



TO: Robert Puff, Director of Engineering, Town of Salem
FROM: Lauren Bizzari, FB Environmental
SUBJECT: **Task 1: Spring Outfall Investigation and Monitoring**
DATE: July 13, 2016
CC: Forrest Bell, Laura Diemer, & Carly Ellis, FB Environmental

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 builds on the preliminary investigations from 2014-2015, and includes sampling of additional outfalls near Captain and Millville Ponds and 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 brief review of Task 1: Spring Outfall Investigation and Monitoring results for select stormwater outfalls at Captain and Millville Ponds.

METHODOLOGY

During the spring sampling season (May – June of 2016), FBE staff visited a total of 30 outfalls (Figures 2 and 3, Table 1). Targeted outfalls included 17 previously-unchecked outfalls along Captain and Millville Ponds that could not be located or were not visited in 2015. A shapefile of updated (though preliminary) stormwater infrastructure data provided by Weston and Sampson (W&S) indicated newly identified outfalls in the area of Captain and Millville Ponds. These additional outfalls were visited as time and resources allowed. The new infrastructure IDs provided by W&S were used to label outfalls.

Outfalls were initially visited during dry weather conditions on 5/17/2016. Those that showed evidence of dry weather flow, but were not flowing during the initial visit, received one additional dry weather follow-up visit on 5/20/2016. Two additional outfalls were also inaccessible during the first visit and were checked during the follow-up. Eight outfalls were selected for continued monitoring during the spring based on the presence of flow during the initial visit: four previously identified as hotspots and four new outfalls. The selected outfalls were visited one additional time during dry weather conditions on 6/16/2016 and twice during wet weather conditions (6/21/2016, 6/30/2016). 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 sampling season, with only one rain event greater than 0.5" (Figure 1), which occurred over a weekend when the processing laboratory for bacteria samples was not open. As a result, most outfalls were dry during the site visits, even immediately after wet weather events (Table 1).

When there was adequate flow to sample, FBE staff recorded dissolved oxygen, salinity, and temperature and collected grab samples for bacterial analysis (*E. coli*). Field testing for ammonia, chlorine, surfactants, and specific conductance (to satisfy MS4 requirements) was also completed at all sites with adequate flow (see Attachment 2 for equipment and specific methodology). Specific conductance (temperature adjusted) was calculated for tributaries with only conductivity data available, using USGS methods (http://water.usgs.gov/owq/FieldManual/Chapter6/6.3_contents.html).

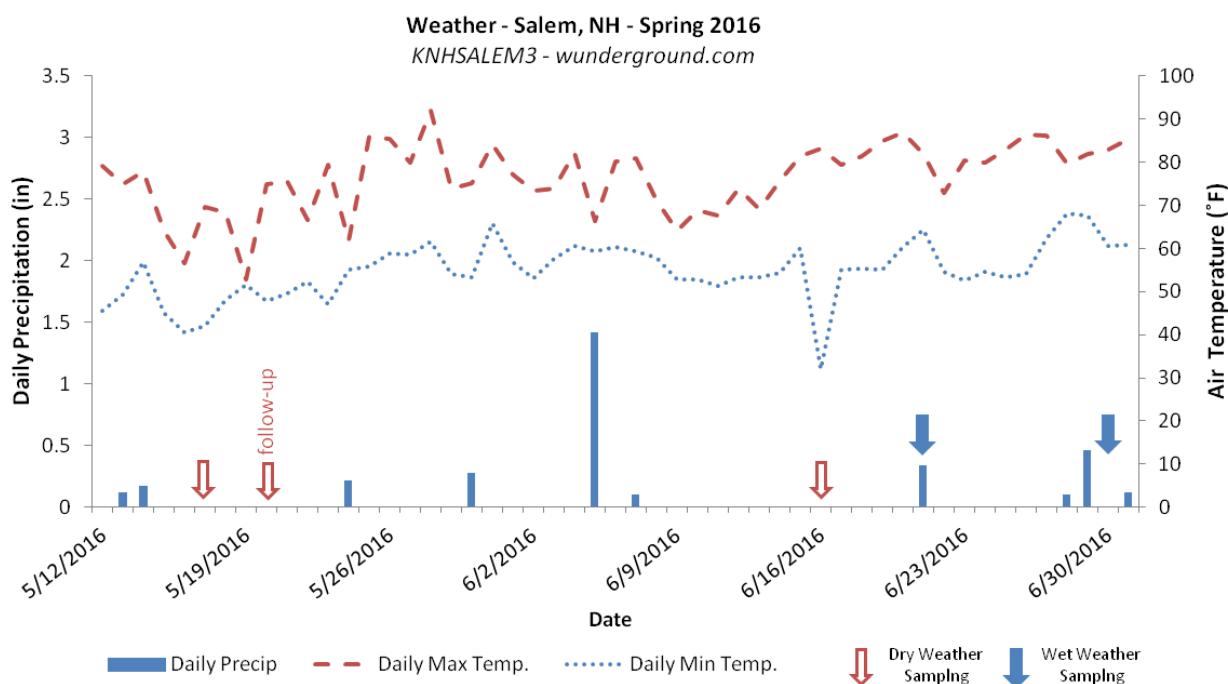


FIGURE 1. Spring sample dates with daily minimum and maximum temperatures and daily cumulative precipitation from weather station KNHSALEM3 ([Weather Underground](#)), located east of Millville Pond.

BACTERIA ANALYSIS RESULTS

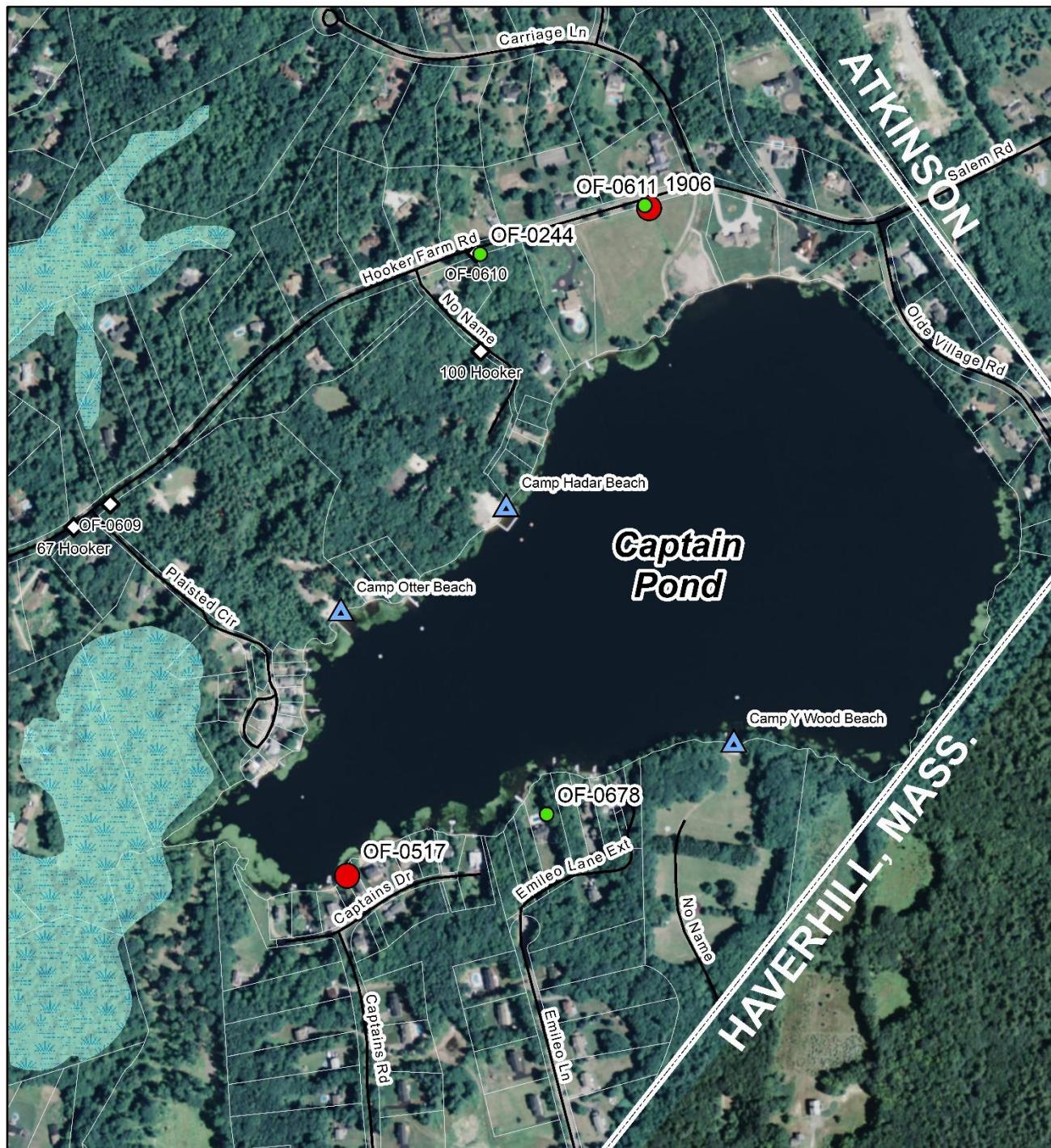
Based on the geometric mean of the five sampling visits, wet weather outfall discharges generally had higher levels of *E. coli* than dry weather (Table 2). Of the two sites with three or more sampling events (meaning enough data to calculate a geometric mean for a single site), both exceeded the State bacterial limit for a 60-day geometric mean in recreational waters with a public beach (47 col/100mL; the limit is 126 col/100mL without a public beach). One of these two sites, OF-0906, is located near Millville Pond between Grove Avenue and Walter Palmer Lane (Figure 3). The other site, 1906, is located on Captain Pond just below Hooker Farm Road (Figure 2). It should be noted that site 1906 may not be considered an outfall under MS4 definitions as it is a culvert which simply conveys waters of the United States (in this case, a wetland area located on private property). However, consistently high bacteria counts from

this culvert pipe over the last three sampling seasons have indicated that this is a “hotspot” of bacteria for Captain Pond.

TABLE 1. Outfall sampling dates for spring 2016, with previously identified “hotspots” shaded in grey. Sites marked “✓” had adequate flow and were sampled on that date. Sites marked “X” could not be sampled due to lack of flow on that date. If a site was marked “X” during the initial visit, the site was not checked again during follow-up. Sites marked “**” showed evidence of potential dry weather flow during the initial visit and were checked again during follow-up. Sites marked “ns” did have flow, but were not sampled (not MS4 outfalls).

Site	Pond	Sample Date				
		5/17/16 (dry)	5/20/16 (dry follow-up)	6/16/16 (dry)	6/21/16 (wet)	6/30/16 (wet)
1906*	Captain	✓		✓	✓	✓
OF-0517 (formerly 4259)	Captain	✓		X	✓	X
OF-0611 (formerly 5025)	Captain	✓		X	X	X
OF-0701 (formerly 5075)	Millville	✓		X	✓	X
2177*	Millville	ns				
No ID 100 Hooker Farm Camp Rd*	Captain	X				
No ID 67 Hooker Farm Rd*	Captain	ns				
OF-0244	Captain	✓		X	X	X
OF-0258	Millville	X				
OF-0260	Millville	X				
OF-0282	Millville	X				
OF-0283	Millville	X				
OF-0573	Millville	X				
OF-0574	Millville	X				
OF-0575	Millville	X				
OF-0576	Millville	X				
OF-0577	Millville	**	✓	X	X	✓
OF-0609	Captain	inaccessible	X			
OF-0610	Captain	**	X			
OF-0620	Millville	X				
OF-0621	Millville	X				
OF-0649	Millville	X				
OF-0655	Millville	X				
OF-0666	Millville	X				
OF-0678	Captain	inaccessible	✓	X	X	X
OF-0680	Millville	X				
OF-0716	Millville	X				
OF-0717	Millville	X				
OF-0906	Millville	✓		✓	✓	✓
OF-0907	Millville	X				

* Sites are culverts which may not be outfalls based on MS4 definitions.



**Captain Pond - Outfall E. coli (Spring 2016)
Geometric Mean, Average, or Single Sample**

E. coli (col/100mL) ● 1-47 ● 47-128 ● >128

Parcels Town Boundary
Wetlands Beach Locations

◆ Not Sampled

0 Miles
0.125 0.25



Data Source: NH GRANIT,
NHD, Town of Salem
Projection: NAD 1983
NH State Plane FIPS 2800 ft
Map Created by FB Environmental
July 2016



FIGURE 2. Summary of stormwater outfall sampling in spring 2016 at Captain Pond.



Millville Pond - Outfall E. coli (Spring 2016) Geometric Mean, Average, or Single Sample

E. coli (col/100mL) ● 1-47 ● 47-126 ● >126

Parcels Town Boundary
Wetlands Beach Locations

◆ Not Sampled

0 Miles
0.125 0.25



Data Source: NH GRANIT, NHD, Town of Salem
Projection: NAD 1983
NH State Plane FIPS 2800 ft
Map Created by FB Environmental
July 2016



FIGURE 3. Summary of stormwater outfall sampling in spring 2016 at Millville Pond.

It should also be noted that Hooker Farm Road was resurfaced in the middle of the spring sampling season (between 5/20/2016 and 6/17/2016), which included replacement of pipes and headwalls for 1906, OF-0611, and OF-0244 (Figure 4). Only 1906 continued to have enough flow to sample after construction was completed, and bacteria counts remained high.

TABLE 2. Summary of bacterial analysis by weather condition. Bold, italicized values exceed geometric mean limits for ponds with (47 col/100mL) and without public beaches (126 col/100 mL).

		<i>E. coli</i> (colonies/100mL)		
Season	Weather	Geometric Mean	Min	Max
Spring	Wet	229	<1*	> 2,420*
	Dry	12	<1*	435

* indicates a value above or below the detectable limit

Additionally, four sites exceeded the instantaneous limit for recreational waters with public beaches (88 col/100mL; 406 col/100mL without beaches; Figures 2 and 3, Attachment 1). Bacteria counts from the outfalls varied with weather conditions. Though fewer sites were sampled during wet weather conditions, all four of the sites exceeding instantaneous limits did so

during wet weather conditions. Two of those sites also exceeded instantaneous limits during a dry sampling period. Similar to spring 2015 sampling results, fewer bacterial colonies were present during dry weather than during wet weather. However, minimum values during both types of weather conditions were low, even below the detectable limit (Table 2).



FIGURE 4. Before and after photos of culvert and headwall replacements at OF-0611 (left pipe) and 1906 (center pipe).

TEMPERATURE AND CHEMICAL ANALYSIS RESULTS

The outfalls to Millville and Captain Ponds generally have warmer temperatures on wet weather days than on dry weather days (Table 3). This may be due to discharges from hot impervious surfaces (i.e., pavement) entering the stormwater system, or the time of year during wet weather sampling (end of June). Dissolved oxygen (DO) was similar for outfalls at both ponds (Table 3), only falling below the criteria (75.0% and 5.0 mg/L) on a few occasions (Attachment 1). Salinity for outfalls at both ponds tended to be slightly higher during dry weather conditions than wet weather conditions.

TABLE 3. Average water quality measurements by weather condition and pond. Bold, italicized text indicates exceedance of (or failure to meet) criteria for water quality parameters.

Pond	Temp. (°C)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Salinity (ppt)
Criteria	28.3	75.0	5.0	0.5
Wet Weather	Millville	18.8	83.9	0
	Captain	20.3	82.2	0
Dry Weather	Millville	13.5	70.5	1.3
	Captain	14.2	90.7	2.6

Ammonia levels were elevated above MS4 criteria at outfalls on both ponds, but the issue was more prevalent at Millville Pond (3 outfalls) than at Captain Pond (1 outfall, Table 4). Total chlorine was detectable, and therefore exceeded the MS4 criteria at every outfall sampled. One site, OF-0577 on Grove Avenue near Millville Pond, was particularly elevated for total chlorine during one sample date and should be further investigated for illicit discharges (Figure 5). The actual outfall is buried, but the catch basin immediately upstream was accessible for sampling. Intermittent flow was observed from a private pipe (potentially a basement floor drain) into the catch basin and was sampled when flowing.

Surfactants were measured at the MS4 criteria value (0.25 ppm) at several Millville Pond outfalls, while only one field test from an outfall to Captain Pond tested at that level (OF-0611). Finally, specific conductivity exceeded the NHDES¹ acute or chronic exposure criteria estimates on only one occasion at one site (OF-0611, Figure 5). Several other sites had elevated specific conductivity readings close to the chronic exposure criteria (Attachment 1), including OF-0678 (Figure 5).



FIGURE 5. OF-0577 (left) intermittent flow, OF-0611 (center) dry conditions, and OF-0678 (right) dry conditions.

¹ http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/vrap_parameters.pdf

TABLE 4. Summary of MS4 water quality measurements by pond and outfall. Bold, italicized text indicates exceedance of criteria for water quality parameters.

Date	Weather	Pond	Site ID	Ammonia (ppm)	Total Chlorine (ppm)	Surfactants (ppm)	Specific Conductivity ($\mu\text{S}/\text{cm}$)
			Criteria	0.5	Detectable	0.25	854
5/17/16	Dry	Captain	1906	0.0	0.11	0	358
6/16/16	Dry	Captain	1906	0.8	0.04	<0.25	453.5
6/21/16	Wet	Captain	1906	0.6	0.07	<0.25	469.7
6/30/16	Wet	Captain	1906	0.6	0.04	<0.25	530
5/17/16	Dry	Captain	OF-0244	0.2	0.03	0	396.6
5/17/16	Dry	Captain	OF-0517	0.2	0.16	0	361.4
6/21/16	Wet	Captain	OF-0517	0.2	0.20	<0.25	449.9
5/17/16	Dry	Captain	OF-0611	0.1	0.12	0.25	1560
5/20/16	Dry	Captain	OF-0678	0.2	0.05	0	826
5/20/16	Dry	Millville	OF-0577*	0.8	0.03	0.25	584
6/30/16	Wet	Millville	OF-0577	0.6	1.17	<0.25	646
5/17/16	Dry	Millville	OF-0701	0.6	0.08	0.25	715
6/21/16	Wet	Millville	OF-0701	0.8	0.11	0.25	777
5/17/16	Dry	Millville	OF-0906	0.2	0.04	0.25	530
6/16/16	Dry	Millville	OF-0906	0.3	0.02	<0.25	548
6/21/16	Wet	Millville	OF-0906	0.6	0.05	<0.25	531
6/30/16	Wet	Millville	OF-0906	0.3	0.02	<0.25	--

*5/20/16 sample was from the catch basin, while 6/30 sample was from the inflow pipe to the catch basin.

RECOMMENDATIONS FOR CATCHMENT INVESTIGATION

Based on results from 2014-2016, follow-up catchment investigation is recommended for **OF-0701**, **OF-0611**, and **OF-0517**. These sites had both high bacteria counts and exceeded MS4 criteria across the three sampling years. Additionally, we recommend that the Town further investigate **OF-0577** to determine if illicit discharges are coming from the private pipe into the upstream catch basin.

ATTACHMENT 1: Individual results of water quality and bacteria measurements by pond and outfall. Bold, italicized text indicates exceedance of (or failure to meet) criteria for water quality parameters. Instantaneous limits for ponds are 88 col/100mL with public beaches and 406 col/100mL without.

Date	Weather	Pond	Site ID	Temp. (°C)	DO (%)	DO (mg/L)	Salinity (ppt)	E. Coli (col/100mL)
			Standards/Thresholds	28.3	75.0	5.0	0.5	88
5/17/16	Dry	Captain	1906	13.5	92.5	9.6	2	2
6/16/16	Dry	Captain	1906	17.9	83.3	7.8	0	435
6/21/16	Wet	Captain	1906	20.0	65.1	5.9	0	>2,420
6/30/16	Wet	Captain	1906	19.1	83.6	7.7	0	192
5/17/16	Dry	Captain	OF-0244	13.7	93.1	9.7	4	1
5/17/16	Dry	Captain	OF-0517	12.4	97.3	10.4	0	211
6/21/16	Wet	Captain	OF-0517	21.7	97.7	8.5	0	173
5/17/16	Dry	Captain	OF-0611	13.6	95.5	9.9	4	8
5/20/16	Dry	Captain	OF-0678	14.2	82.6	8.5	3	14
5/20/16	Dry	Millville	OF-0577	16.0	22.9	2.3	1	<1
6/30/16	Wet	Millville	OF-0577	22.0	96.4	8.4	0	<1
5/17/16	Dry	Millville	OF-0701	11.6	94.6	10.3	2	8
6/21/16	Wet	Millville	OF-0701	18.5	95.5	8.9	0	>2,420
5/17/16	Dry	Millville	OF-0906	11.5	88.5	9.7	2	24
6/16/16	Dry	Millville	OF-0906	14.9	76.0	7.6	0	43
6/21/16	Wet	Millville	OF-0906	17.2	69.7	6.6	0	1,300
6/30/16	Wet	Millville	OF-0906	17.3	73.9	7.1	0	261

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)