TECHNICAL | MEMORANDUM

TO: Dan Hudson, Director of Engineering, Town of Salem

FROM: Laura Diemer & Christine Bunyon, FB Environmental Associates

SUBJECT: **Task 1: 2018 MS4 Outfall Monitoring**

DATE: July 23, 2018

CC: James Danis, Town of Salem; Forrest Bell, FB Environmental Associates

BACKGROUND

Several waterbodies and beaches in Salem, NH have been identified by the NH Department of Environmental Services (NHDES) as impaired for the designated uses of aquatic life and primary and secondary contact recreation due to elevated pollutants such as nutrients, chloride, metals, and fecal indicator bacteria. Elevated levels of these pollutants are likely from nonpoint source pollution in stormwater runoff from developed land. As a designated Municipal Separate Storm Sewer System (MS4) community, the Town of Salem is required to screen all stormwater outfalls for pollutants to help satisfy Illicit Discharge Detection and Elimination procedures under the 2017 New Hampshire Small MS4 General Permit. **This memo provides a brief review of 2018 MS4 outfall monitoring results for select stormwater outfalls to Canobie Lake, Captain Pond, Millville Pond, and the Arlington Mill Reservoir.**

METHODOLOGY

In spring and early summer (April-July 2018), FBE staff conducted dry weather screening at 26 outfalls to Canobie Lake, Captain Pond, Millville Pond, and the Arlington Mill Reservoir, following procedures described in the 2017 New Hampshire Small MS4 General Permit (Tables 1, 2; Figures 1-5). These outfalls were selected by Weston and Sampson (W&S) and the Town of Salem because preliminary data ranked these outfalls as at risk and/or high priority for investigation.

Dry weather screening of the 26 outfalls to Canobie Lake, Captain Pond, Millville Pond, and the Arlington Mill Reservoir was conducted on 4/24/18, 5/3/18, 5/24/18, 6/21/18, and 7/10/18. All dry weather screening days were preceded by less than 0.1" of rainfall for each day in the prior 72 hours. FBE staff was assisted in the field by James Danis (Town of Salem) to locate the inaccessible outfalls, remove catch basin grates, and provide insight on catchment investigations on 6/21/18. Three sites (CAP-0679-OF, CAP-0689-OF, and CAP-0690-OF), were inaccessible during the initial visit on 5/3/18 because of no trespassing signs and high security warnings. Two sites (ARL-0799-OF and CAP-0612-OF) were unable to be located during the initial visits on 4/24/18 and 5/3/18, respectively; ARL-0799-OF was found on 6/21/18 and was submerged in the lake (nearest upstream catch basin was not flowing), while CAP-0612-OF was confirmed by the Town of Salem as non-existent. Twelve outfalls (ARL-0425-OF, ARL-0428-OF, ARL-0878-OF, ARL-0879-OF, ARL-0971-OF, CAN-0272-OF, CAP-0227-OF, CAP-0228-OF, CAP-0229-OF, CAP-0242-OF, CAP-0243-OF, and CAP-0802-OF) had flow and were sampled during the dry weather visits on 4/24/18, 5/3/18, 5/24/18, or 6/21/18. Ten outfalls (ARL-0874-OF, ARL-0972-OF, CAN-0318-OF, CAN-0584-OF, MIL-0285-OF, MIL-0712-OF, MIL-0740-OF, MIL-0908-OF, CAP-0679-OF, and CAP-0690-OF) were not flowing but showed evidence of prior flow (or were stagnant) during the initial visit on 4/24/18 or 5/24/18. These sites were rechecked for dry-weather follow-up on 5/3/18, 5/24/18, 6/21/18, or 7/10/18 and were found to still have no flow. CAP-0689-OF was submerged in the lake during both visits (5/24/18 and 6/21/18) with no flow at the nearest upstream catch basin; ARL-0875-OF was submerged in the lake during the initial visit (4/24/18). ARL-0875-OF and ARL-0799-OF will be revisited after drawdown in fall 2018 when both outfalls will likely be exposed.

Wet weather screening of 8 outfalls to Canobie Lake, Captain Pond, Millville Pond, and the Arlington Mill Reservoir was conducted on 6/25/18 and 6/28/18. Wet weather screening on 6/25/18 was preceded by 0.53" of rainfall within 24 hours, and wet weather screening on 6/28/18 was preceded by 1.13" of rainfall within 24 hours. Three outfalls (CAN-0272-OF, CAP-0802-OF, and CAP-0243-OF) had flow and were sampled on 6/25/18. Three sites (CAN-0318-OF, CAN-0584-OF, and MIL-0712-OF) had no flow but showed evidence of prior flow on 6/25/18. The remaining five outfalls (CAN-0318-OF, CAN-0584-OF, MIL-0285-OF, MIL-0712-OF, and ARL-0425-OF) had flow and were sampled on 6/28/18.

When there was adequate flow to sample during dry or wet weather days, FBE staff recorded temperature, salinity, dissolved oxygen, and specific conductivity, completed field kits for total ammonia and total chlorine, and collected grab samples for bacterial analysis (*E. coli*) and surfactants. In addition to these parameters, samples were also collected for total phosphorus, chlorophyll-a, biological oxygen demand, and pH at Canobie and Captain sites, as well as iron, manganese, aluminum, total suspended solids, alkalinity, and chloride at Canobie sites (refer to Table 2 for parameters and Attachment 1 for equipment and methodology).

TABLE 1. Outfall sampling dates for spring 2018. Sites marked "✓" had adequate flow and were sampled on that date. Sites marked "**" showed evidence of flow during the initial visit and were checked again during dry-weather follow-up. Sites marked "X" were not able to be sampled due to lack of flow during the dry-weather follow-up or showed no evidence of flow during the initial visit and were not checked again during the dry-weather follow-up. Sites marked "\" were unable to be located or were inaccessible during the initial visit. Sites marked "ne" no longer exist. Sites marked "cb" had their nearest upstream catch basin visited, inspected for flow, and sampled, if possible, because the outfall was submerged with lake water.

Site	4/24/18 (dry)	5/3/18 (dry)	5/24/18 (dry)	6/21/18 (dry)	6/25/18 (wet)	6/28/18 (wet)	7/10/18 (dry)
CAN-0272-OF			✓		✓		
CAN-0318-OF	**	X			**	✓	
CAN-0584-OF	**		X		**	✓	
CAP-0227-OF		✓					
CAP-0228-OF			✓				
CAP-0229-OF		✓					
CAP-0612-OF		ne					
CAP-0679-OF		\	**	X			
CAP-0689-OF		\	cb**	cbX			
CAP-0690-OF		\	**				X
CAP-0802-OF			✓		✓		
CAP-0243-OF				✓	✓		
CAP-0242-OF		✓					
MIL-0285-OF	**		X			✓	
MIL-0712-OF	**	X			**	✓	
MIL-0740-OF	**	X					
MIL-0908-OF	**	X					
ARL-0425-OF	✓					✓	
ARL-0428-OF	✓						
ARL-0799-OF *	\		\	cb**			cbX
ARL-0874-OF	**	X					
ARL-0875-OF *	cb**						
ARL-0878-OF	**		✓				

Site	4/24/18 (dry)	5/3/18 (dry)	5/24/18 (dry)	6/21/18 (dry)	6/25/18 (wet)	6/28/18 (wet)	7/10/18 (dry)
ARL-0879-OF			✓				
ARL-0971-OF			✓				
ARL-0972-OF	**			X			

**These sites will be checked again in the fall after the lake has been drawn down.*

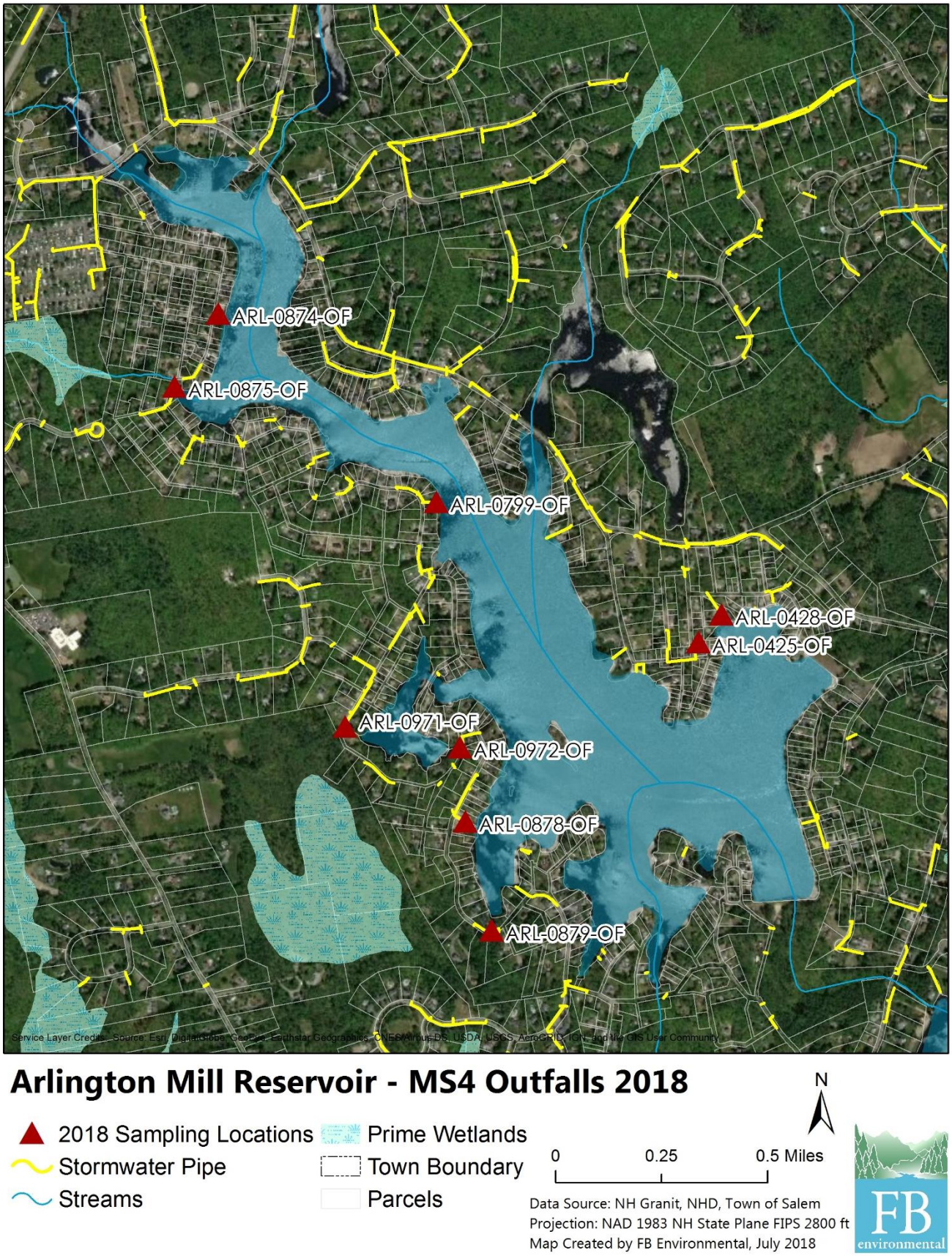

FIGURE 1. Stormwater outfall sampling locations for 2018 MS4 screening at the Arlington Mill Reservoir.

Canobie Lake - MS4 Outfalls 2018

2018 Sampling Locations
Stormwater Pipe
Streams
Prime Wetlands
Town Boundary
Parcels

N

0 0.25 0.5 Miles

Data Source: NH Granit, NHD, Town of Salem
Projection: NAD 1983 NH State Plane FIPS 2800 ft
Map Created by FB Environmental, July 2018

FB environmental

FIGURE 2. Stormwater outfall sampling locations for 2018 MS4 screening at Canobie Lake.

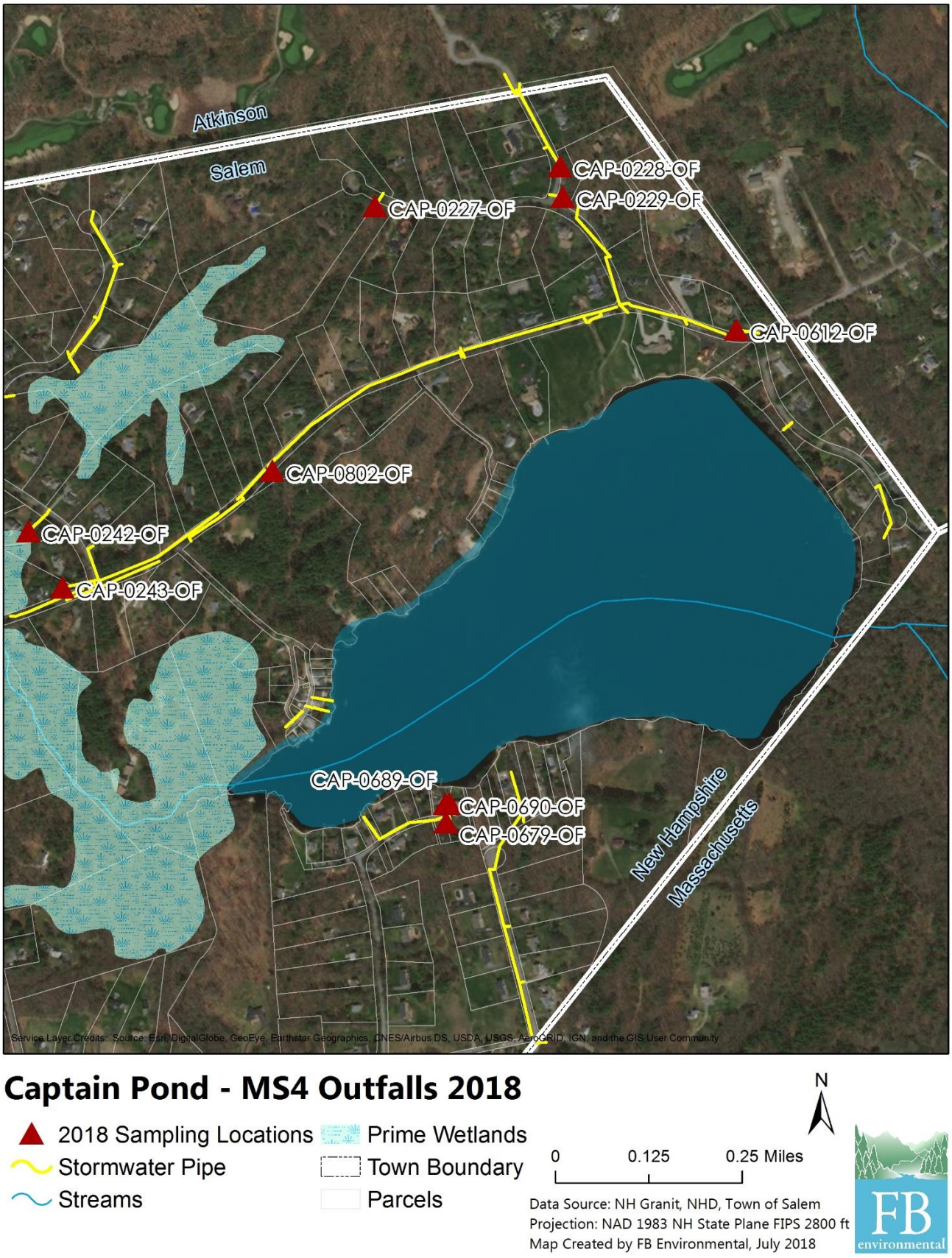

FIGURE 3. Stormwater outfall sampling locations for 2018 MS4 screening at Captain Pond.

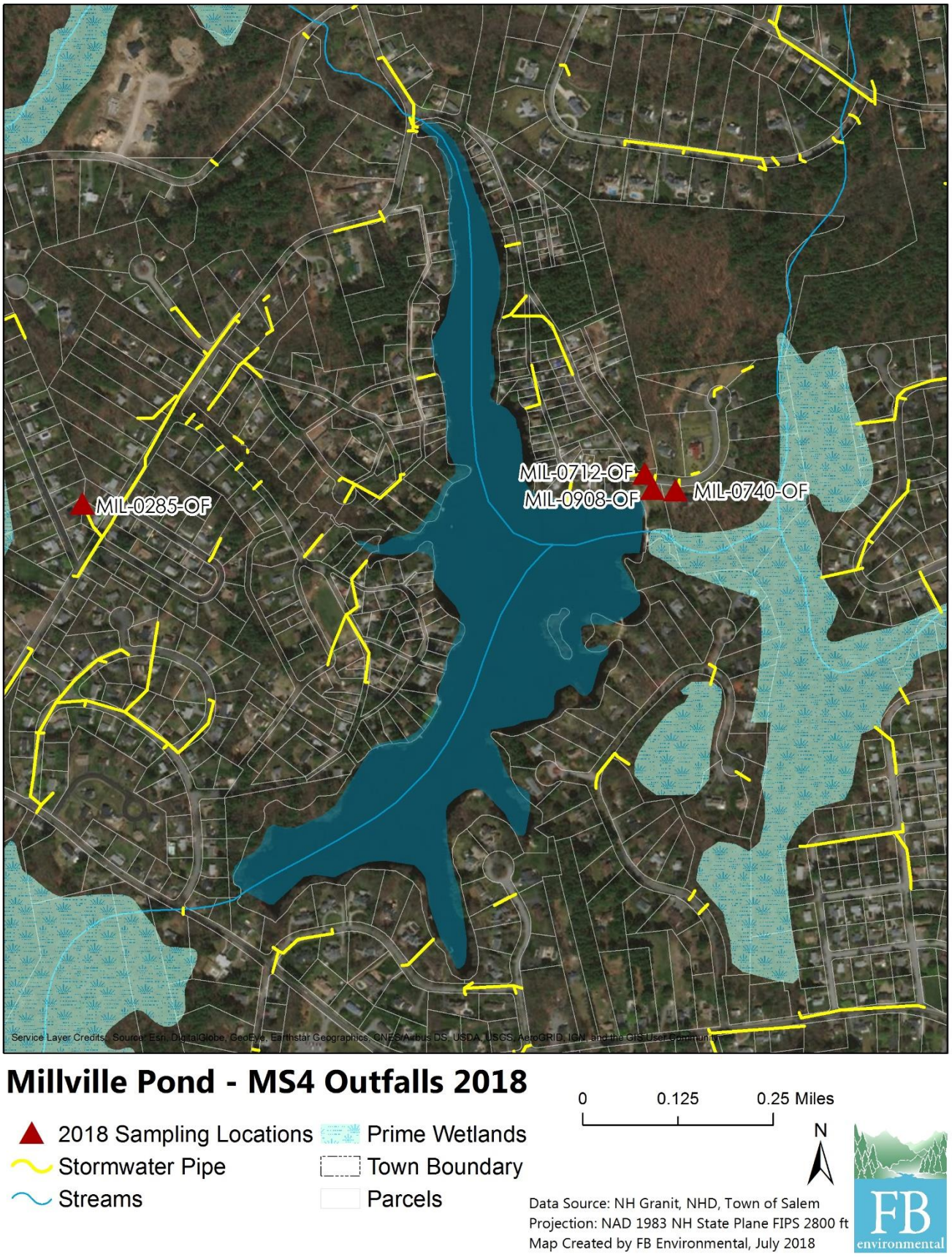

FIGURE 4. Stormwater outfall sampling locations for 2018 MS4 screening at Millville Pond.

TABLE 2. Outfall sampling parameters.

POND	Lab Analyses											Field Meters				Field Kits		
	E. coli	Surfactants	TP	Chl-a	BOD	Fe	Mn	Al	TSS	Alkalinity	pH	DO	Cond	Temp	Salinity	NH3	Chlorine	Chloride
Canobie	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Captain	X	X	X	X	X						X	X	X	X	X	X	X	
Millville	X	X										X	X	X	X	X	X	
Arlington	X	X										X	X	X	X	X	X	

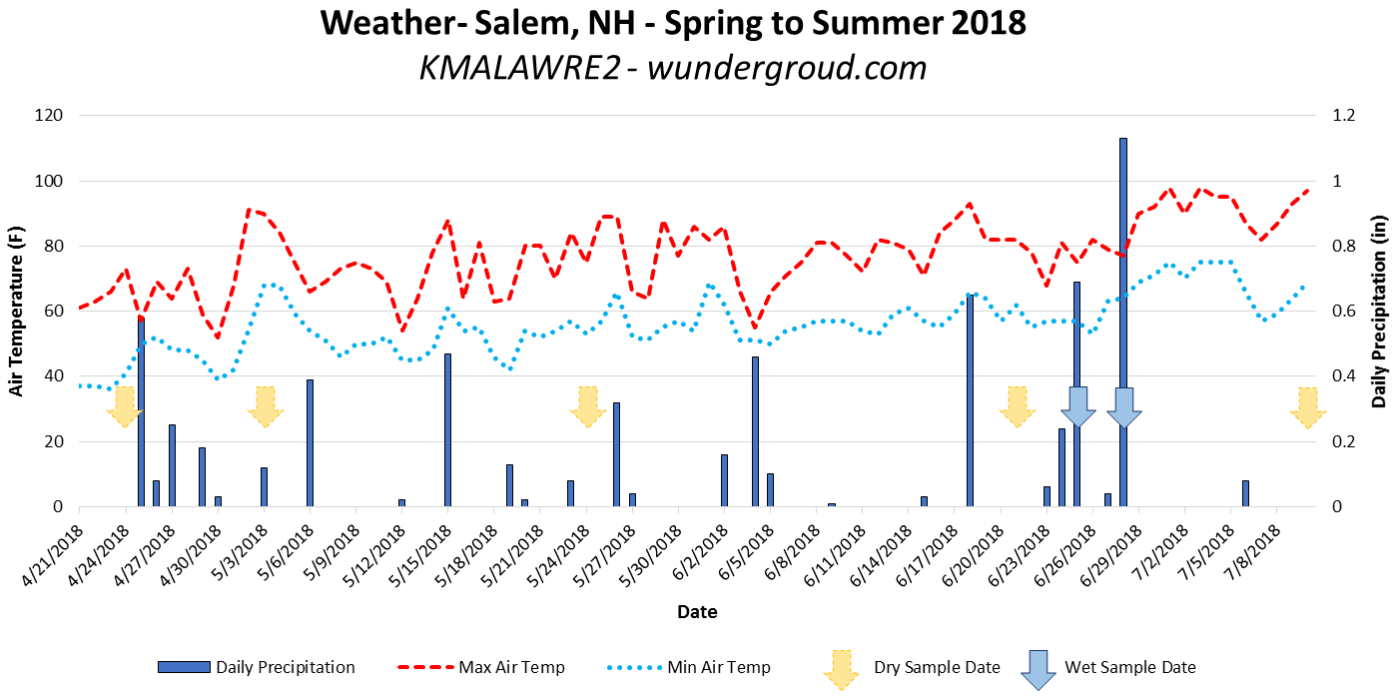

FIGURE 5. Spring to summer dry and wet weather sample dates with daily minimum and maximum temperatures and daily cumulative precipitation from weather station KMALAWRE2 (Weather Underground), located eight miles southeast of Salem, NH.

RESULTS

Fecal indicator bacteria (*E. coli*) measured at three outfalls during dry weather (ARL-0425-OF, ARL-0879-OF, and CAP-0243-OF) failed to meet the instantaneous limit for recreational waters with public beaches (<88 mpn/100mL), indicating possible fecal contamination. One outfall (ARL-0425-OF) showed total ammonia over the limit of 0.50 ppm and total chlorine above the detectable limit of 0.02 ppm, indicating possible human fecal contamination; however, surfactants at this site and all other sampled sites during dry weather were below the limit of 0.25 ppm. Per guidelines in the 2017 New Hampshire Small MS4 General Permit, both total ammonia and surfactants, along with either fecal indicator bacteria or total chlorine, must exceed criteria for an outfall to be considered likely contaminated by human sewage. Olfactory (smell) or visual evidence of sewage alone or in combination with water quality indicators can also flag an outfall for possible human sewage contamination. There were no reported sewage and/or sulfide smells detected at any of the outfalls during dry weather. Eleven of the twelve sampled outfalls exceeded the detectable limit for total chlorine during dry weather, suggesting a possible greywater source. Three outfalls (CAP-0227-OF, CAP-0228-OF, and CAP-0242-OF) were also observed to have soapy bubbles, further indicating greywater sources to these locations. Four outfalls (ARL-0428-OF, ARL-0878-OF, ARL-0879-OF, and CAP-0229-OF) were elevated above recommended levels for specific conductivity and salinity, suggesting that these outfalls were likely impacted by road salt runoff. A petroleum oil sheen was seen at one outfall (CAP-0802-OF), indicating automotive pollution from nearby paved areas. A dead/decomposing animal-like smell was detected near ARL-0425-OF and its nearest upstream catch basin; decaying matter from animals can be the cause of elevated ammonia and *E. coli*. Low dissolved oxygen levels are likely due to slow-moving or nearly stagnant flow sampled at most sites during dry weather. Additional pollutants of concern that were measured were within acceptable limits except for elevated total phosphorus at CAP-0242-OF, which may be from residential lawn fertilizers.

Fecal indicator bacteria (*E. coli*) measured at seven of the eight outfalls during wet weather failed to meet the instantaneous limit for recreational waters with public beaches (<88 mpn/100mL); only one site (CAN-0272-OF) had ammonia at the reporting limit but did not have elevated surfactants. Another site (CAN-0584-OF) had elevated surfactants, but ammonia was below the limit. Ammonia and/or surfactants were not elevated at any other sites during wet weather sampling. Total chlorine was elevated at all sites except two (ARL-0425-OF and CAN-0318-OF) and was especially elevated at CAN-0584-OF and MIL-0285-OF, which along with elevated surfactants at CAN-0584-OF indicates a likely greywater connection. Conductivity and salinity were also elevated at CAP-0802-OF, suggesting contamination from road salts or water softeners in greywater. Additional pollutants of concern that were measured were within acceptable limits except for elevated total phosphorus at three sites (CAN-0272-OF, CAN-0318-OF, and CAP-0243-OF) and elevated total aluminum at two sites (CAN-0318-OF and CAN-0584-OF).

CONCLUSION

Results from the dry and wet weather screening showed the following possible sources of contamination to the 26 monitored outfalls (bolded outfalls had especially elevated indicator levels for each category):

- Greywater – **ARL-0425-OF**, ARL-0428-OF, ARL-0879-OF, ARL-0971-OF, CAN-0272-OF, **CAN-0584-OF**, **CAP-0227-OF**, **CAP-0228-OF**, CAP-0229-OF, **CAP-0242-OF**, CAP-0243-OF, CAP-0802-OF, **MIL-0285-OF**, MIL-0712-OF
- Nutrient enrichment (possibly from fertilizers) – CAN-0272-OF, **CAN-0318-OF**, CAP-0242-OF, CAP-0243-OF
- Fecal matter (likely not human) – **ARL-0425-OF**, **CAN-0272-OF**, **CAN-0318-OF**, CAN-0584-OF, ARL-0879-OF, CAP-0243-OF, **MIL-0285-OF**, MIL-0712-OF
- Road salt – ARL-0428-OF, **ARL-0878-OF**, **ARL-0879-OF**, CAP-0242-OF, CAP-0802-OF

No outfalls showed indications of human sewage contamination. ARL-0425-OF and ARL-0879-OF were prioritized for 2018 follow-up catchment investigations. Other outfalls should be investigated only after outfalls with suspected human

sewage contamination are investigated. Arlington Pond outfalls should be screened in fall following drawdown when submerged outfalls are exposed.

TABLE 3. Summary of MS4 water quality measurements during dry weather screening. Bold, italicized text indicates exceedance of (failure to meet) criteria for water quality parameters.

Site ID	Temp (°C)	DO (%)	DO (ppm)	Salinity (ppt)	Spec Cond (µS/cm)	Total Ammonia (ppm)	Total Chlorine (ppm)
Thresholds	<28.3	>75.0	>5.0	<0.5	<835	<0.50	<0.02
ARL-0425-OF	8.2	***53.4***	5.99	***0.5***	641	***1.00***	***0.42***
ARL-0428-OF	8.3	***74.7***	7.05	***0.7***	***964***	0.25	***0.08***
ARL-0878-OF	13.0	***20.5***	***2.14***	***0.8***	***1196***	0.25	0.00
ARL-0879-OF	12.5	***16.8***	***1.29***	***1.7***	***1694***	0.00	***0.17***
ARL-0971-OF	15.3	***17.0***	***1.69***	0.1	235	0.00	***0.05***
CAN-0272-OF	13.2	***17.7***	***1.85***	***0.5***	745	0.25	***0.13***
CAP-0227-OF	12.7	88.4	9.19	0.4	574	0.25	***0.15***
CAP-0228-OF	14.1	***25.5***	***2.64***	0.2	320	0.25	***0.11***
CAP-0229-OF	14.1	94.5	9.77	0.1	113	0.25	***0.13***
CAP-0242-OF	10.4	81.5	8.99	***0.5***	***937***	0.25	***0.07***
CAP-0243-OF	14.4	***1.2***	***0.12***	0.4	763	0.25	***0.08***
CAP-0802-OF	12.1	***56.1***	5.97	0.4	591	0.25	***0.06***

Site ID	*E. coli* (mpn/100mL)	Surfactants (ppm)	Total Phosphorus (ppb)	BOD (ppm)	Chl-a (ppb)	pH
Thresholds	<88	<0.25	<50	--	<15	6.5-8.0
ARL-0425-OF	***2420***	<0.10				
ARL-0428-OF	16	0.20				
ARL-0878-OF	22	0.20				
ARL-0879-OF	***548***	0.10				
ARL-0971-OF	36	<0.10				
CAN-0272-OF	<1	0.10	20	<5	<1.5	6.9
CAP-0227-OF	<1	<0.10	20	<5	<1.7	7.1
CAP-0228-OF	26	0.20	10	<5	<2.7	6.9
CAP-0229-OF	17	<0.10	20	<5	<1.5	7.3
CAP-0242-OF	20	<0.10	***70***	<5	<1.5	7.0
CAP-0243-OF	***461***	0.10	50	<5	<3.6	6.6
CAP-0802-OF	<1	0.10	20	<5	<1.5	6.9

Site ID	Total Chloride (ppm)	TSS (ppm)	Turbidity (NTU)	Iron (ppm)	Manganese (ppm)	Aluminum (ppm)
Thresholds	<230	<80	1.0	<1.0	--	<0.087
CAN-0272-OF	139	<2.8	<1.0	<0.05	0.08	<0.05

TABLE 4. Summary of MS4 water quality measurements during wet weather screening. Bold, italicized text indicates exceedance of (failure to meet) criteria for water quality parameters.

Site ID	Temp (°C)	DO (%)	DO (ppm)	Salinity (ppt)	Spec Cond (µS/cm)	Total Ammonia (ppm)	Total Chlorine (ppm)
Thresholds	<28.3	>75.0	>5.0	<0.5	<835	<0.50	<0.02
ARL-0425-OF	18.9	***60.0***	5.50	0.2	477	0.25	0.00
CAN-0272-OF	16.6	***9.2***	***0.74***	0.4	807	***0.50***	***0.15***
CAN-0318-OF	20.7	93.0	8.30	0.0	34	0.25	0.01
CAN-0584-OF	21.5	92.0	8.00	0.0	14	0.00	***0.43***
CAP-0243-OF	16.6	***33.2***	***2.88***	0.1	107	0.00	***0.05***
CAP-0802-OF	17.2	***62.1***	5.93	***0.5***	***939***	0.00	***0.10***
MIL-0285-OF	20.2	83.0	7.50	0.1	249	0.25	***0.48***
MIL-0712-OF	20.0	***49.0***	***4.40***	0.1	219	0.00	***0.25***

Site ID	*E. coli* (mpn/100mL)	Surfactants (ppm)	Total Phosphorus (ppb)	BOD (ppm)	Chl-a (ppb)	pH
Thresholds	<88	<0.25	<50	--	<15	6.5-8.0
ARL-0425-OF	***>2420***	<0.1				
CAN-0272-OF	***613***	0.2	***70***	<5	<2.2	6.8
CAN-0318-OF	***>2420***	0.2	***130***	10	<3.6	7.3
CAN-0584-OF	***613***	***0.4***	50	<5	<1.8	6.9
CAP-0243-OF	***980***	<0.1	***90***	6	<3.6	6.9
CAP-0802-OF	19	0.1	30	<5	<3.1	7.0
MIL-0285-OF	***1733***	0.2				
MIL-0712-OF	***326***	0.1				

Site ID	Total Chloride (ppm)	TSS (ppm)	Turbidity (NTU)	Iron (ppm)	Manganese (ppm)	Aluminum (ppm)	Alkalin. (ppm)
Thresholds	<230	<80	1.0	<1.0	--	<0.087	>20
CAN-0272-OF	126	<2.5		0.2	0.88	<0.050	140
CAN-0318-OF	<32	13		0.4	0.02	***0.500***	***10***
CAN-0584-OF	<32	<5		0.1	<0.01	***0.100***	***<5***

ATTACHMENT 1: Equipment and methods used for sample parameters.

Parameter	Units	General Method	Equipment or Method
E. coli bacteria	mpn (most probable number)	Absolute Resource Associates	Standard Method 9223 B
Surfactants	ppm	Absolute Resource Associates	MBAS-5540
pH		Absolute Resource Associates	121, 4500H+-B
Total Phosphorus	ppb	Absolute Resource Associates	121, 4500P-E
Biological Oxygen Demand (BOD)	ppm	Absolute Resource Associates	121, 5210B
Chlorophyll-a (Chl-a)	ppb	Absolute Resource Associates	121, 10200H
Iron	ppm	Absolute Resource Associates	SW3005A6020A
Manganese	ppm	Absolute Resource Associates	SW3005A6020A
Aluminum	ppm	Absolute Resource Associates	SW3005A6020A
Total suspended solids	ppm	Absolute Resource Associates	SM2540D
Alkalinity, Total (as CaCO3)	ppm	Absolute Resource Associates	SM2320B
Temperature	°C	Meter	YSI 85 / YSI ProODO
Salinity	ppt	Meter	YSI 85 / YSI 30
Specific Conductivity	µS/cm	Meter	YSI 85 / YSI 30
Dissolved Oxygen	%, ppm	Meter	YSI 85 / YSI ProODO
Total Ammonia	ppm	Field Kit	HACH Ammonia Test Strips
Total Chlorine	ppm	Field Kit	HACH Pocket Colorimeter II
Total Chloride	ppm	Field Kit	HACH Chloride Test Strips