



## TECHNICAL | MEMORANDUM



**TO:** Roy Sorenson, Director of Municipal Services, Town of Salem  
**FROM:** Lauren Bizzari, FB Environmental  
**SUBJECT:** **Task 2: Hotspot Catchment Investigation**  
**DATE:** September 15, 2016  
**CC:** Forrest Bell, Laura Diemer, & Carly Ellis, FB Environmental

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### BACKGROUND

Several waterbodies and beaches in Salem, NH have been identified by the NH Department of Environmental Services (NHDES) as impaired for various parameters. These impairments include high levels of bacteria from unidentified sources, likely attributed to nonpoint source pollution in stormwater runoff from the watershed. Since 2014, the Town of Salem has contracted FB Environmental (FBE) to conduct investigations around several of its waterbodies, with a focus on Captain and Millville Ponds. Previous investigations included a 2014 survey by Environmental Canine Services (ECS) to detect possible human wastewater contamination and a 2015 follow-up investigation of stormwater outfalls around Captain Pond and Millville Pond. Based on results from 2014 and 2015, continued monitoring of outfalls in the area was recommended. Monitoring for 2016 built on the preliminary investigations from 2014-2015. Task 1 (completed Spring-Summer 2016) included sampling of additional outfalls near Captain and Millville Ponds. Task 2 includes catchment investigations of previously identified “hotspot” outfalls. These efforts will also help satisfy new Illicit Discharge Detection and Elimination procedures that will be required under the anticipated NPDES MS4 Permit for New Hampshire (Draft 2013).

**This memo provides a review of Task 2: Hotspot Catchment Investigation results for select stormwater outfalls at Captain and Millville Ponds.**

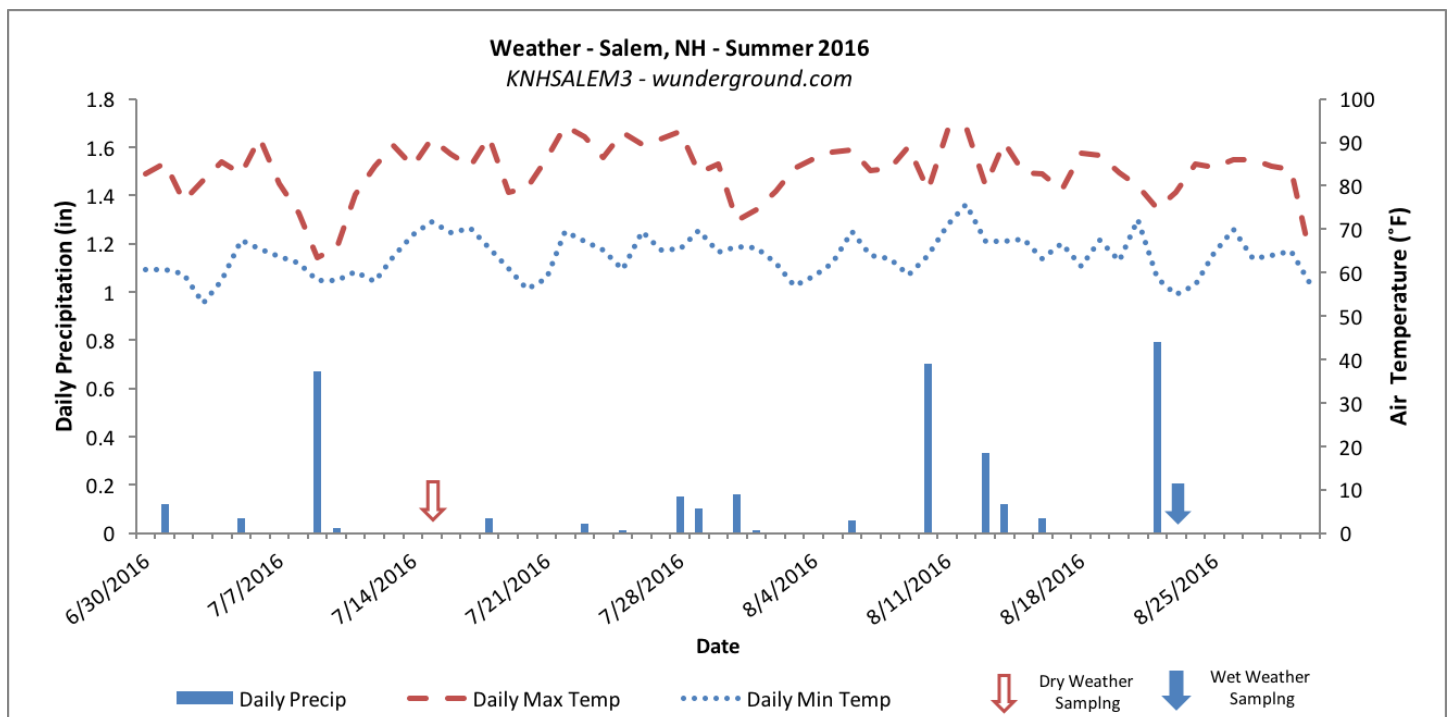
### METHODOLOGY

During the summer sampling season (July – August) of 2016, FBE staff visited catchments of three outfalls identified as “hotspots” based on *Escherichia coli* bacteria testing from the 2014-2016 investigations. *E. coli* bacteria are commonly used as an indicator of the presence of fecal material in freshwater. A shapefile of updated (though preliminary) stormwater infrastructure data was provided by Weston and Sampson (W&S) and aided in the catchment investigation of outfalls contributing high bacteria counts to Captain and Millville Ponds. These outfalls and their catchments were visited twice and the new infrastructure IDs provided by W&S were used to label all relevant drainage structures. Staff from Salem Department of Public Works provided assistance opening catch basins.

During each of the two visits, FBE staff photographed and documented individual inflows and outflows to each catch basin within the catchment area, as well as the terminal outfall (see Attachment 1 for photos of all catch basins surveyed). Those that were flowing were measured for dissolved oxygen, salinity, and

temperature. Grab samples were taken for bacterial analysis. All bacteria samples were analyzed for *E. coli* bacteria at Nelson Analytical Water Testing Laboratory in Kennebunk, Maine. Additional field testing for ammonia, chlorine, surfactants, and specific conductance was completed to satisfy MS4 requirements. See Attachment 2 for equipment and details on methodology.

The first catchment investigation took place on 7/15/2016 during dry weather conditions. The second catchment investigation took place on 8/23/2016 during wet weather conditions. Wet weather was defined as: >0.1" of precipitation in the 24 hours prior to sampling; or >0.25" in the 48 hours prior to sampling; or >2.0" in the 96 hours prior to sampling. Weather conditions were considered dry when precipitation was less than those wet weather thresholds (for MS4 Permit requirements: <0.1" of precipitation in the 24 hours prior to sampling). Rainfall was overall very low during the spring and summer leading up to the sampling season (Figure 1). As a result of the consistently dry conditions, most inflows to catch basins and outfalls were dry during the site visits. Terminal outfalls were also consistently dry. In these cases, grab samples were collected from, and field testing was conducted on, pooled water in the catch basins.



**FIGURE 1.** Summer sample dates with daily minimum and maximum temperatures and daily cumulative precipitation from weather station KNHSALEM3 ([Weather Underground](#)), located east of Millville Pond.

## BACTERIA ANALYSIS RESULTS

While we generally see greater flows or discharges flushing higher levels of *E. coli* into waterways during wet weather, these dry weather versus wet weather investigations around Captain and Millville Ponds show mixed results (Table 1). Of the six sites that were tested on both occasions, half had higher counts of *E. coli* during wet weather and the other half had higher counts during dry weather. Only four of the eight total sampled sites exceeded the State bacterial limit for instantaneous *E. coli* in recreational waters with a public beach (88 col/100 mL; the limit is 406 col/100 mL without a public beach).

Three of the four sites in exceedance were part of the investigation for hotspot OF-0517, draining to Captain Pond (Figure 4). During the dry weather sampling, the highest *E. coli* values were at the upstream-most catch basin that had water, CB-3000. Extremely high levels of bacteria found at CB-3000 confirmed FBE staff's concern about evidence of dumping in this basin found during the site visit (Figure 2). During the wet weather sampling, the highest *E. coli* values were, again, at the upstream-most catch basin that had water, CB-3001 (Figure 2). Concentrations of *E. coli* decreased stepwise at each downstream catch basin towards the outfall (Table 1, Figure 4).

The last of the four sites in exceedance, CB-3375 of the OF-0611 investigation (Figure 5) was well within compliance of these limits during the dry weather investigation, but spiked above the state's threshold after a ~0.8" precipitation event (Table 1, Figure 2). It should be noted that CB-3375 was part of the OF-0611 investigation, but was found to have no direct connection to that outfall. Further catchment sampling in the area of hotspot OF-0611 would help determine which particular basins are contributing to the high *E. coli* concentrations seen in previous monitoring.

**TABLE 1.** Outfall catchment investigation results for summer 2016. Sites with *E. coli* values indicate that there was enough water present to sample and complete MS4 field tests. Bold, italicized samples indicate exceedance of the NH State instantaneous *E. coli* limit for ponds with public beaches (88 col/100 mL).

Outfall Under Investigation	Site	Pond	Sample Dates	
			7/15/16 - DRY <i>E. coli</i> (col/100 mL)	8/23/16 - WET <i>E. coli</i> (col/100 mL)
OF-0517	OF-0517	Captain	Dry	Dry
	DS-0547	Captain	Dry	Dry
	CB-2999	Captain	<b>816</b>	<b>314</b>
	CB-3000	Captain	<b>&gt;2420</b>	<b>461</b>
	CB-3001	Captain	Dry	<b>866</b>
	CB-4335	Captain	Dry	Dry
OF-0611	OF-0611	Captain	Dry	Dry
	CB-3375	Captain	24	<b>186</b>
	CB-3377	Captain	8	10
	CB-3378	Captain	1	42
	CB-3379	Captain	9	2
OF-0701	OF-0701	Millville	Dry	Dry
	DS-1061	Millville	Dry	Dry
Unknown Inflow	CB-0129	Millville	Dry	1





**FIGURE 2.** CB-3000 (left) during dry weather sampling showed evidence of dumping of some sort, perhaps dog feces, which would account for the *E. coli* concentration >2420 col/100 mL. CB-3001 (center) with minimal stormwater present, even after a 0.8" precipitation event the day prior. CB-3375 (right) during dry weather conditions.

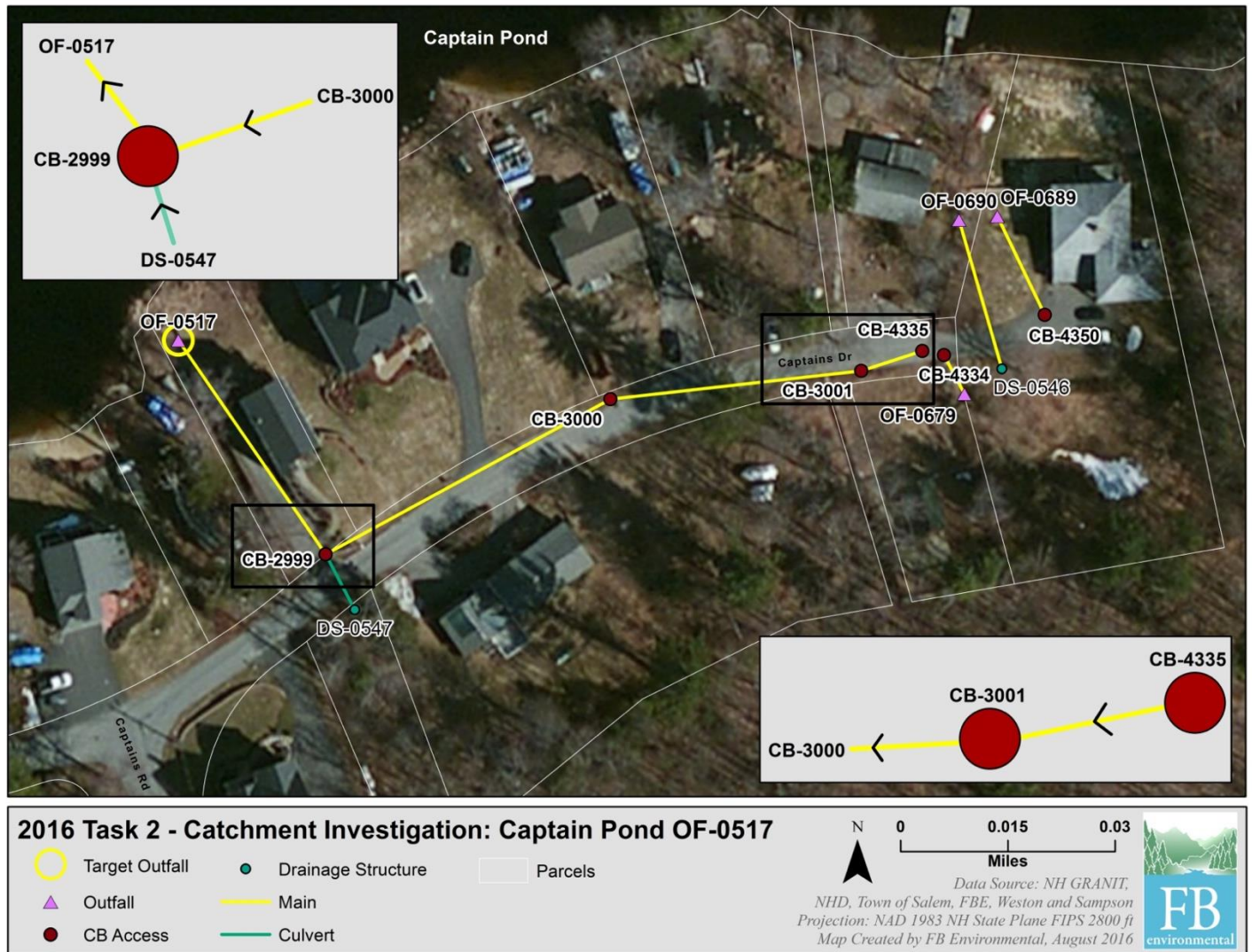
Finally, conditions remained too dry throughout the summer sampling season for any wet-up around the Millville Pond hotspot, OF-0701 (Figure 6). An investigation of this catchment, despite the dry conditions, did provide a better understanding of the stormwater flows to OF-0701. DS-0187 was not present at the surface (Figure 6), and it is likely that this is an underground joint, rather than an above ground structure. Further upstream at DS-1061 (Figure 3), a wetland area surrounded by houses drains into the underground pipe. No other outfall pipes or other stormwater infrastructure were observed in this area.



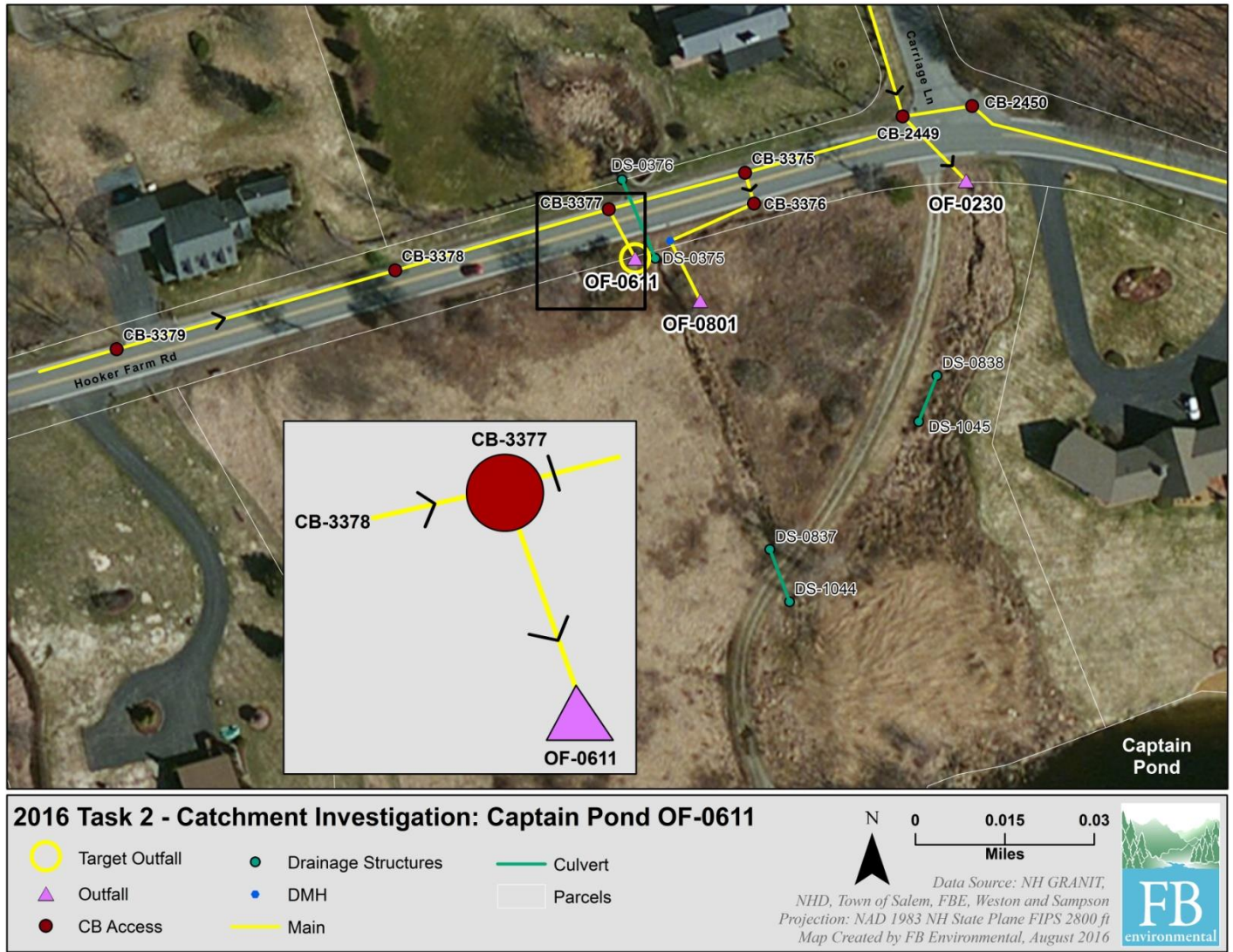
FBE staff also monitored the unknown inflow (likely from a nearby sump pump; see Task 1 Memo) to CB-0129 during both the wet and dry weather investigations. The inflow was not active during either of those instances, but a sample was taken from the catch basin during the wet weather investigation as it appeared that water had been freshly deposited in the catch basin, possibly from the inflow. While *E. coli* remains low in this basin, other parameters (see Temperature and Chemical Analysis) indicate that there may be an illicit discharge here.

**FIGURE 3.** DS-1061 during dry weather sampling (left) and wet weather sampling (right). There was no flow at this site during either sampling occasion.



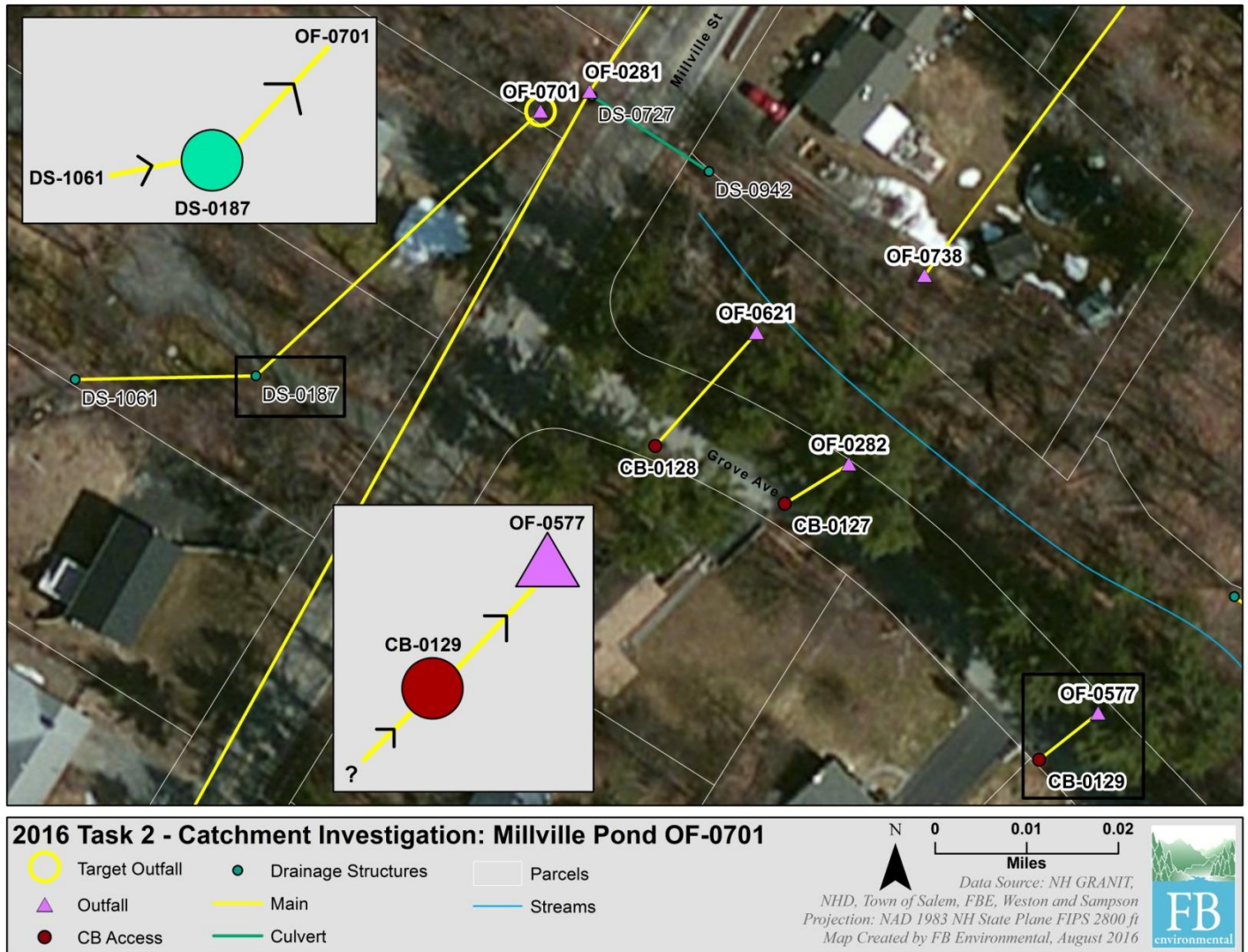


**FIGURE 4.** Map of stormwater system and flow directions related to hotspot OF-0517 on Captain Pond.



**FIGURE 5.** Map of stormwater system and flow directions related to hotspot OF-0611 on Captain Pond.





**FIGURE 6.** Map of stormwater system and flow directions related to hotspot OF-0701 on Captain Pond.

## TEMPERATURE AND CHEMICAL ANALYSIS RESULTS

The catch basins under investigation generally had warmer temperatures on wet weather days than on dry weather days (Table 2). This may be due to discharges from hot impervious surfaces (i.e., pavement) entering the stormwater system. Dissolved oxygen (DO) was below the criteria (75.0% and 5.0 mg/L) at nearly every catch basin, but improved during the wet weather sampling. This is to be expected as catch basins were not actively flowing in most cases. Salinity tended to be slightly higher during dry weather conditions than wet weather conditions, but was rarely in excess.

**TABLE 2.** Water quality measurements from dry and wet weather sampling, organized by outfall hotspot. Bold, italicized text indicates exceedance of (or failure to meet) criteria for water quality parameters.

Outfall Under Investigation	Site	Pond	Temp. (°C)		Dissolved Oxygen (%)		Dissolved Oxygen (mg/L)		Salinity (ppt)	
Criteria:			28.3		75.0		5.0		0.5	
Sample Date:			7/15	8/23	7/15	8/23	7/15	8/23	7/15	8/23
Sample Conditions:			DRY	WET	DRY	WET	DRY	WET	DRY	WET
OF-0517	OF-0517	Captain	Dry		Dry		Dry		Dry	
	DS-0547	Captain	Dry		Dry		Dry		Dry	
	CB-2999	Captain	18.5	20.7	<b>1.1</b>	<b>38.6</b>	<b>0.1</b>	<b>3.5</b>	0.2	0.1
	CB-3000	Captain	19.5	19.7	<b>11.9</b>	<b>0</b>	<b>1.1</b>	<b>0</b>	<b>1.9</b>	<b>0.6</b>
	CB-3001	Captain	Dry	18.9	Dry	<b>8.8</b>	Dry	<b>0.8</b>	Dry	0
	CB-4335	Captain	Dry		Dry		Dry		Dry	
OF-0611	OF-0611	Captain	Dry		Dry		Dry		Dry	
	CB-3375	Captain	19.1	21.2	<b>37.5</b>	<b>70.4</b>	<b>3.5</b>	6.3	<b>1</b>	0
	CB-3377	Captain	17.3	21.4	<b>1.5</b>	<b>74.9</b>	<b>0.1</b>	6.7	0.1	0
	CB-3378	Captain	24.6	19	<b>67.4</b>	<b>72.6</b>	5.6	6.8	0.2	0
	CB-3379	Captain	25.1	23	<b>59.7</b>	<b>37.9</b>	<b>4.9</b>	<b>3.3</b>	0.2	0
OF-0701	OF-0701	Millville	Dry		Dry		Dry		Dry	
	DS-1061	Millville	Dry		Dry		Dry		Dry	
Unknown Inflow	CB-0129	Millville	Dry	23.7	Dry	89.7	Dry	7.6	Dry	0.3

Ammonia levels were elevated above MS4 criteria at nearly all sites during the dry weather investigation and only two sites during the wet weather investigation (Table 3). Past sampling showed that ammonia exceedance was more common at sites around Millville Pond than it is at Captain Pond, so sampling from catch basins near OF-0701 when there is better flow would be informative. Total chlorine was very low in the majority of cases, though still considered “in exceedance” at almost all sites (any detectable amount). CB-0129 had the highest total chlorine (1.06 ppm), which may be related to an illicit discharge from the unknown inflow to that catch basin.

Surfactants were measured at or above the MS4 criteria value (0.25 ppm) at several catchments during dry weather sampling, while only one field test (at CB-3001) from wet weather sampling tested above that level (Table 3). Finally, specific conductivity exceeded the NHDES<sup>1</sup> acute or chronic exposure criteria estimates on both sampling occasions at one site (CB-3000). This is the basin at which FBE staff is concerned may contain some sort of animal feces or other dumped pollutants (Figure 2).

<sup>1</sup> [http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/vrap\\_parameters.pdf](http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/vrap_parameters.pdf)



**TABLE 3.** Results of MS4 water quality measurements from the outfall catchment investigation during dry and wet weather sampling. Bold, italicized values indicate exceedance of the NH State criteria listed for each parameter. For surfactants, <0.25 ppm indicates that some blue tint was visible during the field test (indicative of surfactant presence), but was less than the lowest visual comparator (0.25 ppm).

Outfall Under Investigation	Site	Pond	Ammonia (ppm)		Total Chlorine (ppm)		Surfactants (ppm)		Specific Conductivity (μS/cm)	
Criteria:			0.5		Detectable		0.25		854	
Sample Date:			7/15	8/23	7/15	8/23	7/15	8/23	7/15	8/23
Sample Conditions:			DRY	WET	DRY	WET	DRY	WET	DRY	WET
OF-0517	CB-2999	Captain	0.4		<b>0.10</b>	<b>0.2</b>	<0.25		476	284
	CB-3000	Captain	<b>10</b>	<b>3</b>	<b>0.01</b>	0	<b>0.5</b>	<0.25	<b>3540</b>	<b>1320</b>
	CB-3001	Captain	Dry	<b>1</b>	Dry	<b>0.21</b>	Dry	<b>0.5</b>	Dry	96
	CB-4335	Captain	Dry		Dry		Dry		Dry	
OF-0611	CB-3375	Captain	<b>0.8</b>	0	<b>0.13</b>	<b>0.09</b>	<b>0.25</b>	0	62	22
	CB-3377	Captain	<b>0.6</b>	0.2	<b>0.11</b>	<b>0.05</b>	<0.25	0	144	34
	CB-3378	Captain	<b>0.6</b>	0	<b>0.03</b>	<b>0.04</b>	<b>0.5</b>	<0.25	352	96
	CB-3379	Captain	<b>1</b>	0.3	<b>0.14</b>	<b>0.08</b>	<b>0.75</b>	<0.25	345	94
OF-0701	OF-0701	Millville	Dry		Dry		Dry		Dry	
	DS-1061	Millville	Dry		Dry		Dry		Dry	
Unknown Inflow	CB-0129	Millville	Dry	0.4	Dry	<b>1.06</b>	Dry	0	Dry	663

## RECOMMENDATIONS

Based on results from this hotspot catchment investigation and results from 2014-2016 monitoring, further follow-up catchment investigations are recommended, especially for **OF-0701** and **OF-0611**. These outfalls had both high bacteria counts and exceeded MS4 criteria across the 2014-2016 sampling seasons, but catch basins were either dry or did not point to specific pollutant source areas during the catchment investigation. There is enough evidence of pollution from **OF-0517** beginning in the upper catchments (CB-3000 and CB-3001) that remediation or BMPs should be pursued. There are many dogs in this neighborhood (some unleashed), and we recommend that the town reach out to residents about proper pet waste disposal. Additionally, we recommend that the Town further investigate the unknown inflow to CB-0129 to determine if illicit discharges are entering the catch basin. Task 1 in spring of 2016 revealed that the outfall from this catch basin is currently buried, but during years with larger storm events the contents of this catch basin may flush into the drainage to Millville Pond.

**Attachment 1.** Photos of all catch basins visited during the 2016 summer investigation.



7/15/16 – Dry Weather





7/15/16 – Dry Weather



8/23/16 – Wet Weather



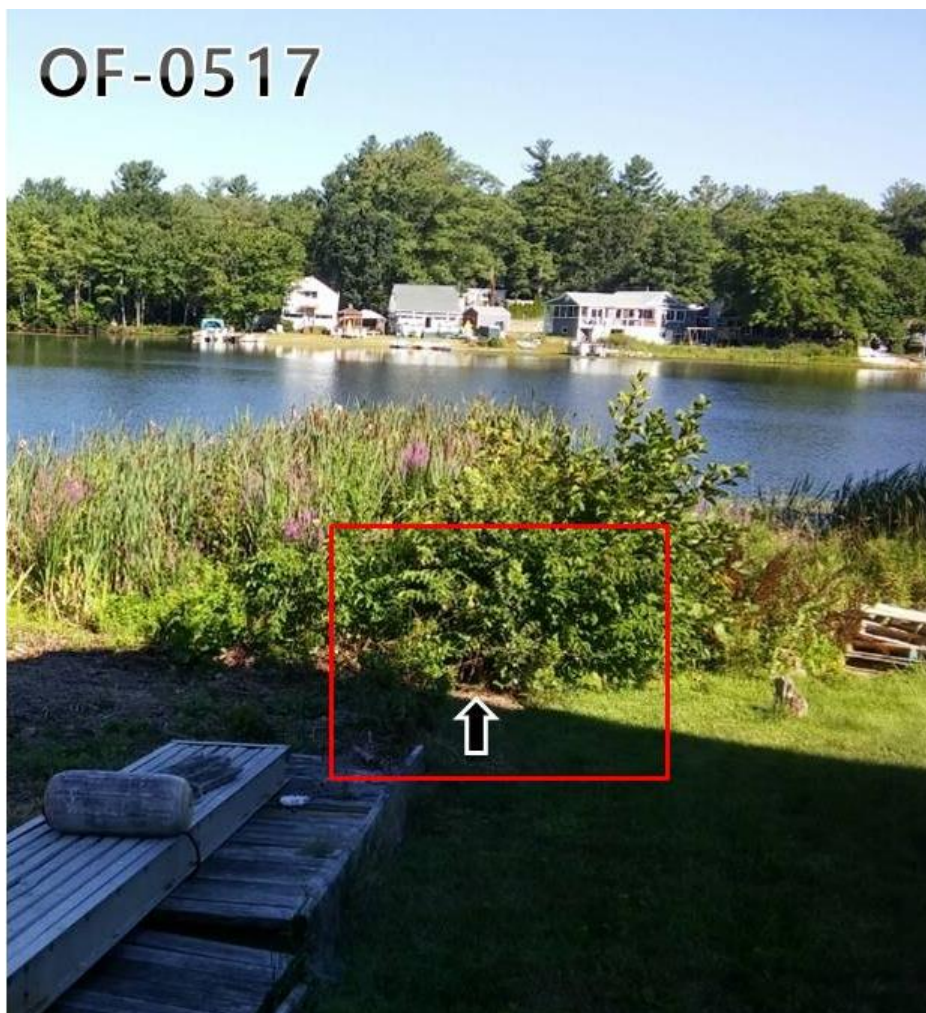


8/23/16 – Wet Weather



7/15/16 – Dry Weather





8/23/16 – Wet Weather



7/15/16 – Dry Weather





8/23/16 – Wet Weather



8/23/16 – Wet Weather





8/23/16 – Wet Weather



8/23/16 – Wet Weather



8/23/16 – Wet Weather





7/15/16 – Dry Weather



7/15/16 – Dry Weather

**ATTACHMENT 2:** Equipment and methodology used for sample parameters.

Parameter	Units	Equipment or Methodology
Dissolved oxygen	% and mg/L	YSI ProODO meter
Temperature	°C	YSI ProODO meter
<i>E. coli</i> bacteria	mpn (most probable number) of colonies/100mL	Standard Method 9223 B
Salinity	ppt	refractometer
Specific conductivity	µS/cm	YSI 30 meter
Ammonia	ppm	CHEMetrics K-1510 (direct nesslerization)
Detergents (anionic surfactants, MBAS)	ppm	CHEMetrics K-9400 (methylene blue)
Chlorine	mg/L	HACH Pocket Colorimeter II (total chlorine)