQS for enterococci and all sites were positive for human wastewater. Upon further investigation of the area upstream of the marsh, an old outhouse was discovered and identified as the likely source of bacteria (**Figure 5-3**). Since the completion of this project, Kittery Department of Public Works has had the outhouse pumped and filled to prevent future

issues. Recommended next steps for this site is to conduct follow-up routine sampling throughout the next season to ensure there are no other sources of bacteria to the beach.

Figure 5-3: Area of Interest at Fort Foster



Logan investigating the beach at Fort Foster