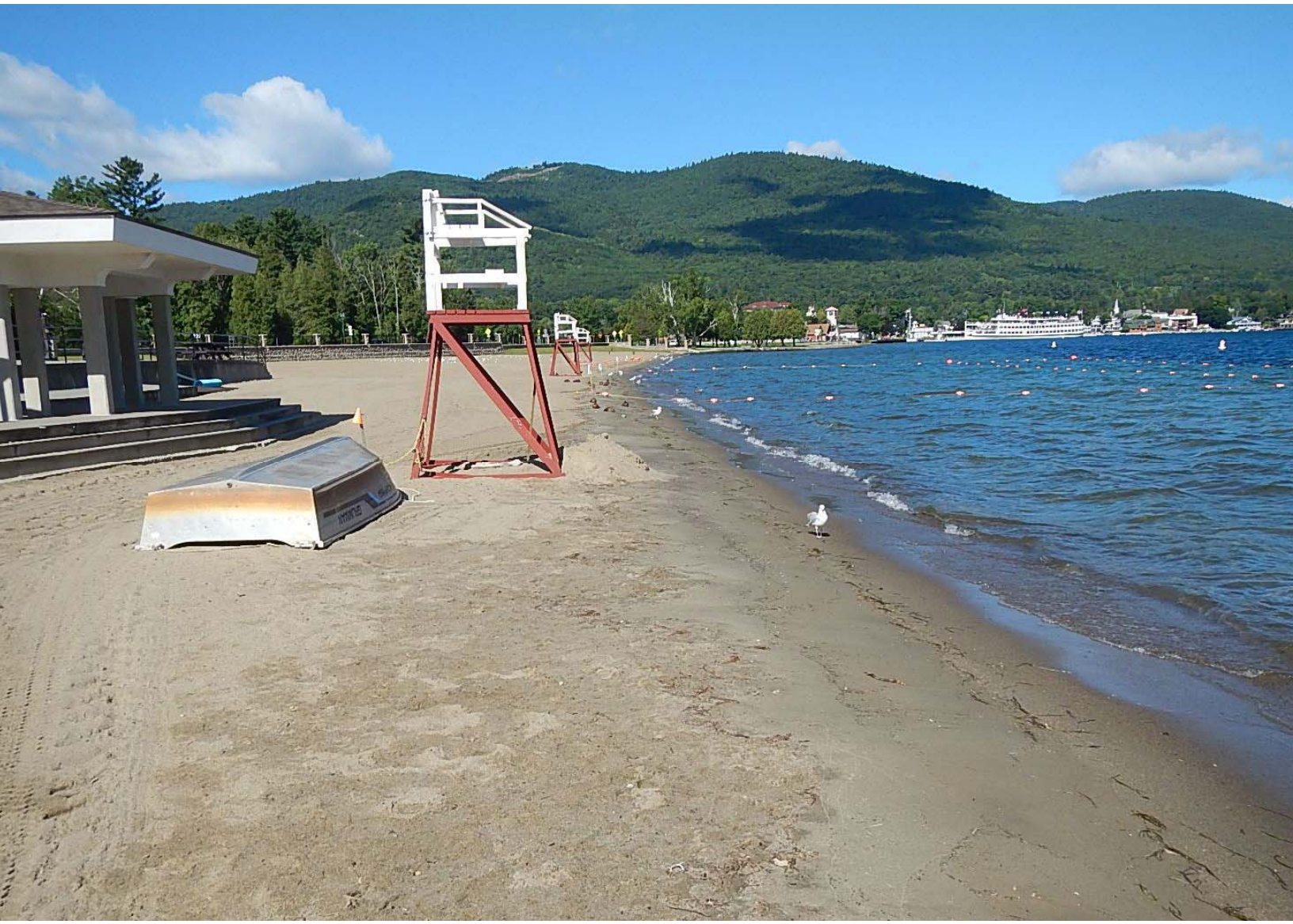
NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation

LAKE GEORGE BEACH

Pollution Source Investigation Update

June 2018



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EXECUTIVE SUMMARY

The New York State Department of Environmental Conservation (DEC) owns and operates Lake George Beach ("Million Dollar Beach"), part of Lake George Beach State Park. In response to elevated bacteria levels that exceeded New York State Department of Health guidelines for bathing beaches during the 2016 swim season, DEC initiated an investigation to determine the sources of bacteria impacting the beach. This investigation continued in 2017 as a cooperative effort between state and local government, along with private organizations. Partners that assisted with the investigation in 2017 included New York State Department of Health (NYSDOH), Village of Lake George, Town of Lake George, Lake George Association, Lake Champlain/Lake George Regional Planning Board, Warren County Soil and Water Conservation District, Lake George Waterkeeper, and Lake George Park Commission.

In order to protect public health, DEC implemented an enhanced water quality monitoring program at multiple locations along the beach shoreline and within the watersheds of East Brook and West Brook. Daily monitoring of water quality conditions within the swim area was conducted throughout the summer. Data from this monitoring effort prompted four swim area closures during the 2017 beach season due to bacteria levels exceeding NYSDOH standards. DEC and its partners also implemented weekly sampling at other beaches along Lake George for comparison purposes and to ensure that they were safe for swimming.

Due to the consistently high bacteria levels detected near the confluence of East Brook, much of the investigation work focused on tracking down and eliminating sources of bacterial contamination within the East Brook watershed. This work included inspecting and testing sewer and stormwater infrastructure. DEC and its partners conducted field surveys and collected water quality samples to isolate hotspot areas and focus on follow-up infrastructure inspections. Infrastructure inspections and maintenance activities included:

- Detailed camera inspections of the Village and Town of Lake George's sanitary sewer and stormwater infrastructure located near the beach and within the East Brook watershed
- Dye testing of commercial facilities, private facilities, and individual homes to identify improper or failing connections to the sanitary sewer system
- Smoke testing of municipal and residential lateral connections to the sanitary sewer system to isolate connection failures
- Cleaning of stormwater infrastructure that ultimately discharges near the beach
- Inspection of holding tanks and sewer pumping systems for tour boat operations in the area of the beach

The extensive camera inspections resulted in the identification of one break in the main sewer line resulting from drilling of a natural gas line. Smoke testing also identified several lateral connections to private residences that were compromised. Both the main sewer line and the lateral connections were repaired or replaced. Stormwater catch basins and treatment devices in the vicinity of the beach were confirmed to contain high levels of bacteria, most likely due to an accumulation of debris and sediment. The stormwater structures were cleaned, and a maintenance plan for this infrastructure is being developed by DEC and its partners.

Preliminary findings from an evaluation of the sewage collection system in the Town of Lake George's Caldwell Sewer District revealed severe defects in numerous pipe segments, manholes, and pump stations. Although no direct connection between these defects and surface waters has yet been established, due to the close proximity of this aging infrastructure to Lake George and Million Dollar Beach, past microbial source testing revealing the presence of human bacteria, and high levels of E.coli in surface water typically found associated with sewage pollution, these defects are likely a contributing source of bacteria to the environment. The estimated cost to repair these issues is $463,000. The town was recently awarded a $343,000 Clean Water Infrastructure Act grant, a $100,000 engineering planning grant, and a $120,000 Water Quality Improvement Project grant through DEC and the New York State Environmental Facilities Corporation to assist with repairing the collection system.

DEC will continue to work with state and local partners to identify areas where further infrastructure testing and repair is needed. Routine water quality monitoring of the swim area will continue during the 2018 beach season to ensure safe swimming conditions for the public.

INTRODUCTION

In response to multiple swim area closures in 2016, the DEC developed and implemented intensive water quality monitoring to identify and eliminate potential sources of bacteria and took steps to prevent further closures of the beach due to bacterial contamination. An investigation report, "Lake George Beach Pollution Source Investigation" was released in April of 2017 and summarized work conducted in the summer and fall of 2017. It was determined that bathing beach water quality had been sporadically impacted by high bacteria levels coming from watershed sources, though more investigation was needed to identify specific sources of bacteria to inform remediation actions. This report details the results of the efforts undertaken since the release of the April 2017 report.

DEC staff coordinated water quality monitoring that followed criteria in the U.S. Environmental Protection Agency (EPA) Great Lakes Beach Sanitary Survey User Manual (USEPA 2008) and New York State Sanitary Code. A Quality Assurance Project Plan (QAPP) was developed and followed for both routine daily monitoring and watershed studies.

BACTERIOLOGICAL MONITORING

Bacteriological Results for Lake George Beach

All water samples collected throughout the 2017 season were tested for *E. coli*. *E. coli* single sample results were compared to Subpart 6-2 of the New York State Sanitary Code to determine acceptable bathing beach water quality. Subpart 6-2 sets a single sample threshold of 235 col./100 mL for *E. coli*.

Pre-season beach monitoring was initiated at the end of April 2017. Monitoring was conducted at three locations within the designated swim areas (Sites #2.5, #3, and #3.5) (Figure 1). Site #2.4 was added as a fourth monitoring station after the swim area was expanded at the end of June.

Figure 1. Map of swim area monitoring locations

Monitoring was initiated on a weekly basis and was increased to daily monitoring after an early season exceedance on June 6. Daily bacteriological results and observed rainfall data collected from the Floyd Bennett Memorial Airport in Glens Falls can be found in Appendix A. Five samples collected from swim area stations exceeded the 235 col./100 mL single sample threshold for *E. coli* during the 2017 swim season (Table 1).

Table 1. Swim Area Exceedances and Rainfall Data (2017)

Sample Date	Sample Location	*E. coli* (col./100mL)	24-hour rainfall (in.)	48-hour rainfall (in.)
6/6/2017	2.5	360.0	0.29	0.81
6/17/2017	3	378.4	0.53	0.53
7/2/2017	2.4	248.1	3.30	3.30
	2.5	686.7		
8/8/2017	3	435.0	0.02	0.04

Data on bacteriological levels in the swim area were compared to observed rainfall to determine if there was a correlation between wet weather and exceedances in the swim area. If there is a strong correlation between rainfall and swim area exceedances, then a preemptive wet weather closure protocol can be implemented.

Three out of the four exceedances occurred after significant wet weather events (greater than 0.5 inch of rainfall within a 24- or 48-hour period). However, there were seven significant wet weather events with greater than 0.5 inch of rain over a 48-hour period that did not result in any swim area exceedances. Based on the available data, there is not a strong enough correlation between swim area exceedances to support the development of a wet weather preemptive closure protocol for the beach at this time.

Lake George Beach Closures

DEC bathing beaches are closed whenever there is a threat to public health and safety. During a closure, no one is permitted in the water. Beaches may be closed because of bacteriological results, environmental factors (e.g., low water clarity), or preemptively closed due to inclement weather (significant rainfall events associated with high bacteria loading).

Swimming was permitted at Lake George Beach for the summer starting on May 27. The beach was only open for swimming on weekends at the beginning of the summer. Water quality samples were collected once per week starting at the end of May. The beach was closed for swimming on Saturday, June 10 following an exceedance at Site #2.5 on June 6. The beach re-opened for one day of swimming on Sunday, June 11 after satisfactory follow-up samples. After this closure, DEC decided to increase the monitoring frequency to daily sampling.

The beach was due to open daily for swimming starting on Saturday, June 17. DEC preemptively closed the beach that day due to a significant rainstorm the day before, where more than 0.5 of rainfall was observed. Samples collected on June 16 indicated levels of bacteria below the single sample threshold, and the beach was opened later in the afternoon on June 17. A sample collected at Site #3 the morning of June 17 exceeded the single sample threshold, and the beach was closed for the rest of the week (through June 23), in order for DEC and its partners to aggressively investigate bacteria sources. The beach was reopened on June 24 after a full week of daily sampling results showed levels of bacteria below the single sample standard.

The beach remained open daily for swimming until an exceedance on July 2, where high levels of bacteria were detected at Sites #2.4 and #2.5. The beach was closed for one day on July 3 and was re-opened following satisfactory results on July 4. One last exceedance occurred on August 8, and the beach was closed for one day on August 9. The beach was reopened the following day and remained open until Labor Day. The beach was closed for the season on September 5, and routine monitoring of the swim area ended on September 7.

SUMMARY OF WATER QUALITY FINDINGS

DEC continued the watershed water quality studies that were initiated in September 2016, including frequent monitoring of non-swim stations, repeated tributary sampling of West Brook and East Brook, and collection of water samples for MST analysis. Findings from water quality studies were used to inform follow-up inspection of sewer and storm infrastructure. Additional data and information on watershed studies can be found in Appendix B.

Typically, bacteriological sampling results at watershed sites are compared to a bacteriological ambient water quality standard. DEC only has an ambient water quality standard for fecal coliform and does not have an ambient water quality standard for *E. coli*. Based on EPA epidemiological studies and criteria, and in consultation with NYSDOH staff, watershed samples collected by DEC were analyzed for *E. coli* and compared to the New York State Sanitary Code bathing beach single sample standard for *E. coli* (235 col./100mL). Though these sites would not be suitable for swimming, the comparison to the bathing beach single sample threshold provides the same basis for comparison between the swim and non-swim stations.

Non-Swim Area Station Monitoring

In addition to daily sampling at multiple stations within the swim area, samples were collected routinely at six other non-swim area locations: the confluence of West Brook (Site #1) and the confluence of East Brook (Site #4), 100 ft. East of Site #4 (Site #5), a storm sewer outfall at Dog Beach (Site SS-2), a 24" pipe culvert pipe that drains into East Brook just upstream of Site #4 (24" culvert) and an open stormwater channel that flows to a culvert on Cedar Lane (Site #1A) (Figure 2). Non-swim area stations were identified by DEC and its partners as potential sites of high bacteria loading requiring more testing.

Figure 2. Map of non-swim station monitoring locations

A total of 399 water samples were collected from the routine six non-swim area stations over the course of the summer. Of the 399 samples, 151 of the samples exceeded the bathing beach single sample standard (40%). Exceedances of the single sample standard were compared to wet weather events greater than 0.5 inch to determine if there was a correlation between rainfall amounts and *E. coli* levels within the watershed of the beach (Figure 3). Approximately 27% of the exceedances were correlated to wet weather events greater than 0.5 inch of rainfall within a 24-hour period.

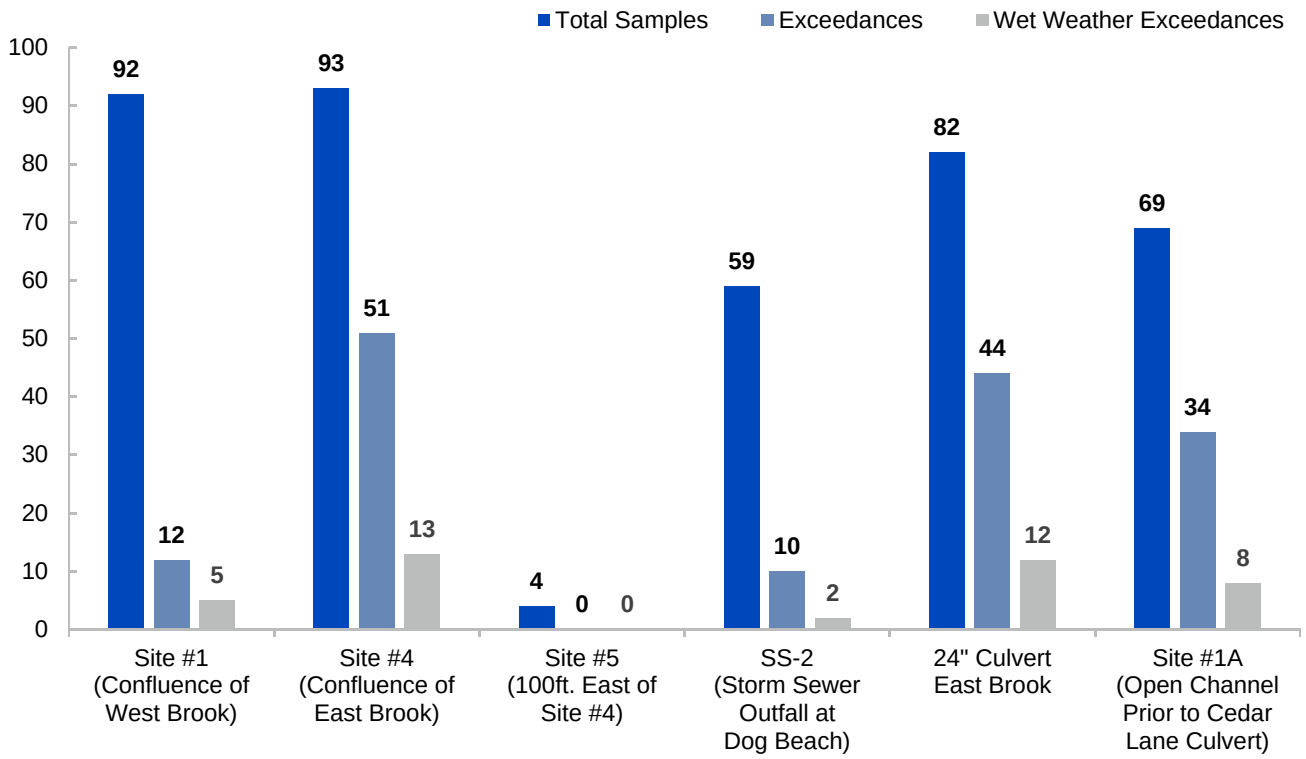
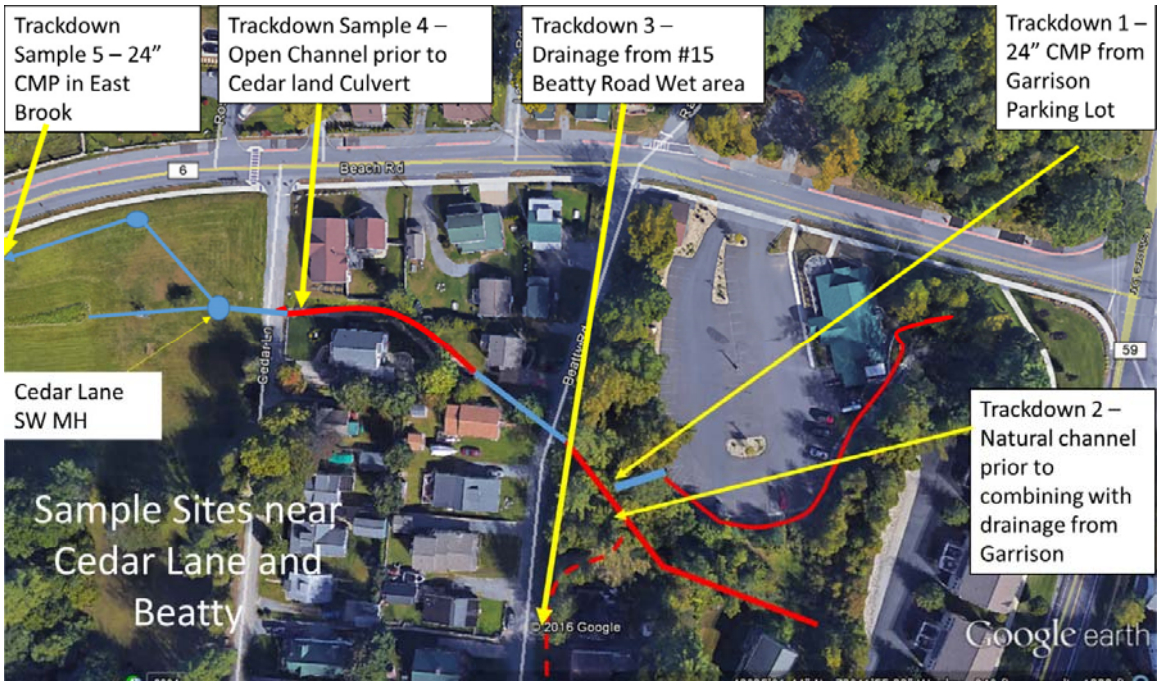


Figure 3. Non-swim area station exceedances

Consistently high *E. coli* levels were detected in the 24”-inch culvert and stormwater channel (Site #1A) that drains to a culvert on Cedar Lane and ultimately discharges from the 24" culvert. The stormwater system in the vicinity of Cedar Lane and Beatty Road became a focus of follow-up trackdown sampling and outfall identification to determine if there were any potential connection failures to the private residences in this neighborhood. Large increases in *E. coli* levels at these sites seemed to correspond to major holiday weekends (i.e., Independence Day weekend), possibly due to an increase in residential occupancy at seasonal homes during holiday weekends.



Cedar Lane and Beatty Road bacterial trackdown sampling sites

Tributary Sampling

A single tributary sampling event was conducted on West Brook and East Brook in June 2017. Repeat monitoring was attempted at all locations sampled during the September 2016 tributary sampling event. Data on additional water quality parameters and visual observations collected during tributary sampling can be found in Appendix B.

West Brook: Samples collected from five repeat sample locations in the stretch of stream located between I-87 and US Route 9 contained *E. coli* below the single sample threshold. *E. coli* levels were slightly elevated in comparison to the results from samples collected in September 2016. Samples were collected following a one-inch rainstorm two days prior.

East Brook: Samples collected from five repeat sample locations in the stretch of stream north of State Route 9L contained levels below the single sample standard for *E. coli*. One site could not be accessed due to flooding around the sample location. *E. coli* levels were comparable to the results from samples collected in September 2016, with the exception of one site located just upstream of the confluence of East Brook (EB-A). There was a significant drop in bacteria at this location compared to the sample collected in September 2016 sample, though consistently high sample results were detected at Site #4 throughout the summer, which is just downstream of Site EB-A. Overall, no additional potential pollution sources were identified during the June tributary sampling event.

A new tributary sample site (EB-G) was established in the wetland pond, approximately 300 feet upstream of the 24" culvert monitoring site. This site was established to determine potential influence of the wetland area on the 24" culvert monitoring site. Site EB-G was sampled for a period of approximately one week at the end of August. Five samples were collected in total, and all five samples exceeded the bathing beach single sample threshold for *E. coli*. A Microbial Source Tracking (MST) sample was collected from this sample site and was positive for *Bacteriodes* associated with birds, non-cow ruminants and humans (see MST analysis summary below). Wetlands typically contain high levels of ambient bacteria originating from animal or bird sources that use the wetland and surrounding area for habitat. However, the presence of human bacteria at this wetland site indicates that bacteria originating from public or privately owned infrastructure sources is being conveyed to the wetland, such as discharges from the 24" culvert.

Stormwater System Trackdown Sampling

Water quality samples were collected at multiple sites within the stormwater drainage system along West Brook Road (West Brook watershed), in the vicinity of Cedar Lane and Beatty Road (East Brook watershed). Samples were also collected from stormwater control structures along Beach Road and in the beach parking lot. With the exception of the open channel prior to the Cedar Lane culvert (established routine sample Site #1A), no other major sources of bacteria were identified from trackdown sampling.

Microbial Source Tracking (MST) Analysis

Using MST analysis, the presence of *Bacteriodes* associated with humans was detected in water samples collected from four site locations: Site #1 (confluence of West Brook), Site #4 (confluence of East Brook), Site #1A (Cedar Lane channel), and EB-G. *Bacteriodes* associated with non-cow ruminants (i.e., deer) were detected at three sites (Site #1, Site #4, and EB-G). *Bacteriodes* associated with birds were detected at EB-G. All samples collected were negative for *Bacteriodes* associated with cows and dogs. MST analysis confirms only the presence/absence of specific *Bacteriodes* markers associated with humans or non-human sources (dogs, ruminants, birds), but does not quantify the concentration of bacteria from each source.

SUMMARY OF POLLUTION SOURCE INVESTIGATION

Sanitary Sewer Infrastructure Inspection and Testing

DEC staff and staff from the Village of Lake George, Town of Lake George, Lake George Association, Lake Champlain/Lake George Regional Planning Board, Warren County Soil and Water Conservation District, Lake George Waterkeeper, and Lake George Park Commission dye tested, smoke tested, and camera inspected the sanitary sewer infrastructure in the vicinity of the beach to verify the integrity of the system and identify any leaks or sections of pipe that needed replacement. The Town of Lake George performed additional testing and inspection of the Caldwell Sewer District sanitary collection system after the close of the swimming season, identifying infrastructure in need of repair or replacement.

Video camera inspection truck

Dye testing was performed on the sanitary sewer lines located on Cedar Lane, Beatty Lane, Latham Road, Rose Point Lane, Front Street, West Brook Road, Route 9, Route 9L and Beach Road. Dye testing was also performed on a number of commercial buildings to verify that they were properly connected to the sanitary sewer system. No evidence of leakage or issues with the sanitary lines were detected through dye testing. Camera inspections were performed in the sanitary lines on Beatty Lane, Cedar Lane, and Beach Road. The camera investigation did reveal a break in the sewer main on Beach Road across from the Garrison Restaurant. A gas line installation had penetrated and broken the sewer pipe. The broken section was repaired the day after it was discovered.

Broken sewer line and actual photo from camera inspection

In addition to dye testing and camera inspection of the main sanitary lines, smoke testing was performed on lateral connections to private residences located on Cedar Lane and Beatty Road. Smoke testing identified issues with several lateral connections to private residences. The connections were replaced.

Stormwater Infrastructure Inspection and Maintenance

Local partners also performed camera inspections of stormwater structures and pipes adjacent to the beach area to determine if there were any illicit connections between the stormwater and sanitary sewer systems. No illicit connections were identified during the camera inspections.

The inspection effort identified a number of stormwater treatment structures in need regular maintenance. Water samples were taken from several stormwater catch basins and analyzed for *E. coli*. Many of the catch basins had filled with accumulated debris and sediment, providing a suitable environment for bacterial growth. Stormwater treatment units (Downstream Defenders) were also cleaned and catch basin cleaning was performed on Beach, West Brook, and Fort George roads. Stormwater pollution control devices in the Million Dollar Beach parking lot were also cleaned and inspected.

Surveys of West Brook and East Brook were conducted to identify and map all stormwater outfalls discharging into the streams. The Warren County Soil and Water Conservation District performed an outfall inspection of stormwater lines discharging into West Brook. Samples were also taken from the outfalls during the Soil and Water Conservation District's inspection of these outfalls.

In August, local forces from the Town and Village of Lake George removed vegetation from the open swale between Cedar Lane and Beatty Road in order to locate any pipes or potential discharges into the swale. Several pipes were identified once the vegetation was removed. Outfall locations were marked and photographed. The pipes are believed to be footing drains or basement sumps from nearby residences. Ground Penetrating Radar (GPR) was brought in to locate the origin of the pipes. Two pipes appear to originate from residences adjacent to the channel. The GPR identified a total of six pipes that appear to discharge into the channel. Many residences in this neighborhood are occupied only seasonally or infrequently throughout the summer. Due to infrequent occupancy, obtaining permission from landowners to conduct follow up dye testing or inspections was difficult. DEC and its partners plan to follow up with dye testing of private residences in the vicinity of the swale in 2018.

Tour Boat Operation Inspections

In July of 2017, DEC staff inspected tour boats that operate within Lake George Village to verify proper disposal of sanitary wastewater. Two different firms operate tour boats that range in size and the number of passengers that they can accommodate. Both of the tour boat firms have established infrastructure for handling sanitary sewage generated onboard the vessels. Each boat has a holding tank onboard. The holding tank facilities are inspected each year as part of a mandatory safety inspection before they can carry passengers. When the tour boats return to shore, there are established standpipes and discharge points where the sewage is safely pumped to the sanitary sewers in the Village of Lake George. The tour boat docks are in an area heavily visited by tourists and any illicit discharge would likely be promptly reported to DEC. No issues were identified during the inspections.

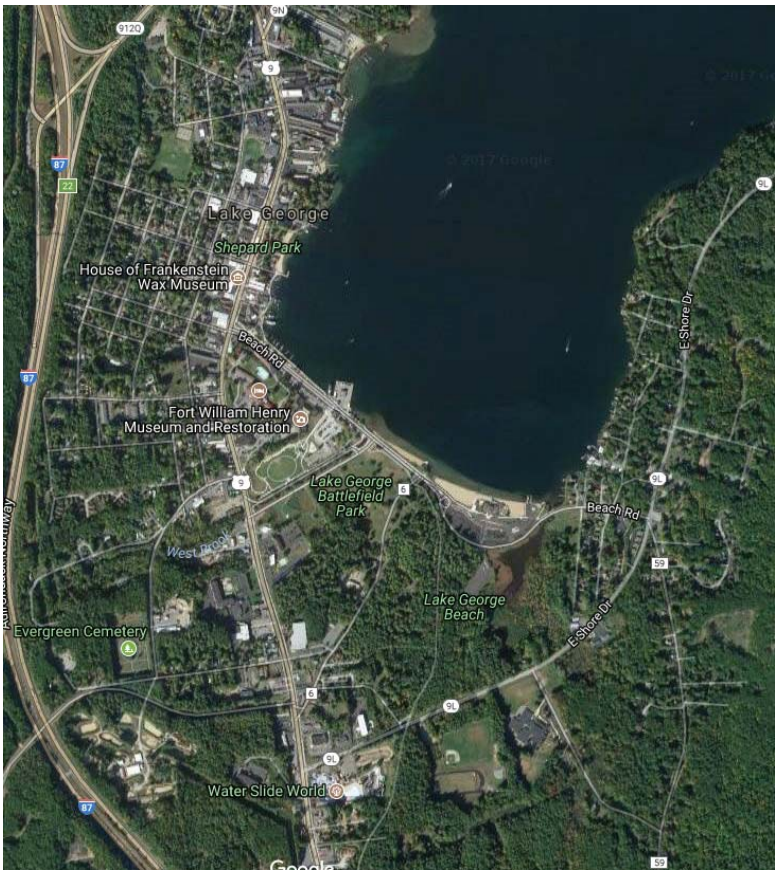
FUTURE ACTIONS

Pollution Source Investigation

DEC will continue to work with its local partners on pollution source investigation in the watershed areas of Lake George near Million Dollar Beach. Staff will provide technical support and assistance to its local partners in their continued efforts to identify and eliminate local sources of bacterial pollution that could enter Lake George.

The Village and Town of Lake George are developed areas with many homes and businesses in close proximity to the lake. DEC and its partners recognize the exceptional resource that is Lake George, and they value the recreation that it provides for local residents and visitors. DEC and its partners will continue attempting to track down and eliminate sources of bacteria that could potentially contaminate Lake George. For example, local partners plan to continue dye testing in the West Brook watershed and will also inspect homes within the watershed that may still be on individual septic systems.

Another issue that DEC and its partners are working to resolve relates to the use of the Lake George Battlefield Park. DEC staff had to remove several truckloads of garbage after the July 4 celebration. There were also documented instances of poor sanitation issues that could have potentially contributed to the bacteria numbers that weekend. The area is a “carry-in, carry-out” park with no garbage receptacles. Revisiting the present park rules to possibly provide garbage collection for special events and additional bathroom facilities will be discussed prior to the next swimming season at Million Dollar Beach.



The Town of Lake George is examining the entire Caldwell Sewer District that serves the town. The town has provided DEC with a report detailing their investigation to date, which identified sewer infrastructure in need of repair or upgrade. Much of this investigation work is close to the lake. They are performing a full camera investigation and cleaning of the entire system and will identify and prioritize any needed repairs that are discovered. This may include future slip lining of aging sewers that might be leaking. The town has been awarded a grant for sewer repairs identified in their 2017 investigation. The town has also submitted a grant application to complete a watershed management/green infrastructure plan for the southern basin area.

Additional stormwater investigation is also planned for 2018. Both the Village and the Town have Municipal Separate Storm Sewer Systems (MS4s) with programs in place to reduce or eliminate pollution issues associated with stormwater runoff. However, finding and eliminating the sources of stormwater contamination is often a lengthy process, and these efforts will continue into 2018.

Pollution Source Remediation

The Town of Lake George will repair the defects in the sewage collection system for the Caldwell Sewer District. The estimated cost to repair the severe defects is $463,000. The town was awarded a $100,000 engineering planning grant and a $120,000 Water Quality Improvement Project grant through DEC and the New York State Environmental Facilities Corporation to assist with the repairs.

The Village of Lake George is conducting additional camera investigation of its sewer infrastructure as well. The Village of Lake George is also in the process of upgrading its wastewater treatment plant, and has been awarded grant funding for the project.

Swim Area Monitoring

DEC will continue routine monitoring of Million Dollar Beach to protect public health. Should bacteria samples exceed the to the New York State Sanitary Code bathing beach single sample standard for *E. coli* (235 col./100mL), the beach will be closed to protect public safety.

Water Quality Studies

DEC will continue monitoring areas outside the swim area including the confluence of East and West brooks, the 24" culvert, and Cedar Lane storm channel as needed to monitor water quality near the beach.

APPENDIX A: SWIM AREA WATER QUALITY DATA

DEC initiated daily sampling of swim area stations beginning on June 5, 2017 and continued until September 7, 2017. Several pre-season and post-season samples were also collected. Results from the swim area station sampling are shown below (Table A1). Results in red exceeded the single sample threshold for *E. coli* (235 col./100mL). Rainfall amounts exceeding 0.5 inch with a 24-hour or 48-hour rainfall are shown in blue. Rainfall data was obtained from the Floyd Bennett Memorial Airport in Glens Falls for comparison to bacteriological results.

Table A1. Swim Area Station Monitoring Data (2017)

Date	Site #2.4 (Left of Expanded Swim Area)	Site #2.5 (Left Swim Area)	Site #3 (Center Swim Area)	Site #3.5 (Right Swim Area)	24-hour Rainfall @ Glens Falls Airport (in.)	48-hour Rainfall @ Glens Falls Airport (in.)
4/27/2017		Non-detectable	Non-detectable	Non-detectable	0.00	0.00
5/23/2017		42.0	25.0	40.0	0.00	0.00
5/30/2017		3.0	ND	ND	0.36	0.36
6/5/2017		2.0	7.0	8.0	0.29	0.62
6/6/2017		360.0	190.0	64.0	0.52	0.81
6/9/2017		61.3	43.2	131.4	0.00	0.00
6/10/2017		2.0	<1	3.1	0.00	0.00
6/12/2017		4.0	3.0	2.0	0.00	0.00
6/15/2017		4.1	<1		0.02	0.02
6/16/2017		4.1	5.2	6.3	0.53	0.55
6/17/2017		8.5	378.4	<1	0.00	0.53
6/18/2017		1.0	1.0	<1	0.00	0.00
6/19/2017		1.0	<1	<1	0.96	0.96
6/20/2017		3.0	2.0	3.1	0.00	0.96
6/21/2017		2.0	1.0	3.1	0.00	0.00
6/22/2017		1.0	4.1	2.0	0.00	0.00
6/23/2017		18.5	44.3	9.7	0.02	0.02
6/24/2017		2.0	6.3	9.8	0.05	0.07
6/25/2017		15.6	6.3	1.0	0.08	0.13
6/26/2017		14.8	29.5	8.5	0.07	0.15
6/27/2017	16.0	10.9	3.1	10.8	0.44	0.51
6/28/2017	45.5	12.2	9.7	12.2	0.00	0.44
6/29/2017	38.3	37.9	21.3	24.6	0.07	0.07
6/30/2017	16.1	36.9	3.1	3.1	0.35	0.42
7/1/2017	10.9	7.5	12.2	3.1	3.30	3.65
7/2/2017	248.1	686.7	135.4	68.3	0.00	3.30

Date	Site #2.4 (Left of Expanded Swim Area)	Site #2.5 (Left Swim Area)	Site #3 (Center Swim Area)	Site #3.5 (Right Swim Area)	24-hour Rainfall @ Glens Falls Airport (in.)	48-hour Rainfall @ Glens Falls Airport (in.)
7/3/2017	105.0	40.0	46.0	38.0	0.00	0.00
7/4/2017	9.0	16.0	17.0	11.0	0.00	0.00
7/5/2017	8.0	11.0	9.0	5.0	0.00	0.00
7/6/2017	26.0	26.0	11.0	10.0	0.03	0.03
7/7/2017	9.0	10.0	16.0	10.0	0.01	0.04
7/8/2017	4.0	4.0	2.0	3.0	0.03	0.04
7/9/2017	13.0	22.0	4.0	7.0	0.00	0.03
7/10/2017	10.0	13.0	26.0	69.0	0.00	0.00
7/11/2017	21.0	14.0	30.0	5.0	0.06	0.06
7/12/2017	2.0	4.0	3.0	1.0	0.22	0.28
7/13/2017	10.0	12.0	1.0	3.0	0.59	0.81
7/14/2017	9.0	3.0	1.0	4.0	0.05	0.64
7/15/2017	8.0	11.0	3.0	1.0	0.04	0.09
7/16/2017	5.0	6.0	11.0	10.0	0.00	0.04
7/17/2017	10.0	2.0	4.0	4.0	0.60	0.60
7/18/2017	228.0	16.0	14.0	10.0	0.00	0.60
7/19/2017	<1	1.0	2.0	3.0	0.00	0.00
7/20/2017	4.0	6.0	1.0	5.0	0.00	0.00
7/21/2017	5.0	3.0	5.0	10.0	0.00	0.00
7/22/2017	2.0	1.0	<1	4.0	0.00	0.00
7/23/2017	4.0	2.0	4.0	2.0	0.00	0.00
7/24/2017	1.0	5.0	4.0	1.0	0.50	0.50
7/25/2017	20.0	39.0	23.0	25.0	0.02	0.52
7/26/2017	3.0	1.0	4.0	1.0	0.00	0.00
7/27/2017	4.0	2.0	2.0	2.0	0.09	0.09
7/28/2017	5.0	10.0	5.0	2.0	0.00	0.09
7/29/2017	<1	<1	<1	2.0	0.00	0.00
7/30/2017	1.0	1.0	<1	1.0	0.00	0.00
7/31/2017	10.0	9.0	34.0	13.0	0.00	0.00
8/1/2017	4.0	8.0	152.0	2.0	0.00	0.00
8/2/2017	6.0	4.0	3.0	9.0	0.00	0.00
8/3/2017	2.0	4.0	<1	2.0	0.00	0.00
8/4/2017	6.0	7.0	1.0	11.0	0.00	0.00

Date	Site #2.4 (Left of Expanded Swim Area)	Site #2.5 (Left Swim Area)	Site #3 (Center Swim Area)	Site #3.5 (Right Swim Area)	24-hour Rainfall @ Glens Falls Airport (in.)	48-hour Rainfall @ Glens Falls Airport (in.)
8/5/2017	24.0	43.0	37.0	18.0	0.65	0.65
8/6/2017	7.0	19.0	23.0	13.0	0.00	0.65
8/7/2017	17.0	13.0	3.0	7.0	0.02	0.02
8/8/2017	29.0	42.0	435.0	21.0	0.02	0.04
8/9/2017	2.0	<1	3.0	3.0	0.02	0.04
8/10/2017	5.0	1.0	15.0	4.0	0.00	0.02
8/11/2017	<1	3.0	1.0	1.0	0.00	0.00
8/12/2017	5.0	4.0	2.0	3.0	0.02	0.02
8/13/2017	2.0	1.0	1.0	1.0	0.00	0.02
8/14/2017	<1	<1	2.0	2.0	0.00	0.00
8/15/2017	1.0	<1	3.0	<1	0.01	0.01
8/16/2017	65.0	1.0	1.0	<1	0.00	0.01
8/17/2017	1.0	2.5	2.0	4.0	0.00	0.00
8/18/2017	1.0	1.0	24.0	4.0	0.40	0.40
8/19/2017	7.0	17.0	11.0	16.0	0.00	0.40
8/20/2017	26.0	26.0	17.0	18.0	0.00	0.00
8/21/2017	5.0	8.0	10.0	3.0	0.00	0.00
8/22/2017		10.0	9.0	19.0	0.37	0.37
8/23/2017		16.0	27.0	32.0	0.00	0.37
8/24/2017		3.0	6.0	4.0	0.00	0.00
8/25/2017		<1	<1	<1	0.00	0.00
8/26/2017		<1	2.0	<1	0.00	0.00
8/28/2017		13.0	2.0	2.0	0.00	0.00
8/29/2017		2.0	4.0	4.0	0.00	0.00
8/30/2017		2.0	2.0	<1	0.00	0.00
8/31/2017		1.0	<1	1.0	0.00	0.00
9/1/2017		5.0	20.0	2.0	0.00	0.00
9/2/2017		<1		8.0	0.00	0.00
9/3/2017		4.0	9.0	8.0	1.37	1.37
9/4/2017		1.0	2.0	5.0	0.00	1.37
9/5/2017		5.0	8.0	4.0	0.04	0.04
9/6/2017		1.0	8.0	4.0	0.36	0.40
9/7/2017		3.0	3.0	3.0	0.20	0.56

Date	Site #2.4 (Left of Expanded Swim Area)	Site #2.5 (Left Swim Area)	Site #3 (Center Swim Area)	Site #3.5 (Right Swim Area)	24-hour Rainfall @ Glens Falls Airport (in.)	48-hour Rainfall @ Glens Falls Airport (in.)
9/8/2017		4.0	3.0	5.0	0.16	0.36
9/11/2017		1.0	<1	1.0	0.00	0.16
9/12/2017		4.0	2.0	3.0	0.00	0.00
9/13/2017		1.0	2.0	1.0	0.00	0.00
9/21/2017		14.0	2.0	2.0	0.00	0.00

APPENDIX B: WATER QUALITY STUDIES

Non-Swim Station Monitoring

A metal stormwater drainage pipe (24" culvert) that discharges into East Brook just before the confluence with the lake was first identified as a potential source during the September 2016 tributary sampling event. Further investigation of this pipe determined that the 24" culvert discharges stormwater from a drainage area that is up-gradient of Cedar Lane in the Town of Lake George. An open drainage swale located between Cedar Lane and Beatty Lane empties into the 24"' culvert and was added as a new monitoring site (Site #1A). A stormwater outfall structure on Dog Beach (SS-2) was identified through the stormwater infrastructure inspections as having a relatively high *E. coli* count and the discharge from this structure was added as a new monitoring site. Site #5 was added as a site towards the end of the sampling season to determine if there were any additional sources of bacteria loading along the eastern shoreline of the lake near the mouth of East Brook.

Results from the non-swim area station sampling are shown below (Table B1). Results in red exceeded the single sample threshold for *E. coli* (235 col./100mL). Rainfall amounts exceeding 0.5 inch with a 24-hour or 48-hour rainfall are shown in blue. Rainfall data was obtained from the Floyd Bennett Memorial Airport in Glens Falls for comparison to bacteriological results.

Table B1. Non-Swim Area Station Monitoring Data (2017)

Date	Site #1 (Confluence of West Brook)	Site #4 (Confluence of East Brook)	Site #5 (100 ft. East of Site #4)	SS-2 (Storm Sewer Outfall at Dog Beach)	24" Culvert (East Brook)	Site #1A (Open Channel Prior to Cedar Lane Culvert)	24-hour Rainfall (in.)	48-hour Rainfall (in.)
4/27/2017		6.0					0.00	0.00
6/6/2017	34.0	210.0					0.52	0.81
6/9/2017	25.6	224.7					0.00	0.00
6/10/2017	235.9	88.2					0.00	0.00
6/15/2017	25.9	290.9					0.02	0.02
6/16/2017	410.6	387.3		980.4			0.53	0.55
6/17/2017	228.2	298.7			579.4	155.3	0.00	0.53
6/18/2017	57.3	119.8					0.00	0.00
6/19/2017	83.6	248.1			209.8		0.96	0.96
6/20/2017	2419.6	435.2			184.2		0.00	0.96
6/21/2017	98.7	172.2		73.3	151.5		0.00	0.00
6/22/2017	122.3	228.2			193.5		0.00	0.00
6/23/2017	105.4	167.0			150.0		0.02	0.02
6/24/2017	290.9	280.9			290.9		0.05	0.07
6/25/2017	63.7	104.3			114.5		0.08	0.13
6/26/2017	75.9	156.5		8.6	69.7		0.07	0.15
6/27/2017	88.2	142.1			206.4		0.44	0.51
6/28/2017	88.2	184.2			980.4		0.00	0.44
6/29/2017	80.9	119.8					0.07	0.07
6/30/2017	90.6	75.4			1299.7		0.35	0.42

Date	Site #1 (Confluence of West Brook)	Site #4 (Confluence of East Brook)	Site #5 (100 ft. East of Site #4)	SS-2 (Storm Sewer Outfall at Dog Beach)	24" Culvert (East Brook)	Site #1A (Open Channel Prior to Cedar Lane Culvert)	24-hour Rainfall (in.)	48-hour Rainfall (in.)
7/1/2017	248.1	816.4			2419.6	2419.6	3.30	3.65
7/2/2017	142.1	307.6			2419.6		0.00	3.30
7/3/2017	111.0	185.0			2420.0		0.00	0.00
7/4/2017	65.0	105.0			5040.0		0.00	0.00
7/5/2017	48.0	84.0			1986.0	2820.0	0.00	0.00
7/6/2017	31.0	185.0		210.0	6131.0	4884.0	0.03	0.03
7/7/2017	48.0	84.0		40.0	3448.0	7701.0	0.01	0.04
7/8/2017	98.0	345.0		365.0	1660.0	2500.0	0.03	0.04
7/9/2017	41.0	250.0		93.0	2480.0	2010.0	0.00	0.03
7/10/2017	40.0	107.0		581.0	1187.0	1723.0	0.00	0.00
7/11/2017	66.0	21.0		39.0	318.0	1246.0	0.06	0.06
7/12/2017	42.0	81.0		26.0	980.0	1300.0	0.22	0.28
7/13/2017	613.0	345.0		158.0	1120.0	1120.0	0.59	0.81
7/14/2017	65.0	124.0		53.0	666.0	727.0	0.05	0.64
7/15/2017	44.0	225.0		49.0	579.0	613.0	0.04	0.09
7/16/2017	30.0	162.0		10.0	1414.0	2420.0	0.00	0.04
7/17/2017	24.0	162.0		4.0	1046.0	2420.0	0.60	0.60
7/18/2017	40.0	248.0		194.0		1226.0	0.00	0.60
7/19/2017	387.0	144.0		13.0	488.0	517.0	0.00	0.00
7/20/2017	34.0	122.0		50.0	411.0	1986.0	0.00	0.00
7/21/2017	435.0	102.0		8.0	435.0	1046.0	0.00	0.00
7/22/2017	73.0	326.0		16.0	488.0	649.0	0.00	0.00
7/23/2017	59.0	150.0		71.0	1733.0	1986.0	0.00	0.00
7/24/2017	579.0	613.0		25.0	>2,420	2420.0	0.50	0.50
7/25/2017	48.0	345.0		11.0	821.0	821.0	0.02	0.52
7/26/2017	45.0	326.0		24.0	345.0	328.0	0.00	0.00
7/27/2017	111.0	125.0		13.0	185.0	219.0	0.09	0.09
7/28/2017	156.0	91.0		17.0	127.0	196.0	0.00	0.09
7/29/2017	86.0	144.0		6.0	205.0	189.0	0.00	0.00
7/30/2017	133.0	210.0		4.0	105.0	178.0	0.00	0.00
7/31/2017	79.0	135.0		155.0	127.0	55.0	0.00	0.00
8/1/2017	63.0	172.0			161.0		0.00	0.00
8/2/2017	82.0	135.0			150.0	185.0	0.00	0.00

Date	Site #1 (Confluence of West Brook)	Site #4 (Confluence of East Brook)	Site #5 (100 ft. East of Site #4)	SS-2 (Storm Sewer Outfall at Dog Beach)	24" Culvert (East Brook)	Site #1A (Open Channel Prior to Cedar Lane Culvert)	24-hour Rainfall (in.)	48-hour Rainfall (in.)
8/3/2017	980.0	162.0			161.0	236.0	0.00	0.00
8/4/2017	62.0	156.0			140.0	238.0	0.00	0.00
8/5/2017	36.0	1553.0			687.0	285.0	0.65	0.65
8/6/2017	461.0	291.0			113.0	108.0	0.00	0.65
8/7/2017	56.0	260.0		435.0	122.0	101.0	0.02	0.02
8/8/2017	82.0	345.0		111.0	345.0	51.0	0.02	0.04
8/9/2017	52.0	649.0		139.0	140.0	41.0	0.02	0.04
8/10/2017	114.0	613.0		82.0	117.0	37.0	0.00	0.02
8/11/2017	46.0	308.0		137.0	75.0	25.0	0.00	0.00
8/12/2017	120.0	308.0		99.0	68.0	45.0	0.02	0.02
8/13/2017	50.0	488.0		96.0	111.0	21.0	0.00	0.02
8/14/2017	20.0	579.0		63.0	172.0	18.0	0.00	0.00
8/15/2017	37.0	206.0		1120.0	579.0	71.0	0.01	0.01
8/16/2017	21.0	345.0			313.0	49.0	0.00	0.01
8/17/2017	42.0	308.0		285.0	313.0	57.0	0.00	0.00
8/18/2017	1986.0	345.0			1986.0	2420.0	0.40	0.40
8/19/2017	172.0	1733.0			1120.0	260.0	0.00	0.40
8/20/2017	67.0	548.0			461.0	194.0	0.00	0.00
8/21/2017	80.0	387.0		60.0	155.0	63.0	0.00	0.00
8/22/2017	49.0	921.0		104.0	228.0	79.0	0.37	0.37
8/23/2017	42.0	980.0		150.0	231.0	299.0	0.00	0.37
8/24/2017	32.0	548.0		31.0	184.0	82.0	0.00	0.00
8/25/2017	40.0	345.0		72.0	155.0	72.0	0.00	0.00
8/26/2017	34.0	365.0		204.0	131.0	63.0	0.00	0.00
8/28/2017	31.0	488.0		38.0	129.0	60.0	0.00	0.00
8/29/2017	72.0	276.0		93.0	194.0	240.0	0.00	0.00
8/30/2017	24.0	345.0			345.0	27.0	0.00	0.00
8/31/2017	22.0	238.0		613.0	260.0	132.0	0.00	0.00
9/1/2017	22.0	326.0		387.0	199.0	365.0	0.00	0.00
9/2/2017	21.0	517.0			192.0		0.00	0.00
9/3/2017	91.0	816.0	54.0	66.0	345.0	227.0	1.37	1.37
9/4/2017	64.0	579.0	11.0	488.0	488.0	461.0	0.00	1.37
9/5/2017	34.0	2420.0	2.0	185.0	488.0	488.0	0.04	0.04

Date	Site #1 (Confluence of West Brook)	Site #4 (Confluence of East Brook)	Site #5 (100 ft. East of Site #4)	SS-2 (Storm Sewer Outfall at Dog Beach)	24" Culvert (East Brook)	Site #1A (Open Channel Prior to Cedar Lane Culvert)	24-hour Rainfall (in.)	48-hour Rainfall (in.)
9/6/2017	86.0	435.0		67.0	2420.0	2420.0	0.36	0.40
9/7/2017	122.0	435.0		57.0	249.0	155.0	0.20	0.56
9/8/2017	51.0	345.0	8.0	30.0	260.0	96.0	0.16	0.36
9/11/2017	17.0	326.0		68.0	204.0	61.0	0.00	0.16
9/12/2017	80.0	291.0		285.0	46.0	58.0	0.00	0.00
9/13/2017	55.0	166.0		58.0	98.0	36.0	0.00	0.00
9/21/2017	49.0	219.0		53.0		102.0	0.00	0.00

Tributary Monitoring

On June 21, 2017, bacteriological samples were collected from two streams within the watershed of the beach, West Brook, and East Brook. Water quality parameters (water temperature, specific conductance, pH, and dissolved oxygen) were also measured, and visual observations (water clarity, water color, odor, wildlife presence, algae presence) were recorded at each sample location. Sampling was conducted under dry weather conditions. The same sites had seen sampled during a single tributary sampling event in September 2016.

***West Brook*.** Samples were collected from five sample sites (Figure B1). Water quality parameters, visual observations, and *E. coli* results are listed in Table B2. All samples showed levels of *E. coli* below the single sample standard. Water clarity was excellent at all sites, and no physical indicators (odor, color, wildlife) of bacterial sources were observed.

Figure B1. West Brook sampling site locations

Table B2. Water quality parameters, visual observations, and *E. coli* results for West Brook sample sites

	Location				YSI				Water Conditions						
Sample Site	Latitude	Longitude	*E. coli* Sample Time	*E. coli* Sample Result (col./100 mL)	Water Temp. (°C)	Conductivity (µs/cm)	pH	D.O.	Depth (cm)	Water Clarity	Water Color	Odor (Y/N?)	Debris Present (Y/N?)	Wildlife Present (Y/N, Types?)	Algae Present (Y/N)
WB-A	43.41833	-73.71083	9:50	151.5	12.0	308	7.3	10.0	50	Clear	None	N	N	N	Y
WB-B	43.42361	-73.71027	9:37	107.6	12.0	288	7.2	10.2	30	Clear	None	N	N	N	Y
WB-C	43.41722	-73.71694	9:05	108.6	11.9	YSI battery died – no measurements collected				Clear	None	N	Y -trash	N	Y
WB-D	43.41684	-73.71694	8:56	139.6	11.9	187	7.4	10.6	50	Clear	None	N	N	N	Y
WB-E	43.41416	-73.72194	8:45	142.1	12.0	157	7.5	10.8	30	Clear	None	N	N	N	N

East Brook. Samples were collected from five sample sites during the June 2017 tributary sampling event (Figure B2). Water quality parameters, visual observations, and *E. coli* results are listed in Table B2. Water quality parameters, visual observations, and *E. coli* results are listed in Table B3. All samples showed levels of *E. coli* below the single sample standard. Water clarity was excellent at all sites, and no physical indicators of bacterial sources were observed at any site. EB-G was added as a new monitoring site to determine potential influence of the wetland area on the 24"' culvert monitoring site. Five samples were collected in total at EB-G, and all samples exceeded the bathing beach single sample threshold for *E. coli* (Table B4).

Figure B2. East Brook sampling sites locations

Table B3. Water quality parameters, visual observations, and *E. coli* results for East Brook sample sites

	Location				YSI				Water Conditions						
Sample Site	Latitude	Longitude	*E. coli* Sample Time	*E. coli* Sample Result (col./100 mL)	Water Temp. (°C)	Conductivity (µs/cm)	pH	D.O.	Depth (cm)	Water Clarity	Water Color	Odor (Y/N?)	Debris Present (Y/N?)	Wildlife Present (Y/N, Types?)	Algae Present (Y/N)
EB-A	43.41719	-73.70084	11:02		17.0	577	7.88	11.6	100	Clear	None	N	N	Y - fish	N
EB-B	43.41516	-73.70249	10:50		15.3	592	7.47	9.4	15	Clear	None	N	N	Y – ducks	N
EB-C	Sample site inaccessible due to flooding														
EB-D	43.41333	-73.69972	12:23		13.4	606	7.64	9.3	120	Clear	None	N	N	N	N
EB-E	43.41333	-73.70056	12:16		15.3	604	7.7	9.3	50	Clear	None	N	N	N	N
EB-F	43.41361	-73.69917	12:11		13.5	602	7.8	10.2	150	Clear	None	N	N	N	N

Table B4. *E. coli* results for EB-G Sample Site

Sample Date	*E. coli* Sample Result (col./100 mL)
8/24/2017	238.0
8/28/2017	980.0
9/3/2017	248.0
9/7/2017	276.0
9/8/2017	261.0

Stormwater System Trackdown Sampling

Table B5. Cedar Lane/Beatty Road stormwater system trackdown sampling results

Sample Date	Site ID	Site Description	*E. coli* Sample Result (col./100 mL)
6/17/2017	1	24" CMP from Garrison Parking Lot	4.1
6/17/2017	2	Natural Drainage Area prior to Garrison	108.1
6/17/2017	3	Drainage from #15 Beatty wet area	90.9
6/29/2017	Cedar LN MH 24"	Cedar Lane	>2419.6
6/29/2017	Cedar Lane, Culvert	Cedar Lane	>2419.6
7/1/2017	1	24" CMP from Garrison Parking Lot	<1
7/1/2017	2	Natural Drainage Area prior to Garrison	325.5
7/1/2017	4	Drainage from #15 Beatty wet area	43.9
7/5/2017	Site #2A	100' Upstream from Cedar Lane	210.0
7/5/2017	Site #3A	200' Upstream from Cedar Lane	111.0
8/1/2017		Open Channel next to Beatty Road	199.0
8/2/2017		Beatty Lane Culvert	108.0
8/4/2017		Beatty Lane Culvert	111.0
8/8/2017	Site #1B	Cedar Lane Open Channel	24.0

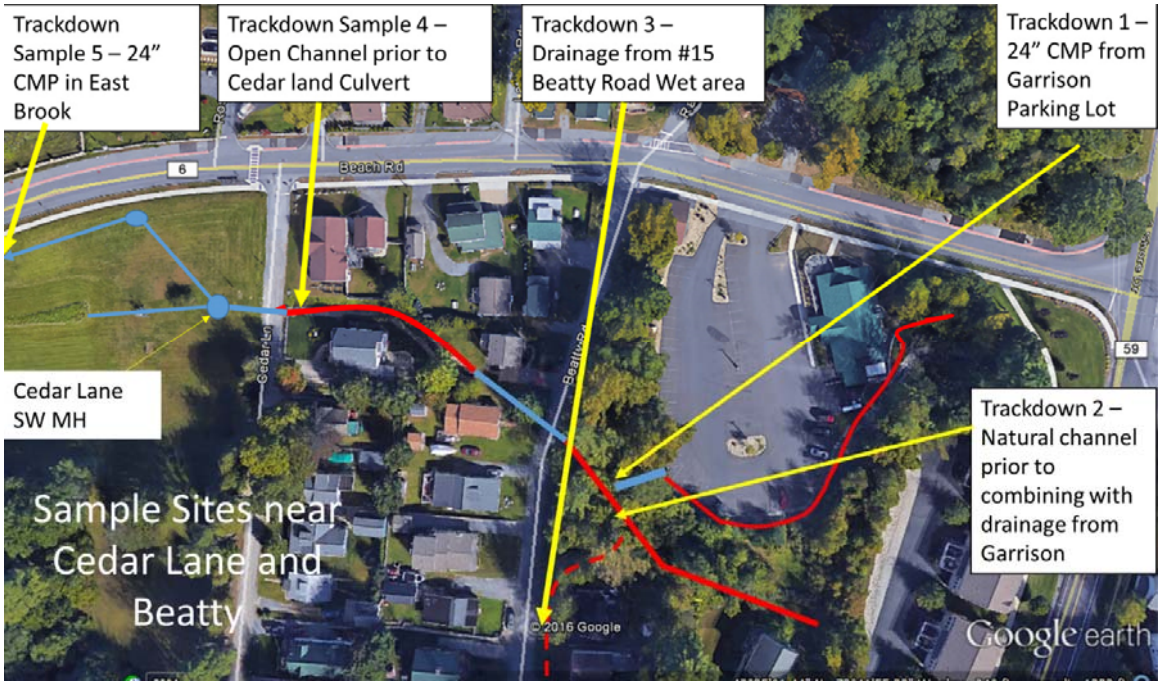


Figure B3. Cedar Land/Beatty Road stormwater system trackdown sampling locations

Table B6. West Brook Road stormwater system trackdown sampling results

Sample Date	Site ID	Site Description	*E. coli* Sample Result (col./100 mL)
6/22/2017	1	West Brook Road	57.1
6/22/2017	2	West Brook Road	111.9
6/22/2017	3	West Brook Road	71.7
6/29/2017	CB1, NWBPL	West Brook Road	30.1
6/29/2017	CB2, NWBPL	West Brook Road	156.5
6/29/2017	CB3, NWBPL	West Brook Road	7.4
6/29/2017	CB4, NWBPL	West Brook Road	4.1
6/29/2017	CB4A, NWBPL	West Brook Road	4.1

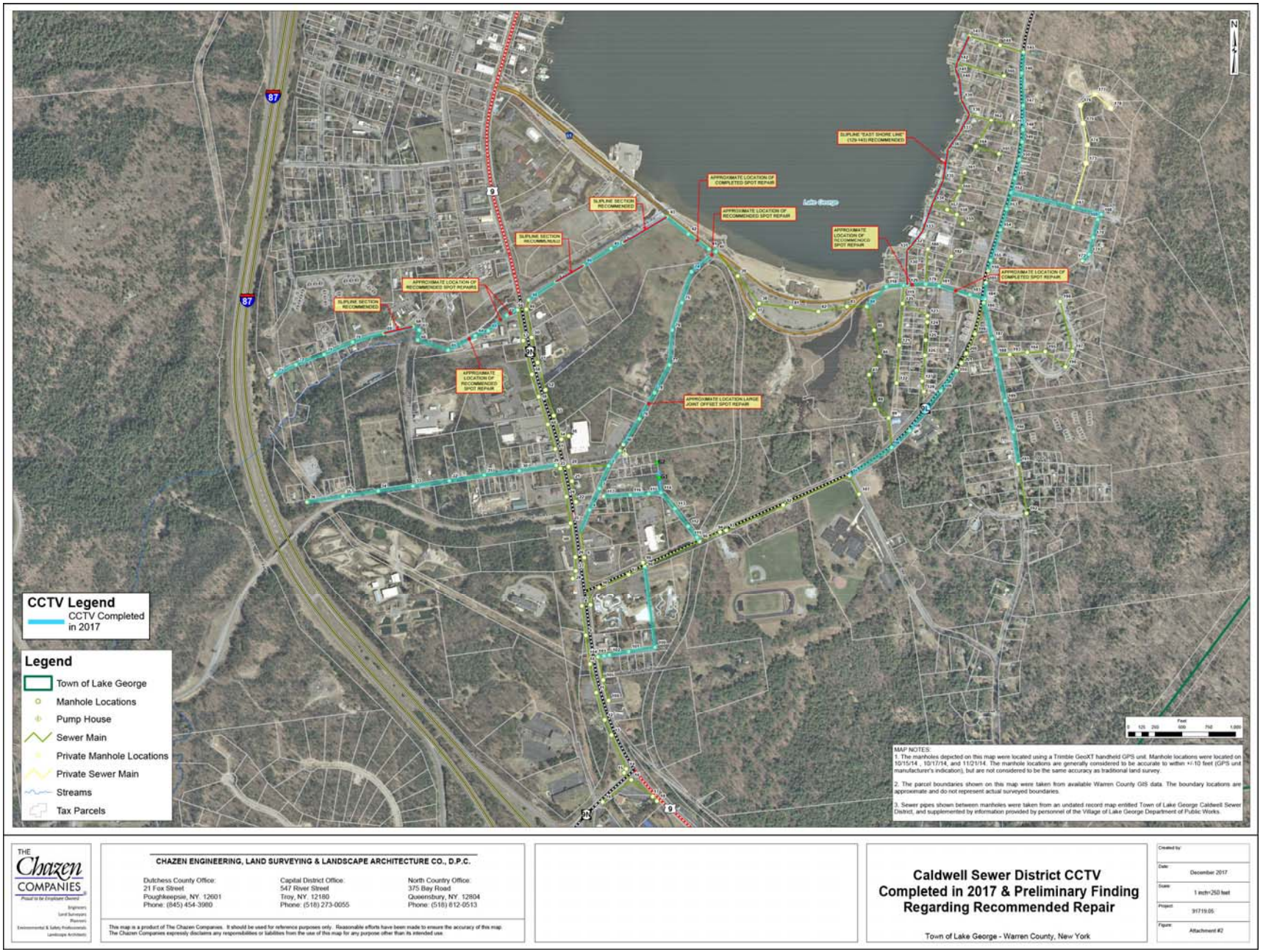
Microbial Source Tracking

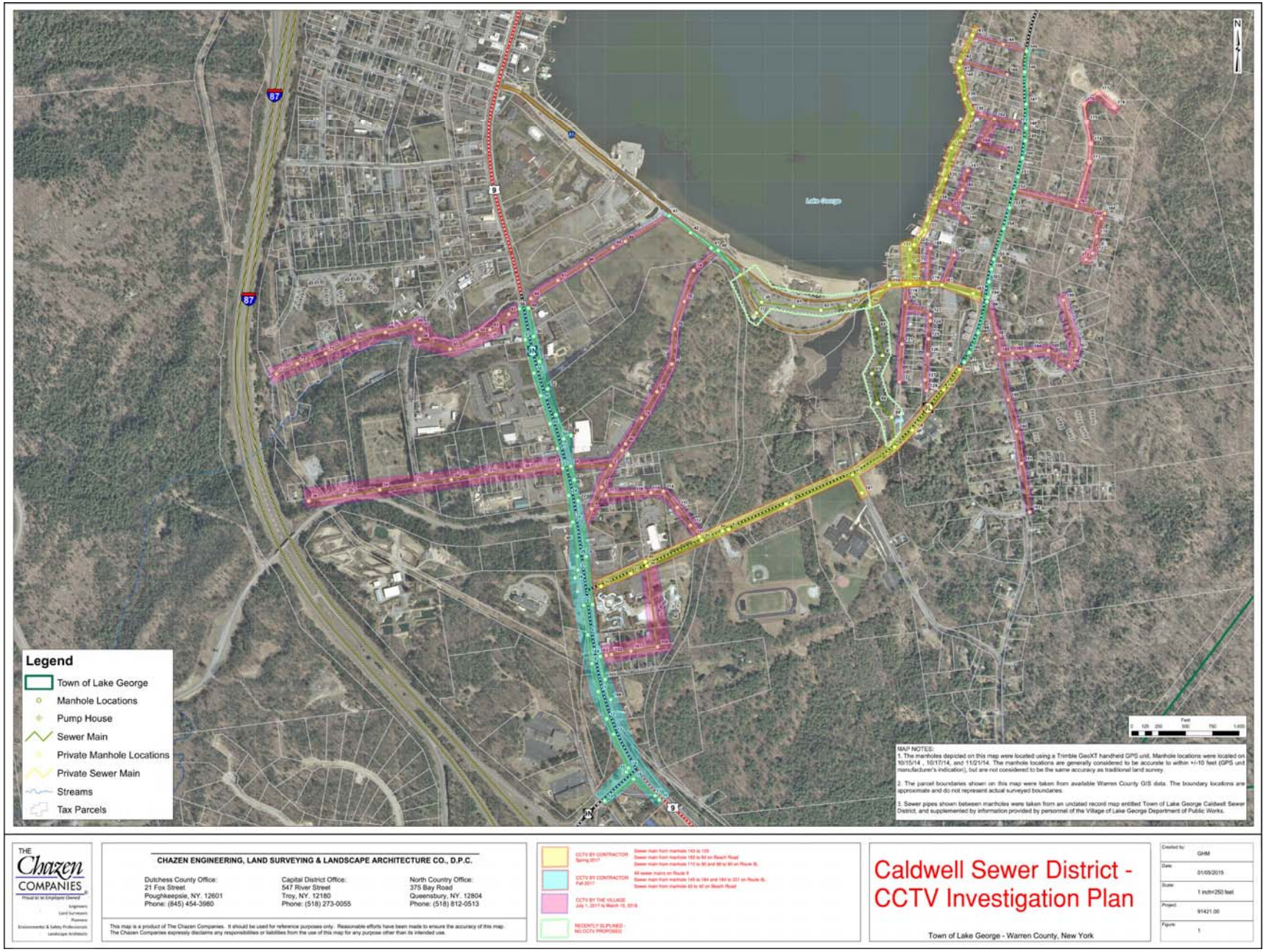
Water samples were collected for MST analysis by the DOH Wadsworth Laboratory. MST is a set of techniques used to determine whether fecal bacteria is being introduced into surface water through human, wildlife or domestic animal sources. PCR and qPCR analysis are used to differentiate between bacteria associated with different human/animal hosts. Unlike traditional bacteriological analysis methods, MST does not quantify the amount of bacteria in a sample. Water samples must be tested for *E. coli* prior to MST analysis to determine if there are enough bacteria present in a sample to run the PCR and qPCR analysis. *Bacteriodes* associated with humans were detected in water samples collected on four sampling days (Table B7). In each case, multiple primer sets or primer/probe sets were used. *Bacteriodes* associated with dogs and cows were not detected in any samples.

Table B7. Microbial Source Tracking (MST) Analysis Results

Sample Date	Sample ID	Positive Markers (PCR)	Final Source Determination
6/10/2017	Site #1 – Confluence of West Brook	Hum163, Rum	Human, Ruminants (non-cow)
	Site #4 – Confluence of East Brook	Hum163	Human
6/16/2017	Site #1 – Confluence of West Brook	Hum163, Rum	Human, Ruminants (non-cow)
	Site #4 – Confluence of East Brook	Hum163, Rum	Human, Ruminants (non-cow)
7/10/2017	Site #1A – Open Channel to Cedar Land Culvert	Hum163	Human
8/31/2017	Site EB-G – East Brook Wetland	Bac32, Rum, HF183, Hum163, Avian	Human, Ruminants, Birds
	Field Blank	None	None

APPENDIX C: POLLUTION SOURCE INVESTIGATION




Legend
Town of Lake George
Manhole Locations
Pump House
Sewer Main
Private Manhole Locations
Private Sewer Main
Streams
Tax Parcels
MAP NOTES:
1. The manholes depicted on this map were located using a Trimble GeoXT handheld GPS unit. Manhole locations were located on 10/15/14 , 10/17/14, and 11/21/14. The manhole locations are generally considered to be accurate to within +/-10 feet (GPS unit manufacturer's indication), but are not considered to be the same accuracy as traditional land survey.
2. The parcel boundaries shown on this map were taken from available Warren County GIS data. The boundary locations are approximate and do not represent actual surveyed boundaries.
3. Sewer pipes shown between manholes were taken from an undated record map entitled Town of Lake George Caldwell Sewer District, and supplemented by information provided by personnel of the Village of Lake George Department of Public Works.
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CCTV BY CONTRACTOR Spring 2017
CCTV BY CONTRACTOR Fall 2017
CCTV BY THE VILLAGE July 1, 2017 to March 15, 2018
RECENTLY SLIPLINED - NO CCTV PROPOSED
Caldwell Sewer District - CCTV Investigation Plan
Town of Lake George - Warren County, New York
Created by: GHM
Date: 01/05/2015
Scale: 1 inch=250 feet
Project: 91421.00
Figure: 1


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