



# TECHNICAL | MEMORANDUM



**TO:** Dan Hudson, Director of Engineering, Town of Salem  
**FROM:** Laura Diemer & Jacqueline Boudreau, FB Environmental Associates  
**SUBJECT:** **2017 MS4 Outfall Monitoring**  
**DATE:** July 31, 2017  
**CC:** James Danis, Town of Salem; Forrest Bell, FB Environmental Associates

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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 the designated uses of aquatic life and primary and secondary contact recreation due to elevated pollutants like fecal indicator bacteria. Elevated levels of fecal indicator bacteria 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 2017 MS4 outfall monitoring results for select stormwater outfalls to Canobie Lake and Arlington Pond.**

## METHODOLOGY

In spring (May-June 2017), FBE staff conducted dry weather screening at 32 outfalls to Canobie Lake and Arlington Pond, following procedures described in the 2017 New Hampshire Small MS4 General Permit (Table 1; Figures 1, 2). 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. Ten of the 32 outfalls to Canobie Lake and Arlington Pond were also flagged by W&S as having at least one System Vulnerability Factor (SVF) – in this case, one or more septic system failures in the outfall drainage area; the permit requires all outfalls with SVFs to be sampled during a wet weather event that produces discharge.

Dry weather screening of the 32 outfalls to Canobie Lake and Arlington Pond was conducted on 5/10/2017, 5/11/2017, 5/17/2017, 5/18/2017, 5/24/2017, 6/14/2017, 6/15/2017, and 6/23/2017. Nine outfalls (ARL-0426-OF, ARL-0427-OF, ARL-0434-OF, ARL-0866-OF, ARL-0877-OF, CAN-0247-OF, CAN-0248-OF, CAN-0268-OF, and CAN-0270-OF) had flow and were sampled during the initial visit on 5/10/2017, 5/11/2017, or 5/18/2017; these outfalls were also sampled for total chloride on 5/24/2017, except for ARL-0866-OF, which was not flowing. Two outfalls (ARL-0626-OF and ARL-0854-OF) were not flowing, but showed evidence of prior flow during the initial visit on 5/18/2017 and were revisited on 5/24/2017 (when both had no flow, but evidence of prior flow). One outfall (ARL-0785-OF) was not flowing and showed no evidence of prior flow during the initial visit on 5/18/2017 (no follow-up visit necessary). Eleven outfalls (ARL-0163-OF, ARL-0424-OF, ARL-0429-OF, ARL-0430-OF, ARL-0432-OF, ARL-0433-OF, ARL-0652-OF, ARL-0685-OF, ARL-0699-OF, ARL-0876-OF, and CAN-0267-OF) were unable to be located during the initial visit on 5/11/2017, 5/17/2017, or 5/18/2017. Five outfalls (ARL-0698-OF, CAN-0292-OF, CAN-0293-OF, CAN-0316-OF, and CAN-0317-OF) were inaccessible during the initial visit on 5/11/2017 or 5/18/2017 because of no trespassing signs and high security warnings. Three outfalls

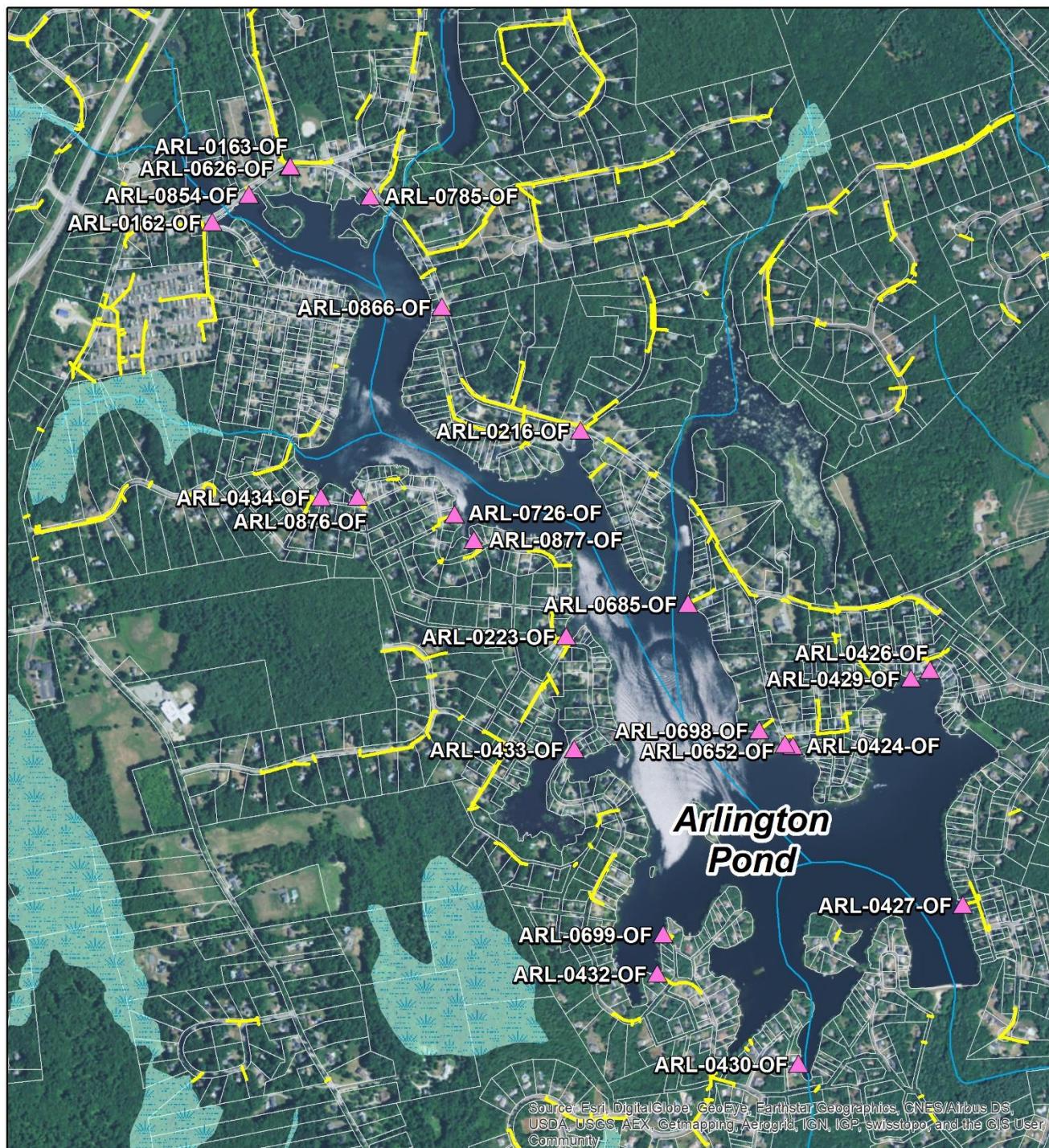
(ARL-0162-OF, ARL-0216-OF, and ARL-0726-OF) were submerged and field staff were unable to open the grate to the nearest upstream catch basin during the initial visit on 5/18/2017.

FBE staff was assisted in the field by James Danis (Town of Salem) to locate the inaccessible outfalls and/or remove catch basin grates on 6/14/2017 and 6/15/2017. One outfall (CAN-0293-OF) was located and sampled. One outfall (ARL-0430-OF) was located and found not flowing, but had evidence of prior flow and was revisited on 6/23/2017 (when found with no flow, but evidence of prior flow). One outfall (ARL-0429-OF) was located and found not flowing with no evidence of prior flow (no follow-up visit necessary). Three outfalls (ARL-0876-OF, CAN-0316-OF, and CAN-0317-OF) were found submerged and the nearest upstream catch basin had flow and was sampled. Note that CAN-0317-OF was found flooded during dry weather screening on 6/14/2017 due to a nearby home releasing its water collection system, but was not flooded during wet weather screening on 6/5/2017 and was sampled directly. Ten outfalls (ARL-0162-OF, ARL-0216-OF, ARL-0223-OF, ARL-0432-OF, ARL-0652-OF, ARL-0685-OF, ARL-0698-OF, ARL-0699-OF, ARL-0726-OF, and CAN-0292-OF) were found submerged and the nearest upstream catch basin had no flow; only one outfall (CAN-0292-OF) was revisited on 6/23/2017 (was found submerged with no flow at catch basin) because the Arlington Pond submerged outfalls will likely be exposed during drawdown in the fall, which would be a more appropriate time to sample those outfalls. Two outfalls (ARL-0432-OF and CAN-0267-OF) were found submerged without upstream catch basins to check. One outfall (ARL-0163-OF) was found submerged and the nearest upstream catch basin was welded shut, making it inaccessible for sampling. One outfall (ARL-0433-OF) was confirmed by the Town of Salem as non-existent. One outfall (ARL-0877-OF) was sampled again on 6/15/2017.

Wet weather screening of 9 of the 10 outfalls to Canobie Lake and Arlington Pond with SVFs was conducted on 5/26/2017 and 6/5/2017. FBE staff was assisted in the field by James Danis (Town of Salem) to locate the inaccessible outfalls and/or remove catch basin grates on 6/5/2017. Four outfalls (ARL-0426-OF, ARL-0427-OF, ARL-0434-OF, and CAN-0317-OF) had flow and were sampled. Three outfalls (ARL-0216-OF, ARL-0685-OF, and ARL-0698-OF) were not flowing, but showed evidence of prior flow (no follow-up visit was conducted because it is not specified as a requirement in the permit, but should be considered for incorporation to the Salem-specific sampling plan). One outfall (CAN-0316-OF) was submerged and the nearest upstream catch basin had flow and was sampled. One outfall (ARL-0652-OF) was submerged and the nearest upstream catch basin had no flow.

All dry weather screening days were preceded by 0" of rainfall within 24 hours; wet weather screening on 5/26/2017 was preceded by 1.17" of rainfall within 24 hours; and wet weather screening on 6/5/2017 was preceded by 0.32" of rainfall within 24 hours (Figure 3).

When there was adequate flow to sample, 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*), surfactants, total chloride, and total phosphorus (see Attachment 1 for equipment and specific methodology).



## Arlington Pond - MS4 Outfalls 2017

- ▲ Outfall
- Prime Wetlands
- ~~~~ Stormwater Pipe
- Town Boundary
- ~~~~ Streams
- Parcels

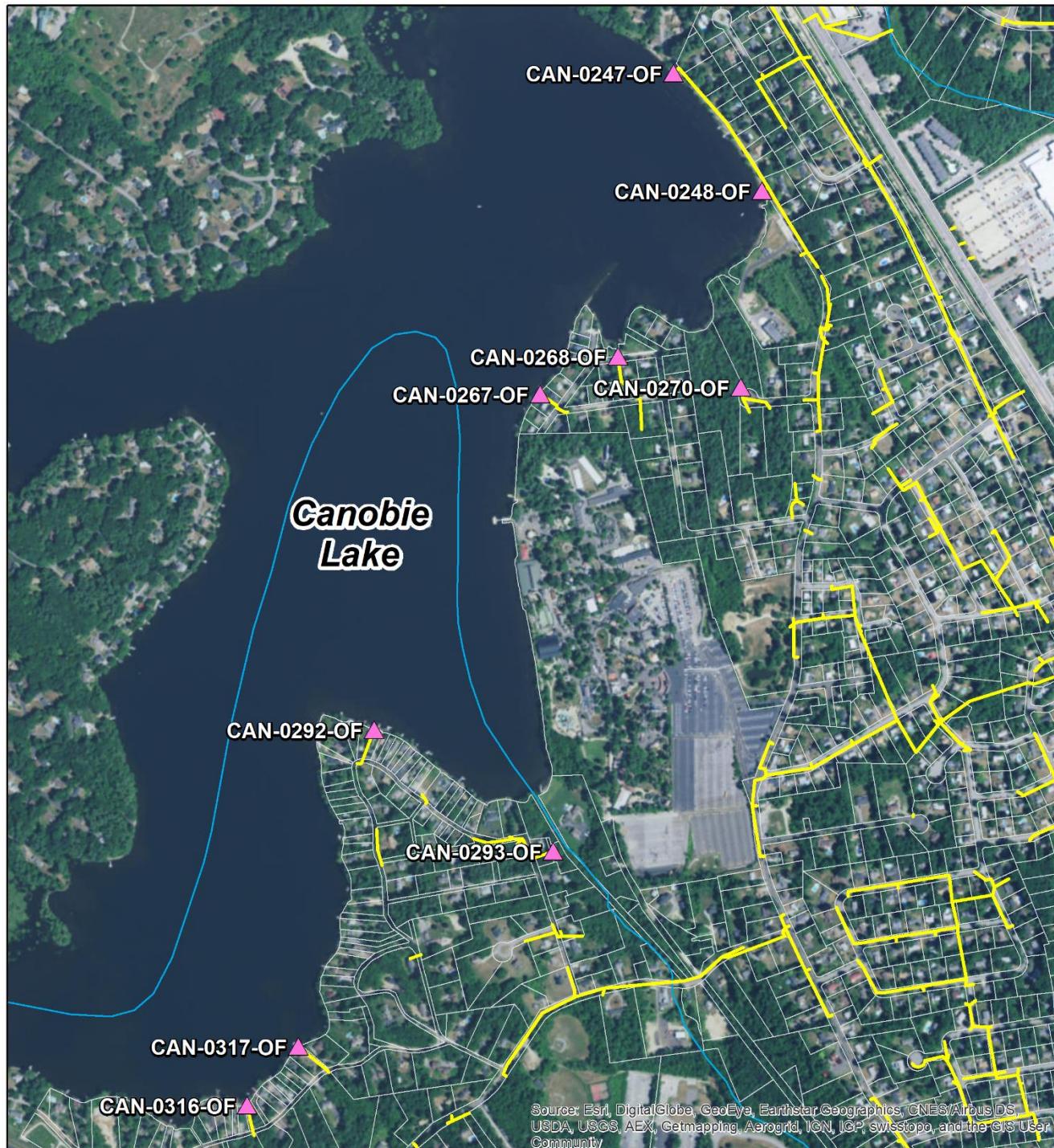
0 0.125 0.25 Miles



Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental, July 2017



**FIGURE 1.** Stormwater outfall sampling locations for 2017 MS4 screening at Arlington Pond.



## Canobie Lake - MS4 Outfalls 2017

- ▲ Outfall
- Prime Wetlands
- ~~~~ Stormwater Pipe
- Stream
- Town Boundary
- Parcels

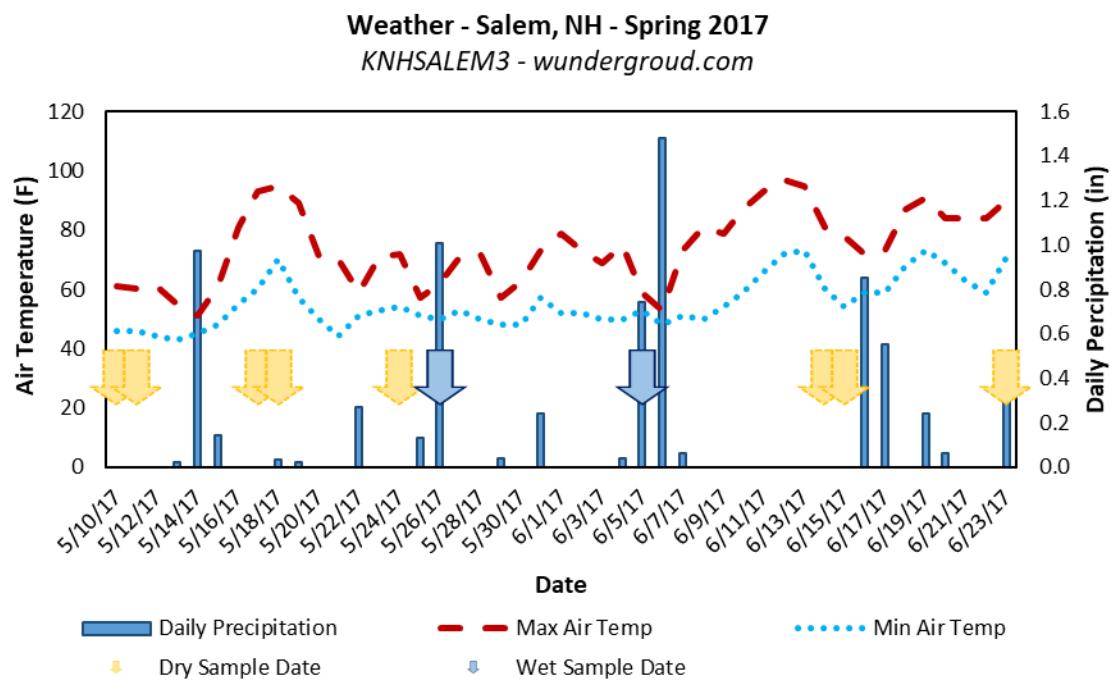
0 0.125 0.25 Miles  
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Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental, July 2017



FIGURE 2. Stormwater outfall sampling locations for 2017 MS4 screening at Canobie Lake.

**TABLE 1.** Outfall sampling dates for spring 2017. 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 “\” 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. Samples on 5/24/2017 were collected for total chloride only.

| Site        | 5/10/17<br>(dry) | 5/11/17<br>(dry) | 5/17/17<br>(dry) | 5/18/17<br>(dry) | 5/24/17<br>(dry) | 5/26/17<br>(wet) | 6/5/17<br>(wet) | 6/14/17<br>(dry) | 6/15/17<br>(dry) | 6/23/17<br>(dry) |
|-------------|------------------|------------------|------------------|------------------|------------------|------------------|-----------------|------------------|------------------|------------------|
| CAN-0247-OF | ✓                |                  |                  |                  | ✓                |                  |                 |                  |                  |                  |
| CAN-0248-OF | ✓                |                  |                  |                  | ✓                |                  |                 |                  |                  |                  |
| CAN-0267-OF |                  | \                |                  |                  |                  |                  |                 | cb ne            |                  |                  |
| CAN-0268-OF | ✓                |                  |                  |                  | ✓                |                  |                 |                  |                  |                  |
| CAN-0270-OF | ✓                |                  |                  |                  | ✓                |                  |                 |                  |                  |                  |
| CAN-0292-OF |                  | \                |                  |                  |                  |                  |                 | cb **            |                  | cb X             |
| CAN-0293-OF |                  | \                |                  |                  |                  |                  |                 |                  | ✓                |                  |
| CAN-0316-OF |                  | \                |                  |                  |                  |                  | cb ✓            | cb ✓             |                  |                  |
| CAN-0317-OF |                  | \                |                  |                  |                  |                  |                 | ✓                | cb✓              |                  |
| ARL-0162-OF |                  |                  |                  | \                |                  |                  |                 |                  | cb **            |                  |
| ARL-0163-OF |                  |                  |                  | \                |                  |                  |                 |                  | cb \             |                  |
| ARL-0216-OF |                  |                  |                  | \                |                  |                  | cb **           |                  | cb **            |                  |
| ARL-0223-OF |                  |                  |                  |                  |                  |                  |                 | cb **            |                  |                  |
| ARL-0424-OF |                  |                  |                  | \                |                  |                  |                 |                  |                  |                  |
| ARL-0426-OF |                  |                  |                  | ✓                | ✓                | ✓                |                 |                  |                  |                  |
| ARL-0427-OF | ✓                |                  |                  |                  | ✓                | ✓                |                 |                  |                  |                  |
| ARL-0429-OF |                  |                  |                  | \                |                  |                  |                 |                  | X                |                  |
| ARL-0430-OF |                  | \                |                  |                  |                  |                  |                 | **               |                  | X                |
| ARL-0432-OF |                  | \                |                  |                  |                  |                  |                 | cb **            |                  |                  |
| ARL-0433-OF |                  |                  |                  | \                |                  |                  |                 |                  |                  | ne               |
| ARL-0434-OF |                  |                  |                  | ✓                | ✓                | ✓                |                 |                  |                  |                  |
| ARL-0626-OF |                  |                  |                  | **               | X                |                  |                 |                  |                  |                  |
| ARL-0652-OF |                  |                  |                  | \                |                  |                  | cb \            |                  | cb X             |                  |
| ARL-0685-OF |                  |                  |                  | \                |                  |                  | cb X            |                  | cb X             |                  |
| ARL-0698-OF |                  |                  |                  | \                |                  |                  | cb X            |                  | cb X             |                  |
| ARL-0699-OF |                  | \                |                  |                  |                  |                  |                 | cb X             |                  |                  |
| ARL-0726-OF |                  |                  |                  | \                |                  |                  |                 | cb **            |                  |                  |
| ARL-0785-OF |                  |                  |                  | X                |                  |                  |                 |                  |                  |                  |
| ARL-0854-OF |                  |                  |                  | **               | X                |                  |                 |                  |                  |                  |
| ARL-0866-OF |                  |                  |                  | ✓                | X                |                  |                 |                  |                  |                  |
| ARL-0876-OF |                  |                  | \                |                  |                  |                  |                 | cb ✓             |                  |                  |
| ARL-0877-OF |                  |                  |                  | ✓                | ✓                |                  |                 |                  | ✓                |                  |



**FIGURE 3.** Spring dry and wet weather sample dates with daily minimum and maximum temperatures and daily cumulative precipitation from weather station KNHSALEM3 (Weather Underground), located east of Millville Pond.

## RESULTS

Eleven outfalls (ARL-0426-OF, ARL-0427-OF, ARL-0434-OF, ARL-0866-OF, ARL-0876-OF, ARL-0877-OF, CAN-0247-OF, CAN-0248-OF, CAN-0268-OF, CAN-0270-OF, and CAN-0293-OF) and nearest upstream catch basins to two submerged outfalls (CAN-0316-CB and CAN-0317-CB) had enough flow to be sampled during dry weather screening (Table 2). Fecal indicator bacteria (*E. coli*) measured at or to three outfalls (ARL-0434-OF, CAN-0316-CB, and CAN-0317-CB) failed to meet the instantaneous limit for recreational waters with public beaches (<88 mpn/100mL), indicating possible fecal contamination. One catch basin to an outfall (CAN-0317-CB) showed total ammonia at 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 were far 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. In this case, a sewage and sulfide smell was easily detected at CAN-0317-CB where the water collected was visibly brown and slightly cloudy and dissolved oxygen was extremely low (2.4 ppm)<sup>1</sup>, all of which suggests possible human sewage contamination. All thirteen sampled outfalls or nearest upstream catch basins to submerged outfalls exceeded the detectable limit for total chlorine, except for three outfalls (ARL-0427-OF, CAN-0248-OF, and CAN-0270-OF), suggesting a possible greywater source. Two outfalls (ARL-0426-OF and

<sup>1</sup> Low dissolved oxygen can be the result of rapid decomposition of organic matter, such as from human waste.

ARL-0434-OF) exceeded the chronic exposure criterion for total chloride (<230 ppm) and were also elevated above recommended levels for specific conductivity and/or salinity, suggesting that these outfalls were likely impacted by road salt runoff. Specific conductivity and/or salinity (along with total chlorine) were also elevated above recommended levels at three outfalls (ARL-0876-OF, CAN-0247-OF, and CAN-0293-OF), suggesting a possible greywater source (though total chloride was not measured at ARL-0876-OF and CAN-0293-OF, so impact of road salt runoff is indeterminant at those outfalls). Three outfalls (ARL-0426-OF, ARL-0427-OF, and ARL-0293-OF) were also observed to have soapy bubbles, further indicating greywater sources to these locations. One nearest upstream catch basin to a submerged outfall (ARL-0652-CB) was not sampled due to stagnant flow, but a sewage-like smell was easily detected; decaying organic matter from algae and detritus can also be misconstrued with sewage odors, but the drainage should be flagged for further investigation.

Four outfalls (ARL-0426-OF, ARL-0427-OF, ARL-0434-OF, and CAN-0317-OF) and nearest upstream catch basin to one submerged outfall (CAN-0316-CB) had enough flow to be sampled during wet weather screening (Table 3). Fecal indicator bacteria (*E. coli*) measured at or to all five outfalls failed to meet the instantaneous limit for recreational waters with public beaches (<88 mpn/100mL), indicating possible fecal contamination; however, both total ammonia and surfactants were below the limit of 0.50 ppm and 0.25 ppm, respectively, at all sites, suggesting that human sewage was not likely impacting these sites. Total chlorine was elevated at all sites, particularly CAN-0316-CB, which also exhibited low dissolved oxygen, suggesting a greywater source to all sites. One outfall (ARL-0426-OF) again exceeded the chronic exposure criterion for total chloride (<230 ppm), suggesting that this outfall is likely impacted by road salt runoff.

**TABLE 2.** 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           | Flow (mL/s)                | Temp (°C)                   | DO (%)                     | DO (ppm)                 | Salinity (ppt)              | Spec Cond (µS/cm)             |
|-------------------|----------------------------|-----------------------------|----------------------------|--------------------------|-----------------------------|-------------------------------|
| <b>Thresholds</b> | --                         | >28.3                       | ≥75.0                      | ≥5.0                     | >0.5                        | >835                          |
| ARL-0426-OF       |                            | 18.8                        |                            |                          | 0.5                         | <b>968</b>                    |
| ARL-0427-OF       |                            | 12.5                        |                            |                          | 0.3                         | 253                           |
| ARL-0434-OF       |                            | 13.2                        |                            |                          | <b>0.6</b>                  | 829                           |
| ARL-0866-OF       |                            | 15.9                        |                            |                          | 0.1                         | 246                           |
| ARL-0876-CB       | 187                        | 13.0                        | 81.2                       | 7.9                      | 0.5                         | <b>841</b>                    |
| ARL-0877-OF       |                            | 13.8                        |                            |                          | 0.1                         | 168                           |
| ARL-0877-OF       | 43                         | 14.8                        | 90.3                       | 9.1                      | 0.1                         | 200                           |
| CAN-0247-OF       |                            | 12.4                        |                            |                          | <b>0.9</b>                  | 110                           |
| CAN-0248-OF       |                            | 13.4                        |                            |                          | 0.4                         | 328                           |
| CAN-0268-OF       |                            | 11.5                        | 93.9                       | 9.8                      | 0.2                         | 174                           |
| CAN-0270-OF       |                            | 13.8                        | <b>66.0</b>                | 6.8                      | 0.3                         | 434                           |
| CAN-0293-OF       | 16                         | 15.4                        | 94.0                       | 9.3                      | <b>0.9</b>                  | <b>1,366</b>                  |
| CAN-0316-CB       |                            | 18.6                        | <b>64.4</b>                | 5.8                      | 0.1                         | 136                           |
| CAN-0317-CB       |                            | 20.7                        | <b>27.2</b>                | <b>2.4</b>               | 0.4                         | 783                           |
| <b>Site ID</b>    | <b>Total Ammonia (ppm)</b> | <b>Total Chlorine (ppm)</b> | <b>E. coli (mpn/100mL)</b> | <b>Surfactants (ppm)</b> | <b>Total Chloride (ppm)</b> | <b>Total Phosphorus (ppb)</b> |
| <b>Thresholds</b> | ≥0.50                      | ≥0.02                       | ≥88                        | ≥0.25                    | ≥230                        | ≥50                           |
| ARL-0426-OF       | 0.25                       | <b>0.14</b>                 | 24                         | 0.07                     | <b>360</b>                  |                               |
| ARL-0427-OF       | 0.25                       | 0.01                        | 15                         | <0.05                    | 130                         |                               |
| ARL-0434-OF       | 0.25                       | <b>0.05</b>                 | <b>291</b>                 | <0.05                    | <b>300</b>                  |                               |
| ARL-0866-OF       | 0.25                       | <b>0.30</b>                 | 2                          | <0.05                    |                             |                               |
| ARL-0876-CB       | 0.00                       | <b>0.07</b>                 | <1                         | 0.03                     |                             |                               |
| ARL-0877-OF       | 0.25                       | <b>0.03</b>                 | 1                          | 0.05                     | 41                          |                               |
| ARL-0877-OF       | 0.00                       | <b>0.02</b>                 | 10                         | 0.02                     |                             |                               |
| CAN-0247-OF       | 0.25                       | <b>0.06</b>                 | 2                          | 0.07                     | 86                          |                               |
| CAN-0248-OF       | 0.25                       | 0.01                        | <1                         | <0.05                    | 140                         |                               |
| CAN-0268-OF       | 0.00                       | <b>0.02</b>                 | 20                         | <0.05                    | 120                         |                               |
| CAN-0270-OF       | 0.25                       | 0.00                        | <1                         | <0.05                    | 160                         |                               |
| CAN-0293-OF       | 0.25                       | <b>0.10</b>                 | 16                         | 0.05                     |                             |                               |
| CAN-0316-CB       | 0.25                       | <b>0.12</b>                 | <b>194</b>                 | 0.06                     |                             |                               |
| CAN-0317-CB       | <b>0.50</b>                | <b>0.27</b>                 | <b>93</b>                  | 0.08                     |                             |                               |

**TABLE 3.** 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           | Flow (mL/s)         | Temp (°C)            | DO (%)                     | DO (ppm)          | Salinity (ppt)       | Spec Cond (µS/cm)      |
|-------------------|---------------------|----------------------|----------------------------|-------------------|----------------------|------------------------|
| <b>Thresholds</b> | --                  | >28.3                | ≥75.0                      | ≥5.0              | >0.5                 | >835                   |
| ARL-0426-OF       |                     | 12.0                 |                            |                   | 0.5                  | 755                    |
| ARL-0427-OF       |                     | 12.8                 |                            |                   | 0.1                  | 215                    |
| ARL-0434-OF       |                     | 11.3                 |                            |                   | 0.4                  | 531                    |
| CAN-0316-CB       |                     | 14.3                 | <b>48.6</b>                | <b>4.9</b>        | 0.3                  | 600                    |
| CAN-0317-OF       |                     | 12.9                 | 77.1                       | 8.0               | 0.2                  | 407                    |
| <hr/>             |                     |                      |                            |                   |                      |                        |
| Site ID           | Total Ammonia (ppm) | Total Chlorine (ppm) | <i>E. coli</i> (mpn/100mL) | Surfactants (ppm) | Total Chloride (ppm) | Total Phosphorus (ppb) |
| <b>Thresholds</b> | ≥0.50               | ≥0.02                | ≥88                        | ≥0.25             | ≥230                 | ≥50                    |
| ARL-0426-OF       | 0.25                | <b>0.04</b>          | <b>613</b>                 | 0.06              | <b>280</b>           |                        |
| ARL-0427-OF       | 0.25                | <b>0.11</b>          | <b>2,420</b>               | 0.08              | 52                   |                        |
| ARL-0434-OF       | 0.25                | <b>0.37</b>          | <b>649</b>                 | 0.09              | 160                  |                        |
| CAN-0316-CB       | 0.25                | <b>0.80</b>          | <b>150</b>                 | 0.07              | 140                  | 39                     |
| CAN-0317-OF       | 0.25                | <b>0.30</b>          | <b>122</b>                 | 0.05              | 37                   | 15                     |

## RECOMMENDATIONS FOR CATCHMENT INVESTIGATION

Based on these results, two outfalls (ARL-0652-OF and CAN-0317-OF) should be considered a priority for follow-up catchment investigations due to suspicions of human sewage contamination. All thirteen sampled outfalls or nearest upstream catch basins (except CAN-0248-OF and CAN-0270-OF) are likely impacted by greywater sources and two outfalls (ARL-0426-OF and ARL-0434-OF) are likely impacted by road salt runoff; these 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.

**ATTACHMENT 1:** Equipment and methods used for sample parameters.

| Parameter               | Units  | General Method    | Equipment or Method        |
|-------------------------|--|-------------------|----------------------------|
| <i>E. coli</i> bacteria | mpn (most probable number) of colonies/100mL | Nelson Analytical | Standard Method 9223 B     |
| Surfactants             | ppm  | Alpha Analytical  | MBAS-5540                  |
| Total Chloride          | ppm  | Alpha Analytical  | 121, 4500CL-E              |
| Total Phosphorus        | ppb  | Alpha Analytical  | 121, 4500P-E               |
| Temperature             | °C   | Meter             | YSI 30                     |
| Salinity                | ppt  | Meter             | YSI 30                     |
| Specific Conductivity   | µS/cm  | Meter             | YSI 30                     |
| Dissolved Oxygen        | %, ppm                                       | Meter             | YSI ProODO                 |
| Total Ammonia           | ppm  | Field Kit         | HACH Ammonia Test Strips   |
| Total Chlorine          | ppm  | Field Kit         | HACH Pocket Colorimeter II |



# TECHNICAL | MEMORANDUM



**TO:** Dan Hudson, Director of Engineering, Town of Salem  
**FROM:** Laura Diemer & Jacqueline Boudreau, FB Environmental Associates  
**SUBJECT:** [Task 1: Spring Outfall Investigation](#)  
**DATE:** July 11, 2017  
**CC:** James Danis, Town of Salem; Forrest Bell, FB Environmental Associates

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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 the designated uses of aquatic life and primary and secondary contact recreation due to elevated pollutants like fecal indicator bacteria. Elevated levels of fecal indicator bacteria 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.

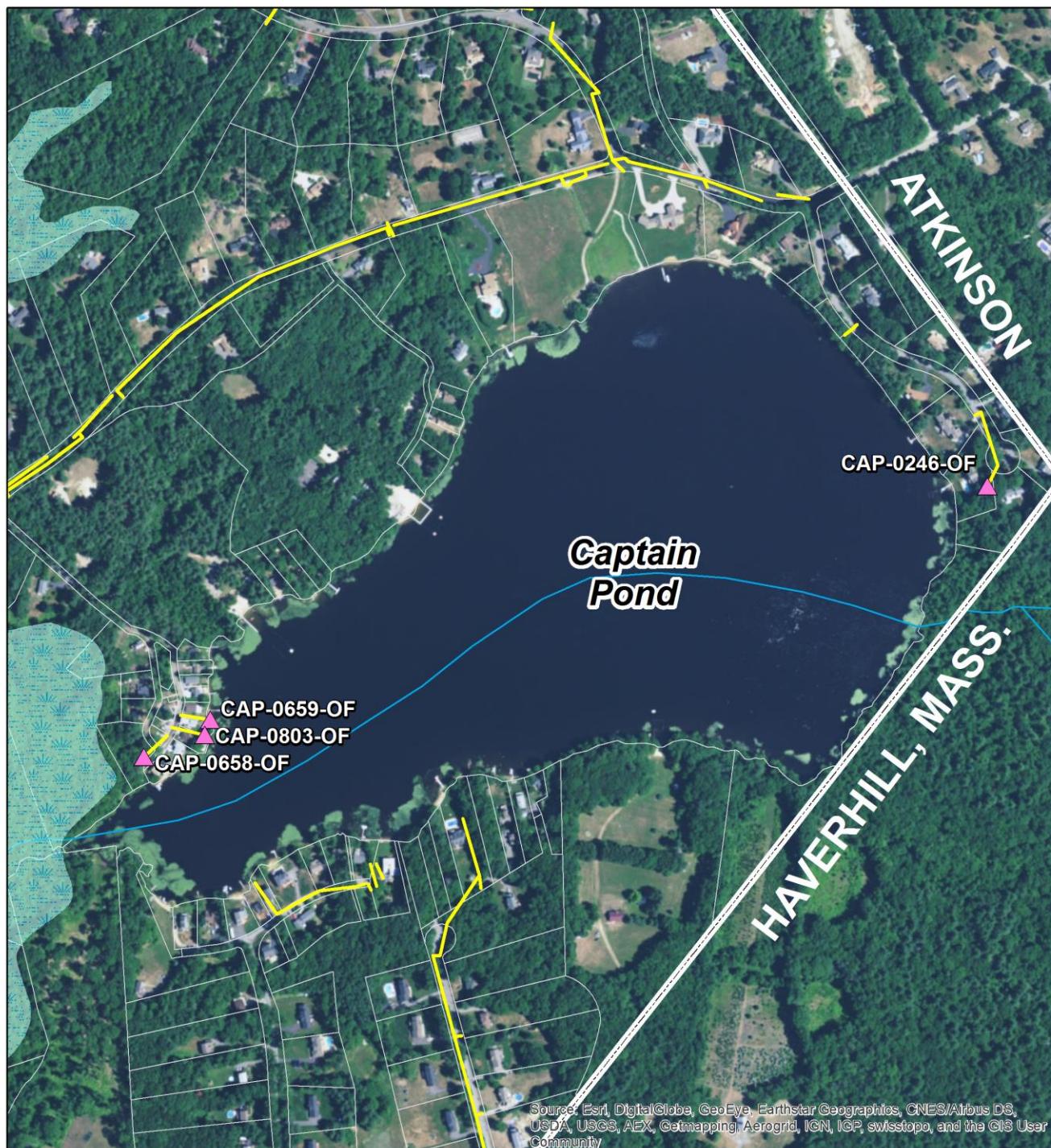
**This memo provides a brief review of Task 1: Spring Outfall Investigation results for select stormwater outfalls to Captain and Millville Ponds.**

## METHODOLOGY

In spring (May-June 2017), FBE staff conducted dry weather screening at six new outfalls to Captain and Millville Ponds, following procedures described in the 2017 New Hampshire Small MS4 General Permit (Table 1; Figures 1, 2). Preliminary stormwater infrastructure data provided by Weston and Sampson (W&S) showed several newly-identified outfalls to Captain and Millville Ponds; W&S and the Town of Salem selected six of the newly-identified outfalls for dry weather screening by FBE.

Outfalls (CAP-0246-OF, CAP-0658-OF, CAP-0659-OF, CAP-803-OF, MIL-0702-OF, and MIL-1007-OF) were visited during dry weather conditions on 5/11/2017. Three outfalls (CAP-0246-OF, CAP-0658-OF, and CAP-803-OF) were unable to be located or inaccessible; two outfalls (CAP-0659-OF and MIL-1007-OF) were not flowing, but showed evidence of prior flow and were revisited on 5/17/2017 (CAP-0659-OF was flowing and sampled; MIL-1007-OF was not flowing); and one outfall (MIL-0702-OF) was not flowing and showed no evidence of prior flow (no follow-up visit necessary). FBE staff was assisted in the field by James Danis (Town of Salem) to locate the three inaccessible outfalls on 6/14/2017; CAP-0246-OF was not flowing, but had evidence of prior flow and was revisited on 6/23/2017 (found not flowing); CAP-0658-OF was not flowing and showed no evidence of prior flow (no follow-up visit necessary); CAP-0803-OF was unable to be located by Town of Salem staff. All sample days were preceded by 0" of rainfall within 24 hours (Figure 3).

None of the six outfalls were flagged by W&S for a System Vulnerability Factor (SVF), but these outfalls may need wet weather screenings once the stormwater infrastructure data and ranking system are finalized for the Town.



## Captain Pond - Task 1 Outfalls 2017

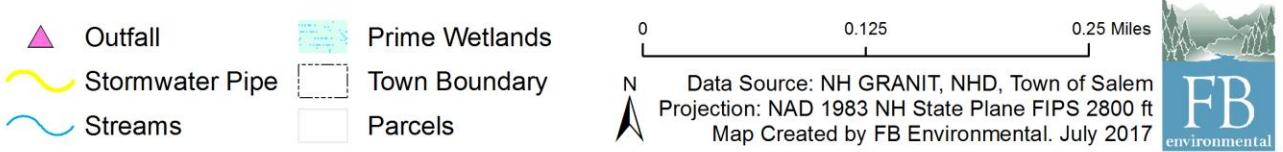


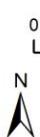
FIGURE 1. Stormwater outfall sampling locations for Task 1 2017 at Captain Pond.



## Millville Pond - Task 1 Outfalls 2017

- ▲ Outfall
- ~~~~ Stormwater Pipe
- ~~~~ Streams

- Prime Wetlands
- Town Boundary
- Parcels

0  
N

0.125

0.25 Miles

Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental. July 2017



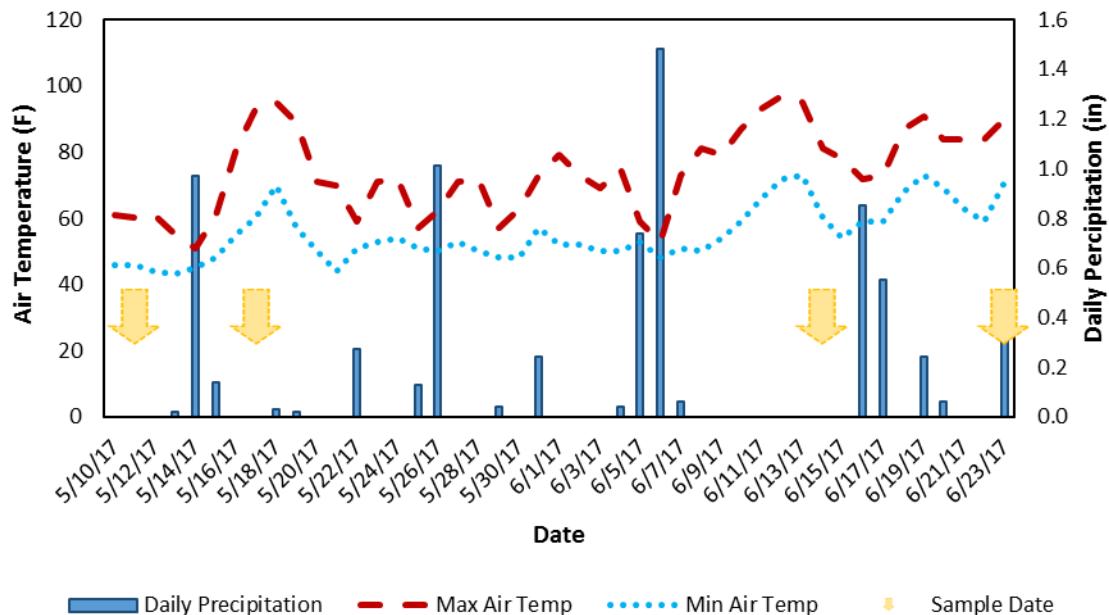
FIGURE 2. Stormwater outfall sampling locations for Task 1 2017 at Millville Pond.

When there was adequate flow to sample, FBE staff recorded temperature, salinity, and specific conductivity, completed field kits for total ammonia and total chlorine, and collected grab samples for bacterial analysis (*E. coli*) and surfactants (see Attachment 1 for equipment and specific methodology).

**TABLE 1.** Outfall sampling dates for spring 2017. 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 “＼” were unable to be located or were inaccessible during the initial visit. Sites marked “ne” no longer exist.

| Site        | Pond      | Sample Date      |                            |                  |                            |
|-------------|-----------|------------------|----------------------------|------------------|----------------------------|
|             |           | 5/11/17<br>(dry) | 5/17/17 (dry<br>follow-up) | 6/14/17<br>(dry) | 6/23/17 (dry<br>follow-up) |
| CAP-0246-OF | Captain   | \                |                            | **               | X                          |
| CAP-0658-OF | Captain   | \                |                            | X                |                            |
| CAP-0659-OF | Captain   | **               | ✓                          |                  |                            |
| CAP-0803-OF | Captain   | ne               |                            |                  |                            |
| MIL-0702-OF | Millville | X                |                            |                  |                            |
| MIL-1007-OF | Millville | **               | X                          |                  |                            |

**Weather- Salem, NH - Spring 2017**  
KNHSALEM3 - [wundergroud.com](http://wundergroud.com)



**FIGURE 3.** Spring dry weather sample dates with daily minimum and maximum temperatures and daily cumulative precipitation from weather station KNHSALEM3 (Weather Underground), located east of Millville Pond.

## RESULTS

Only one outfall (CAP-0659-OF) had enough flow to be sampled (Table 2). Fecal indicator bacteria (*E. coli*) measured at CAP-0659-OF was at the instantaneous limit for recreational waters with public beaches (88 mpn/100mL), indicating marginally-elevated bacteria concentrations. While total ammonia and surfactants were low, chlorine, salinity, and specific conductivity were high, suggesting a greywater source to the outfall.

**TABLE 2.** Summary of MS4 water quality measurements. Bold, italicized text indicates exceedance of (failure to meet) criteria for water quality parameters.

| Date      | Outfall ID  | Waterbody    | Temp (°C)       | Salinity (ppt) | Specific Conductivity (µS/cm) | Total Ammonia (ppm) | Total Chlorine (ppm) | <i>E. coli</i> (mpn/100mL) | Surfactants (ppm) |
|-----------|-------------|--------------|-----------------|----------------|-------------------------------|---------------------|----------------------|----------------------------|-------------------|
|           |             |              | <b>&gt;28.3</b> | <b>&gt;0.5</b> | <b>&gt;835<sup>1</sup></b>    | <b>≥0.50</b>        | <b>≥0.02</b>         | <b>≥88</b>                 | <b>≥0.25</b>      |
| 5/17/2017 | CAP-0659-OF | Captain Pond | 17.8            | <b>1.0</b>     | <b>1,608</b>                  | 0.25                | <b>2.20</b>          | <b>88</b>                  | 0.10              |

## RECOMMENDATIONS FOR CATCHMENT INVESTIGATION

Based on these results, all six outfalls should be considered low priority for follow-up catchment investigations. CAP-0659-OF may be contaminated by a greywater source and should be investigated only after outfalls with suspected human wastewater contamination are investigated.

## ATTACHMENT 1: Equipment and methods used for sample parameters.

| Parameter               | Units  | General Method    | Equipment or Method        |
|-------------------------|--|-------------------|----------------------------|
| <i>E. coli</i> bacteria | mpn (most probable number of colonies/100mL) | Nelson Analytical | Standard Method 9223 B     |
| Surfactants             | ppm  | Alpha Analytical  | MBAS-5540                  |
| Temperature             | °C   | Meter             | YSI 30                     |
| Salinity                | ppt  | Meter             | YSI 30                     |
| Specific Conductivity   | µS/cm  | Meter             | YSI 30                     |
| Total Ammonia           | ppm  | Field Kit         | HACH Ammonia Test Strips   |
| Total Chlorine          | ppm  | Field Kit         | HACH Pocket Colorimeter II |

<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)



# TECHNICAL | MEMORANDUM



**TO:** Dan Hudson, Director of Engineering, Town of Salem  
**FROM:** Laura Diemer & Jacqueline Boudreau, FB Environmental Associates  
**SUBJECT:** [Task 2: Hotspot Monitoring](#)  
**DATE:** July 25, 2017  
**CC:** James Danis, Town of Salem; Forrest Bell, FB Environmental Associates

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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 the designated uses of aquatic life and primary and secondary contact recreation due to elevated pollutants like fecal indicator bacteria. Elevated levels of fecal indicator bacteria are likely from nonpoint source pollution in stormwater runoff from developed land. Since 2014, the Town of Salem has contracted FB Environmental Associates (FBE) to conduct monitoring and investigations of “hotspot” outfalls to Captain and Millville Ponds. These “hotspot” outfalls have shown elevated fecal indicator bacteria levels and/or received positive hits for human wastewater contamination by Environmental Canine Services (ECS). 2017 monitoring of “hotspot” outfalls to Captain and Millville Ponds builds on preliminary investigations from 2014-16 and helps inform the Town on proper remediation efforts, if necessary.

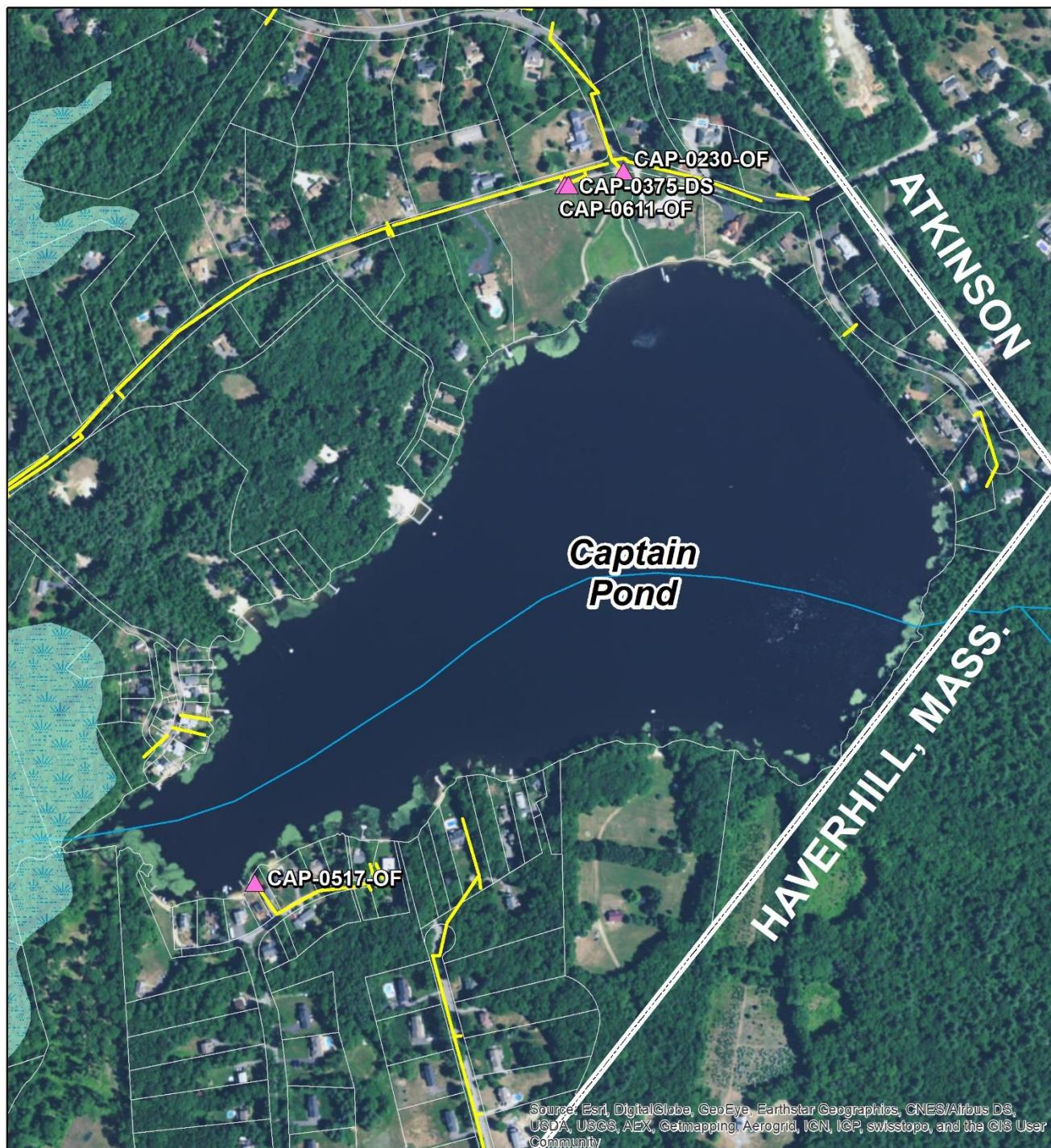
**This memo provides a brief review of Task 2: Hotspot Monitoring results for select stormwater outfalls to Captain and Millville Ponds.**

## METHODOLOGY

In spring (May-June 2017), FBE staff conducted dry and wet weather monitoring at six previously-identified “hotspot” outfalls to Captain and Millville Ponds, following procedures described in the 2017 New Hampshire Small MS4 General Permit (Table 1; Figures 1, 2). Selected outfalls showed elevated levels of fecal indicator bacteria during screenings in 2015 and/or 2016.

Outfalls (CAP-0230-OF, CAP-0375-DS, CAP-0517-OF, CAP-0611-OF, MIL-0701-OF, and MIL-0738-OF) were visited during dry weather conditions on 5/11/2017 or 5/17/2017, 5/24/2017, and 6/23/2017 and during wet weather conditions on 5/26/2017 and 6/5/2017. One outfall (CAP-0611-OF) did not flow and showed no evidence of prior flow during all visits except during wet weather monitoring on 6/5/2017; the outfall still had no flow, but showed some evidence of prior flow. One outfall (MIL-0738-OF) was sampled during all visits except during dry weather monitoring on 6/23/2017. All other outfalls had flow and were sampled during all visits.

All dry weather monitoring events were preceded by 0” of rainfall within 24 hours; wet weather monitoring on 5/26/2017 was preceded by 1.17” of rainfall within 24 hours; and wet weather monitoring on 6/5/2017 was preceded by 0.32” of rainfall within 24 hours (Figure 3).



## Captain Pond - Task 2 Outfalls 2017

- ▲ Outfall
- ~~~~ Stormwater Pipe
- ~~~~ Streams
- Prime Wetlands
- Town Boundary
- Parcels

0 0.125 0.25 Miles  
N Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental. July 2017

FIGURE 1. Stormwater outfall sampling locations for Task 2 2017 at Captain Pond.



## Millville Pond - Task 2 Outfalls 2017

- ▲ Outfall
- ~~~~ Stormwater Pipe
- ~~~~ Streams

- Prime Wetlands
- Town Boundary
- Parcels



N

0 0.125 0.25 Miles  
Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental, July 2017

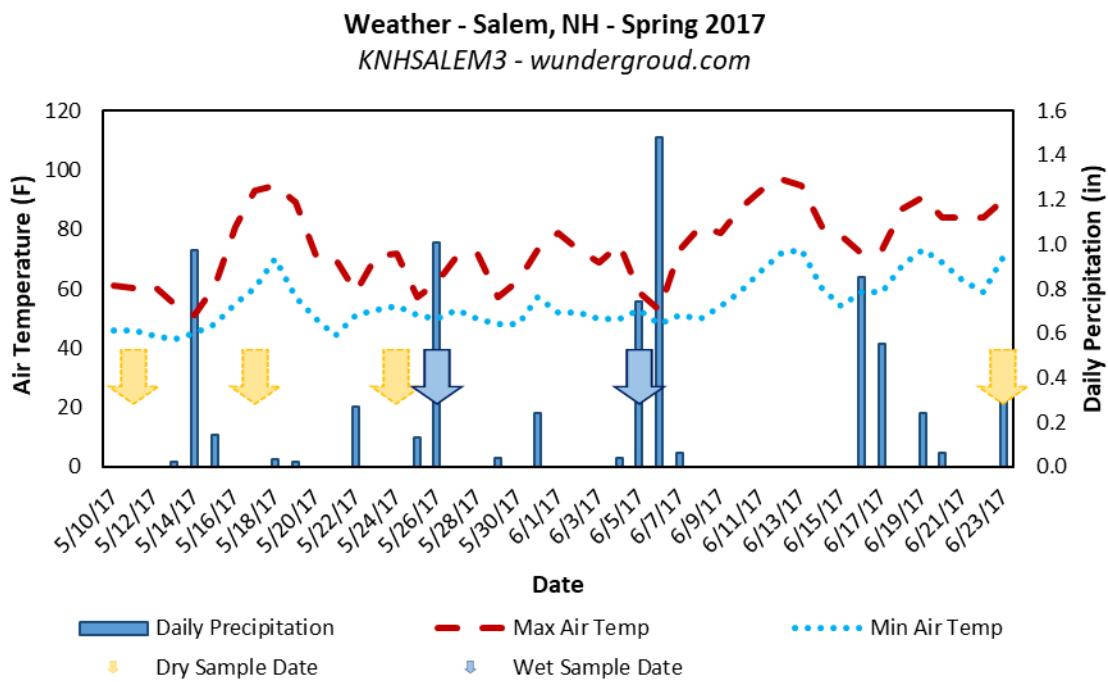


**FIGURE 2.** Stormwater outfall sampling locations for Task 2 2017 at Millville Pond.

When there was adequate flow to sample, 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 (see Attachment 1 for equipment and specific methodology). Some samples were also collected for chloride, pH, and total phosphorus.

**TABLE 1.** Outfall sampling dates for spring 2017. 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.

| Site        | Pond      | Sample Date      |                  |                  |                  |                 |                  |
|-------------|-----------|------------------|------------------|------------------|------------------|-----------------|------------------|
|             |           | 5/11/17<br>(dry) | 5/17/17<br>(dry) | 5/24/17<br>(dry) | 5/26/17<br>(wet) | 6/5/17<br>(wet) | 6/23/17<br>(dry) |
| CAP-0230-OF | Captain   |                  | ✓                | ✓                | ✓                | ✓               | ✓                |
| CAP-0375-DS | Captain   | ✓                |                  | ✓                | ✓                | ✓               | ✓                |
| CAP-0517-OF | Captain   | ✓                |                  | ✓                | ✓                | ✓               | ✓                |
| CAP-0611-OF | Captain   | X                |                  |                  | X                | X               | X                |
| MIL-0701-OF | Millville | ✓                |                  | ✓                | ✓                | ✓               | ✓                |
| MIL-0738-OF | Millville |                  | ✓                | ✓                | ✓                | ✓               | X                |



**FIGURE 3.** Spring dry and wet weather sample dates with daily minimum and maximum temperatures and daily cumulative precipitation from weather station KNHSALEM3 (Weather Underground), located east of Millville Pond.

## RESULTS

Based on the geometric mean of the 4-5 sampling visits, wet weather outfall discharges generally had higher levels of *E. coli* than dry weather (Table 2). The highest *E. coli* levels (up to 2,420 mpn/100mL at MIL-0738-OF) were measured during the larger wet weather sampling event on 5/26/2017. All five sampled outfalls exceeded the State criterion for a 60-day geometric mean in recreational waters with a public beach (47 mpn/100mL) and had detectable levels of total chlorine ( $\geq 0.02$  ppm). Soapy suds possibly from detergents and other household cleaners (which would be indicated by total chlorine and surfactants) were noted at all five sampled outfalls. Both total ammonia and surfactants measured below MS4 thresholds at all five sampled outfalls, indicating that human waste contamination was likely not a significant source. Total chlorine and total phosphorus were highest and exceeded recommended thresholds at CAP-0375-DS, suggesting possible runoff from lawns or greywater contamination. A sewage odor and brown-colored sample water were noted at CAP-0375-DS; though rotting plant matter can be misconstrued with sewage odor. Percent dissolved oxygen (DO) saturation was low at CAP-0375-DS and MIL-0738-OF, which may reflect excessive plant growth from nutrient enrichment. Total chloride exceeded the State criteria of 230 ppm at MIL-0701-OF, which is likely impacted by road salt in runoff. Notes from previous monitoring years indicated that grass clippings and pet waste were likely being dumped into storm drains in the residential neighborhoods draining to CAP-0517-OF.

## RECOMMENDATIONS FOR CATCHMENT INVESTIGATION

Based on these results, all six outfalls should be considered low priority for follow-up catchment investigations, except for CAP-0375-DS. Given the detectable total chlorine levels and evidence of soapy suds, the five sampled outfalls are likely contaminated by a greywater source and should be investigated only after outfalls with suspected human wastewater contamination are investigated. CAP-0375-DS showed elevated concentrations of total phosphorus, low DO, and likely a rotting plant material odor, all of which indicate nutrient enrichment likely coming from runoff from residential lawns. Previous monitoring years also noted excessive algae growth below CAP-0230-OF, indicating nutrient enrichment, and noted grass clippings and pet waste in storm drains to CAP-0517-OF. These neighborhoods would greatly benefit from a public awareness campaign on proper pet and yard waste management. Both MIL-0701-OF and MIL-0738-OF are likely impacted by road salt in runoff based on elevated specific conductivity and salinity and an exceedance of chloride criterion at MIL-0701-OF.

**TABLE 2.** Summary of water quality measurements at select Captain and Millville Pond outfalls. Bold, italicized text indicates exceedance of criteria for water quality parameters.

| Site ID           | Data  | Temp (°C)            | DO (%)                     | DO (ppm)          | Salinity (ppt)       | Spec Cond (µS/cm) | Total Ammonia (ppm)    |
|-------------------|-------|----------------------|----------------------------|-------------------|----------------------|-------------------|------------------------|
| <b>Thresholds</b> |       | >28.3                | ≥75.0                      | ≥5.0              | >0.5                 | >835              | ≥0.50                  |
| CAP-0230-OF       | TOTAL | 14.8                 | 95.4                       | 9.6               | 0.2                  | 353               | 0.25                   |
| CAP-0375-DS       | TOTAL | 14.4                 | <b>74.2</b>                | 7.3               | 0.1                  | 226               | 0.06                   |
| CAP-0517-OF       | TOTAL | 13.6                 | 95.0                       | 9.6               | 0.1                  | 268               | 0.13                   |
| MIL-0701-OF       | TOTAL | 13.1                 | 90.2                       | 9.0               | 0.3                  | 439               | 0.19                   |
| MIL-0738-OF       | TOTAL | 13.8                 | <b>73.1</b>                | 7.5               | 0.5                  | 361               | 0.25                   |
| CAP-0230-OF       | DRY   | 15.9                 | 94.3                       | 9.1               | 0.3                  | 476               | 0.25                   |
| CAP-0375-DS       | DRY   | 15.2                 | <b>67.3</b>                | 6.4               | 0.2                  | 256               | 0.00                   |
| CAP-0517-OF       | DRY   | 14.6                 | 96.5                       | 9.5               | 0.2                  | 332               | 0.25                   |
| MIL-0701-OF       | DRY   | 13.7                 | 91.1                       | 8.9               | 0.4                  | 438               | 0.13                   |
| MIL-0738-OF       | DRY   | 15.7                 |                            |                   | 1.0                  | 428               | 0.25                   |
| CAP-0230-OF       | WET   | 13.3                 | 96.6                       | 10.0              | 0.2                  | 229               | 0.25                   |
| CAP-0375-DS       | WET   | 13.3                 | 81.2                       | 8.3               | 0.1                  | 196               | 0.13                   |
| CAP-0517-OF       | WET   | 12.1                 | 93.5                       | 9.8               | 0.1                  | 205               | 0.00                   |
| MIL-0701-OF       | WET   | 12.3                 | 89.2                       | 9.2               | 0.3                  | 440               | 0.25                   |
| MIL-0738-OF       | WET   | 12.0                 | <b>73.1</b>                | 7.5               | 0.3                  | 327               | 0.25                   |
| Site ID           | Data  | Total Chlorine (ppm) | <i>E. coli</i> (mpn/100mL) | Surfactants (ppm) | Total Chloride (ppm) | pH                | Total Phosphorus (ppb) |
| <b>Thresholds</b> |       | ≥0.02                | ≥47                        | ≥0.25             | ≥230                 | 6.5-8.0           | ≥50                    |
| CAP-0230-OF       | TOTAL | <b>0.11</b>          | <b>55</b>                  | 0.05              | 75                   | 6.8               | 17                     |
| CAP-0375-DS       | TOTAL | <b>0.12</b>          | <b>107</b>                 | 0.04              | 58                   | 6.6               | <b>53</b>              |
| CAP-0517-OF       | TOTAL | <b>0.09</b>          | <b>49</b>                  | 0.03              | 52                   | 6.8               | 16                     |
| MIL-0701-OF       | TOTAL | <b>0.06</b>          | <b>112</b>                 | 0.05              | 193                  |                   |                        |
| MIL-0738-OF       | TOTAL | <b>0.06</b>          | <b>181</b>                 | 0.07              | 113                  |                   |                        |
| CAP-0230-OF       | DRY   | <b>0.17</b>          | 21                         | 0.05              | 85                   | 6.7               | 8                      |
| CAP-0375-DS       | DRY   | <b>0.22</b>          | <b>79</b>                  | 0.03              | 61                   | 6.5               | 48                     |
| CAP-0517-OF       | DRY   | <b>0.18</b>          | <b>51</b>                  | 0.03              | 78                   | 6.8               | 14                     |
| MIL-0701-OF       | DRY   | <b>0.05</b>          | 27                         | 0.05              | <b>250</b>           |                   |                        |
| MIL-0738-OF       | DRY   | <b>0.10</b>          | 19                         | 0.07              | 140                  |                   |                        |
| CAP-0230-OF       | WET   | <b>0.05</b>          | <b>145</b>                 | 0.05              | 70                   | 6.8               | 21                     |
| CAP-0375-DS       | WET   | <b>0.02</b>          | <b>146</b>                 | 0.05              | 56                   | 6.7               | <b>56</b>              |
| CAP-0517-OF       | WET   | 0.01                 | 46                         | 0.04              | 40                   | 6.9               | 17                     |
| MIL-0701-OF       | WET   | <b>0.08</b>          | <b>461</b>                 | 0.06              | 165                  |                   |                        |
| MIL-0738-OF       | WET   | <b>0.04</b>          | <b>561</b>                 | 0.07              | 99                   |                   |                        |

**ATTACHMENT 1:** Equipment and methods used for sample parameters.

| Parameter               | Units  | General Method    | Equipment or Method        |
|-------------------------|--|-------------------|----------------------------|
| <i>E. coli</i> bacteria | mpn (most probable number) of colonies/100mL | Nelson Analytical | Standard Method 9223 B     |
| Surfactants             | ppm  | Alpha Analytical  | MBAS-5540                  |
| Total Chloride          | Ppm  | Alpha Analytical  | 121, 4500CL-E              |
| pH                      |  | Alpha Analytical  | 121, 4500H+-B              |
| Total Phosphorus        | ppb  | Alpha Analytical  | 121, 4500P-E               |
| Temperature             | °C   | Meter             | YSI 30                     |
| Salinity                | ppt  | Meter             | YSI 30                     |
| Specific Conductivity   | µS/cm  | Meter             | YSI 30                     |
| Dissolved Oxygen        | %, ppm                                       | Meter             | YSI Pro ODO                |
| Total Ammonia           | ppm  | Field Kit         | HACH Ammonia Test Strips   |
| Total Chlorine          | ppm  | Field Kit         | HACH Pocket Colorimeter II |

**ATTACHMENT 2:** All water quality monitoring results for select Captain and Millville Pond outfalls. Bold, italicized text indicates exceedance of (or failure to meet) criteria for water quality parameters.



# TECHNICAL | MEMORANDUM



**TO:** Dan Hudson, Director of Engineering, Town of Salem  
**FROM:** Laura Diemer & Jacqueline Boudreau, FB Environmental Associates  
**SUBJECT:** [Task 3: Catchment Investigation](#)  
**DATE:** October 3, 2017  
**CC:** James Danis, Town of Salem; Forrest Bell, FB Environmental Associates

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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 the designated uses of aquatic life and primary and secondary contact recreation due to elevated pollutants like nutrients, chloride, metals, and fecal indicator bacteria. 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. Outfalls that are known problem areas or have water quality that does not meet permit criteria must be further investigated via upstream catchbasins or other connecting stormwater conveyances to identify possible pollutant sources for remediation.

**This memo provides a brief review of Task 3: Catchment Investigation results for select stormwater outfalls to Arlington Mill Reservoir, Canobie Lake, and Captain Pond.**

## METHODOLOGY

In spring (May-June 2017), FBE staff conducted dry and wet weather monitoring at previously-identified “hotspot” outfalls, as well as dry and wet weather screening at newly-prioritized outfalls, to Arlington Mill Reservoir, Canobie Lake, Captain Pond, and Millville Pond (total of 44 outfalls), following procedures described in the 2017 New Hampshire Small MS4 General Permit. Out of the 44 outfalls monitored or screened, four outfalls (ARL-0652-OF, CAN-0317-OF, CAP-0230-OF, and CAP-0659-OF) were flagged for further investigation.

Two outfalls (ARL-0652-OF and CAN-0317-OF) showed signs of possible human sewage contamination (Table 1). The nearest upstream catchbasin to a submerged outfall (ARL-0652-OF) was not sampled due to stagnant flow, but a sewage-like smell was easily detected. Note that decaying organic matter from algae and detritus can also be misconstrued with sewage odors. The nearest upstream catchbasin to a submerged outfall (CAN-0317-OF) was sampled, and failed to meet the instantaneous limit for recreational waters with public beaches (<88 mpn/100mL) and showed total ammonia at the MS4 permit limit of 0.5 ppm and total chlorine above the MS4 permit detectable limit of 0.02 ppm, indicating possible human fecal contamination; however, surfactants at this site and all other sampled sites were far 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. In this case, a sewage and sulfide smell was easily detected at CAN-0317-CB where the water collected was visibly brown and slightly cloudy and dissolved oxygen was extremely low (2.4 ppm), all of which suggests possible human sewage contamination.

CAP-0230-OF was monitored multiple times under dry and wet weather conditions because it has been a known “hotspot” for elevated fecal indicator bacteria since 2014. Elevated fecal indicator bacteria and total chlorine were found, particularly during wet weather, and soapy suds possibly from detergents and other household cleaners were noted at the site, indicating a possible greywater source. Previous monitoring years also noted excessive algae growth below CAP-0230-OF, indicating nutrient enrichment.

CAP-0659-OF was sampled, and failed to meet the instantaneous limit for recreational waters with public beaches (<88 mpn/100mL) and showed elevated salinity, specific conductivity, and total chlorine above recommended thresholds or MS4 permit criteria, suggesting a possible greywater source to the outfall.

**TABLE 1.** Summary of MS4 water quality measurements during dry and wet weather screenings. Bold, italicized text indicates exceedance of (failure to meet) criteria for water quality parameters. CAP-0230-OF results are the average of multiple samples for each weather condition.

| Site ID           | Flow (mL/s)         | Temp (°C)            | DO (%)                     | DO (ppm)          | Salinity (ppt)       | Spec Cond (µS/cm)      |
|-------------------|---------------------|----------------------|----------------------------|-------------------|----------------------|------------------------|
| <b>Thresholds</b> | --                  | >28.3                | ≥75.0                      | ≥5.0              | >0.5                 | >835                   |
| CAN-0317-OF (Wet) | --                  | 20.7                 | <b>27.2</b>                | <b>2.4</b>        | 0.4                  | 783                    |
| CAN-0317-OF (Dry) | --                  | 12.9                 | 77.1                       | 8.0               | 0.2                  | 407                    |
| CAP-0230-OF (Wet) | --                  | 13.3                 | 96.6                       | 10.0              | 0.2                  | 229                    |
| CAP-0230-OF (Dry) | --                  | 15.9                 | 94.3                       | 9.1               | 0.3                  | 476                    |
| CAP-0659-OF (Dry) | --                  | 17.8                 | --                         | --                | <b>1.0</b>           | <b>1,608</b>           |
| Site ID           | Total Ammonia (ppm) | Total Chlorine (ppm) | <i>E. coli</i> (mpn/100mL) | Surfactants (ppm) | Total Chloride (ppm) | Total Phosphorus (ppb) |
| <b>Thresholds</b> | ≥0.50               | ≥0.02                | ≥88                        | ≥0.25             | ≥230                 | ≥50                    |
| CAN-0317-OF (Wet) | <b>0.50</b>         | <b>0.27</b>          | <b>93</b>                  | 0.08              | --                   | --                     |
| CAN-0317-OF (Dry) | 0.25                | <b>0.30</b>          | <b>122</b>                 | 0.05              | 37                   | 15                     |
| CAP-0230-OF (Wet) | 0.25                | <b>0.05</b>          | <b>145</b>                 | 0.05              | 70                   | 21                     |
| CAP-0230-OF (Dry) | 0.25                | <b>0.17</b>          | 21                         | 0.05              | 85                   | 8                      |
| CAP-0659-OF (Dry) | 0.25                | <b>2.20</b>          | <b>88</b>                  | 0.10              | --                   | --                     |

Drainages to the four outfalls (ARL-0652-OF, CAN-0317-OF, CAP-0230-OF, and CAP-0659-OF) were investigated on 8/16/2017 during dry weather (preceded by 0" of rainfall within 24 hours) (Table 2). Each drainage area was surveyed and remapped according to in-field observations of hydrologic conveyance overland and to stormwater drains. Upstream catchbasins at major junctions (if applicable) were opened and inspected for flow. Only one sample could be collected at CAP-0230-OF. Observations were also noted for potential nutrient enrichment sources (e.g., fertilizers, pet waste, wildlife waste, etc.). Leachfields were assessed for breakouts or sewage-like odors.

When there was adequate flow to sample, 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*), total phosphorus, biological oxygen demand, chlorophyll-a, pH, and surfactants (see Attachment 1 for equipment and specific methodology).

**TABLE 2.** Investigative catchment sampling summary.

| Site        | Waterbody | 8/16/17 (dry)   |
|-------------|-----------|---|
| ARL-0652-OF | Arlington | No active flow at catchbasins; outfall was submerged                |
| CAN-0317-OF | Canobie   | No active flow at outfall or catchbasins                            |
| CAP-0230-OF | Captain   | Able to sample outfall, all other catchbasins were dry or submerged |
| CAP-0659-OF | Captain   | No active flow at outfall or catchbasins                            |

## RESULTS

Observations, notes, and photographs were taken during each stormwater drainage investigation (Table 3) and maps were updated for corrected drainage area and possible pollutant sources (Figures 1-4).

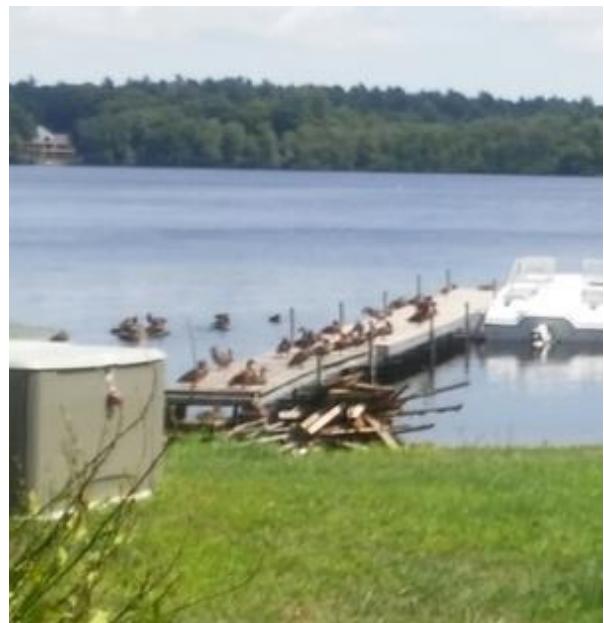
The drainage area to ARL-0652-OF includes several new homes with new leachfields. These homes have well-manicured and possibly fertilized lawns that may be contributing nutrients to the outfall. Pet, human, and bird waste are also likely contributing nutrients and fecal bacteria to areas at or near the beach at the outfall.

Several possible contamination sources were noted in the drainage area to CAN-0317-OF. Several properties appear to regularly fertilize their lawns or stage fertilizers on the driveway (noted at one property). Though there was no visible pet waste, dogs were present and may be a nutrient and/or fecal bacteria source to the outfall. The outfall likely contributes high amounts of chloride to Canobie Lake in winter when road salt used on the parking lot of one property and staged in the driveway of another are washed downstream. Nutrients may also attach to soil particles and erode downstream on one property with un-stabilized, grass-less soil. The seven-family building on one property may have been contributing human fecal contamination to the outfall; this issue was remedied by connecting the building to sewer in June 2017. It is recommended that this outfall be re-sampled in 2018 to ensure that water quality parameters and olfactory observations no longer indicate human sewage. Oils and grease and household detergents were also noted as possible pollutant sources to the outfall.

Newer, larger homes in the drainage area to CAP-0230-OF may be taxing their septic systems with excessive use of garbage disposals and water for washing. Pet waste and fertilizers are also likely sources to the outfall.



Soapy suds noted immediately below and adjacent to CAN-0317-OF, indicating greywater source.



Hundreds of ducks noted on dock near CAP-0659-OF.

Pet and bird waste were noted as likely contamination sources to CAP-0659-OF. No evidence of household detergents (greywater) or road salt runoff were found during the site visit.

**TABLE 3.** Catchment investigation notes and observations made on 8/16/17 during dry weather conditions.

| <b>Site</b> | <b>Map-Lot</b> | <b>Catchment Investigation Observations</b>   |
|-------------|----------------|---|
| ARL-0652-OF | 28-5506,       | These properties had well-manicured, possibly fertilized lawns. This area has brand new homes and associated leachfields have either been replaced or maintained. No active flow was noted at catchbasins; outfall was submerged and inaccessible for sampling. Beach located at outfall is heavily used and visited in the summer with people and dogs. Pet waste was present along main roads in drainage area. There were several properties nearby to drainage area with a large amount of birds (seagulls) visiting and depositing fecal matter on properties adjacent to water. |
|             | 28-5507,       |   |
|             | 28-5522,       |   |
|             | 28-5521,       |   |
|             | 28-5569        |   |
| ARL-0652-OF | 28-5504        | This property has a trailer camper residing on it and the owner is likely using a pit.  |
| CAN-0317-OF | 79-4540        | Property likely uses fertilizer on lawn. Soapy bubbles were noted on the surface water by CAN-0317-OF, along lake edge. There was no active flow at catchbasins. The associated wetland to the drainage area was dry. Brookdale Road had high groundwater table flowing downhill. Checked all leachfields in the drainage area and none had odor. Dogs were present in area, but no visible pet waste was noted.  |
| CAN-0317-OF | 79-4433        | Seven-family building on property; previously added high contribution to septic flow, as property sits on ledge that drains into catchment/outfall area. Switched to sewer, as of June 2017.  |
| CAN-0317-OF | 79-4539        | Property has no grass, lots of loose sediment and strong trash odor.  |
| CAN-0317-OF | 79-4536        | Property likely uses fertilizer on lawn. Stream that feeds wetland in drainage area off Brookdale Road is linked to an industrial building (11 Northeastern Blvd) that uses salt in parking lot during the winter time.   |
| CAN-0317-OF | 79-4537        | Property likely uses fertilizer on lawn; owner is a backyard mechanic, so possibility of oil and grease contamination. Resident across the street (59 Brookdale Road) is a commercial landscaper and snow plow and stages all trucks and equipment in driveway, including salt and fertilizers. The driveway is steep and would contribute high channelized groundwater (and surface water) flow into wetland to outfall.   |
| CAP-0230-OF | 51-6686,       | These properties have a high groundwater table and likely use fertilizers on lawns. Outfall had flow and was sampled. Catchbasin immediately upstream was submerged. All other catchbasins in drainage area were either dry or submerged. Leachfields did not have odor.  |
|             | 43-6694,       |   |
|             | 43-6696,       |   |
|             | 43-6719,       |   |
|             | 43-6733,       |   |
| CAP-0659-OF | 43-6730,       |   |
|             | 43-6728        | The newer homes have garbage disposers that are often problematic for leachfields (garbage grinders will turn garbage matter into fine particulate matter which travels to leachfield and clogs it up). These large homes also have a heavy laundry usage and may be contributing flow to drainage area. No pet waste was noted, but these homes have fenced-in backyards for these purposes.   |
| CAP-0659-OF | 51-5872,       | Leachfield immediately uphill is brand new. Pet waste noted throughout drainage area.   |
|             | 51-5887        |   |
| CAP-0659-OF | 51-5879        | Hundreds of ducks and large amounts of bird fecal matter on docks and a deck adjacent to the lakeshore. The outfall is very small and was dry. The associated catchbasin uphill was also dry.   |

CAP-0230-OF was sampled during the site visit on 8/16/17; all other catchbasins in the drainage area were either dry or submerged. The outfall only exceeded detectable levels of total chlorine ( $\geq 0.02$  ppm), indicating possible greywater source.

**TABLE 4.** Summary of water quality measurements at CAP-0230-OF. Bold, italicized text indicates exceedance of (failure to meet) criteria for water quality parameters.

| Site ID           | BOD (ppm)           | Chl-a (ppb)          | Temp (°C)                  | DO (%)            | DO (ppm)   | Salinity (ppt)         | Spec Cond ( $\mu\text{S}/\text{cm}$ ) |
|-------------------|---------------------|----------------------|----------------------------|-------------------|------------|------------------------|---------------------------------------|
| <b>Thresholds</b> | >2.0                | --                   | >28.3                      | $\geq 75.0$       | $\geq 5.0$ | >0.5                   | >835                                  |
| CAP-0230-OF (Dry) | <2.0                | <2.0                 | 23.1                       | 192.3             | 16.3       | 0.3                    | 552                                   |
| Site ID           | Total Ammonia (ppm) | Total Chlorine (ppm) | <i>E. coli</i> (mpn/100mL) | Surfactants (ppm) | pH         | Total Phosphorus (ppb) |                                       |
| <b>Thresholds</b> | $\geq 0.50$         | $\geq 0.02$          | $\geq 88$                  | $\geq 0.25$       | 6.5-9.0    | $\geq 50$              |                                       |
| CAP-0230-OF (Dry) | 0.25                | <b>0.08</b>          | <1                         | 0.02              | 7.8        | 33                     |                                       |

## RECOMMENDATIONS FOR NEXT STEPS

All four drainages had evidence of potential greywater sources and/or nutrient enrichment. Potential pollutant sources observed included fertilizer, pet, human, and wildlife waste, road salt, and oil and grease.

The drainage area to **ARL-0652-OF** was investigated because of a strong sewage odor noted during the initial outfall screening. The outfall may be receiving pollutants from a variety of sources, including pet, human, and wildlife waste and fertilizer. The beach at the outfall is heavily-used by humans and wildlife (notably birds).

- Post signs at the beach that encourages proper waste disposal (for pets and humans) and discourages bird feeding.
- Investigate one property assumed to be using a pit for waste disposal; ensure that untreated human waste is not making its way to Arlington Pond.
- Distribute educational materials about the water quality benefits of minimizing fertilizer use, maintaining septic systems, and picking up after pets.

The drainage area to **CAN-0317-OF** was investigated because of a strong sewage odor noted during the initial outfall screening, when the water collected was brown and cloudy with low oxygen and elevated levels of fecal indicator bacteria, total chlorine, and total ammonia. The outfall may be receiving pollutants from a variety of sources, including pet and human waste, fertilizer, un-stabilized soil (with associated nutrients), road salt, and oil and grease. One property owner operates a backyard mechanic shop where oil and grease may not be properly contained. Another property owner operates a landscaping and snow plowing business and stages equipment, road salt, and fertilizer in the steep driveway that may act as a conduit for runoff to the wetland area before reaching the outfall. An industrial building with a large parking lot to the southeast of the drainage area may be seasonally connected to the drainage area by an ephemeral stream; thus, road salt may be flushing to these critical wetland areas. Concerns with the proper functioning of a septic system accepting waste from a seven-family building were remedied in June 2017 by hooking up the building to sewer.

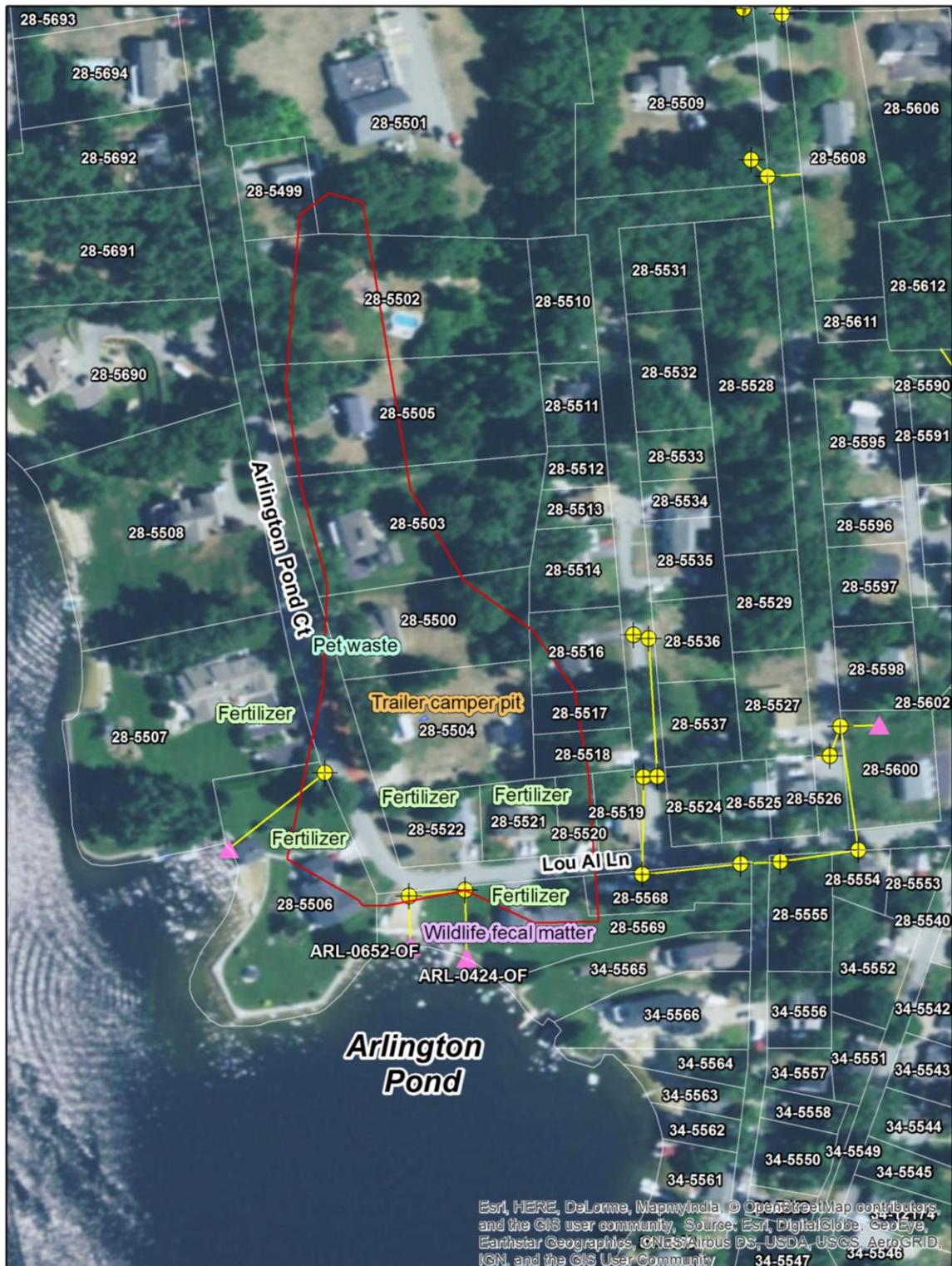
- Investigate properties with commercial staging to ensure proper controls are in place for containing pollutants from entering surface water or groundwater.
- Work with private and public entities to reduce salt usage on roads and parking lots.
- Re-sample the outfall in 2018 to ensure that water quality parameters and olfactory observations no longer indicate human sewage (assuming the seven-family building septic system was in failure).
- Distribute educational materials about the water quality benefits of minimizing fertilizer use, maintaining septic systems, and picking up after pets.

The drainage area to **CAP-0230-OF** was investigated because of elevated fecal indicator bacteria and total chlorine, as well as the presence of soapy suds and algae growth, indicating a possible greywater source and nutrient enrichment. Densely-packed residential neighborhoods with large, new homes in the drainage area may be contributing excess greywater flow from leachfields and use of garbage disposals may be threatening the proper functioning of leachfields. Well-manicured and large lawns are likely fertilized and contributing to nutrient enrichment noted downstream.

- Distribute educational materials about the water quality benefits of minimizing fertilizer use, maintaining septic systems, and picking up after pets.

The drainage area to **CAP-0659-OF** was investigated because of elevated fecal indicator bacteria, salinity, specific conductivity, and total chlorine measured during the initial outfall screening, suggesting a possible greywater source. The outfall may be receiving pollutants from pet and wildlife waste.

- Discourage birds from roosting on lawns, docks, and decks immediately on or adjacent to Captain Pond.
- Post signs in the neighborhood that encourages proper pet waste disposal.
- Distribute educational materials about the water quality benefits of minimizing fertilizer use, maintaining septic systems, and picking up after pets.



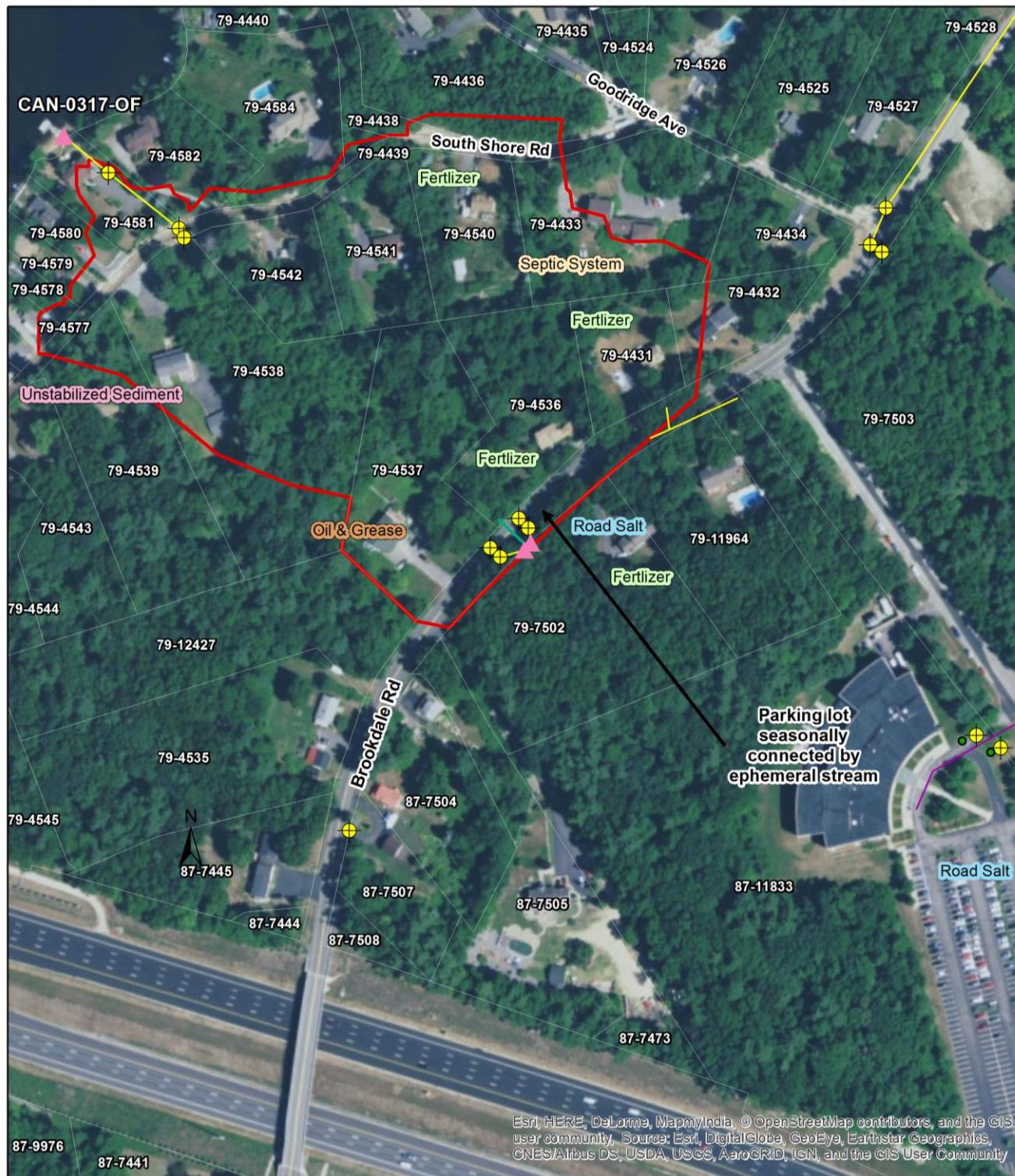
Arlington Pond Potential Pollutant Sources - Drainage to ARL-0652-OF

- ▲ Outfall
- Prime Wetlands
- ~ Stormwater Pipe
- Parcels
- ⊕ Stormwater Inlet
- Catchment Area
- Culvert Crossing

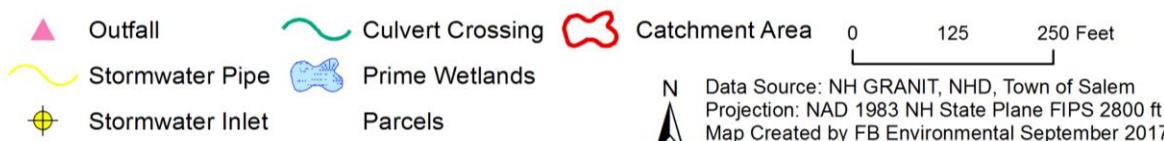
Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental Sept 2017



**FIGURE 1.** Stormwater outfall drainage to ARL-0652-OF at Arlington Mill Reservoir. Potential pollutant sources noted.



### Canobie Lake Potential Pollutants - Drainage to CAN-0317-OF



Data Source: NH GRANIT, NHD, Town of Salem  
 Projection: NAD 1983 NH State Plane FIPS 2800 ft  
 Map Created by FB Environmental September 2017



**FIGURE 2.** Stormwater outfall drainage to CAN-0317-OF at Canobie Lake. Potential pollutant sources noted.



- ▲ Outfall
- ~~~~~ Culvert Crossing
- ~~~~~ Stormwater Pipe
- ~~~~~ PrimeWetlands
- ◆ Stormwater Inlet
- ◆ Stormwater Manhole
- ◆ Parcels



0 200 400 Feet

Data Source: NH GRANIT, NHD, Town of Salem  
 Projection: NAD 1983 NH State Plane FIPS 2800 ft  
 Map Created by FB Environmental Sept 2017



**FIGURE 3.** Stormwater outfall drainage to CAP-0230-OF at Captain Pond. Potential pollutant sources noted.



### Captain Pond Potential Pollutant Sources - Drainage to CAP-0659-OF

- ▲ Outfall
- Prime Wetlands
- ~~~~ Stormwater Pipe
- Parcels
- Stormwater Inlet
- Catchment Area
- ~~~~ Culvert Crossing



0 100 200 Feet

Data Source: NH GRANIT, NHD, Town of Salem  
Projection: NAD 1983 NH State Plane FIPS 2800 ft  
Map Created by FB Environmental Sept 2017



**FIGURE 4.** Stormwater outfall drainage to CAP-0659-OF at Captain Pond. Potential pollutant sources noted.

**ATTACHMENT 1:** Equipment and methods used for sample parameters.

| Parameter                      | Units  | General Method    | Equipment or Method        |
|--------------------------------|--|-------------------|----------------------------|
| <i>E. coli</i> bacteria        | mpn (most probable number of colonies/100mL) | Nelson Analytical | Standard Method 9223 B     |
| Surfactants                    | ppm  | Alpha Analytical  | MBAS-5540                  |
| pH                             |  | Alpha Analytical  | 121, 4500H+-B              |
| Total Phosphorus               | ppb  | Alpha Analytical  | 121, 4500P-E               |
| Biological Oxygen Demand (BOD) | ppm  | Alpha Analytical  | 121, 5210B                 |
| Chlorophyll-a (Chl-a)          | ppb  | Alpha Analytical  | 121, 10200H                |
| Temperature                    | °C   | Meter             | YSI 30                     |
| Salinity                       | ppt  | Meter             | YSI 30                     |
| Specific Conductivity          | µS/cm  | Meter             | YSI 30                     |
| Dissolved Oxygen               | %, ppm                                       | Meter             | YSI Pro ODO                |
| Total Ammonia                  | ppm  | Field Kit         | HACH Ammonia Test Strips   |
| Total Chlorine                 | ppm  | Field Kit         | HACH Pocket Colorimeter II |