FAIRFIELD COUNTY
RIVER REPORT

Harbor Watch | 2016

Fairfield County River Report: 2016

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This report includes data on:

Byram River, Farm Creek, Mianus River, Mill River, Noroton River, Norwalk River, Poplar Plains Brook, Rooster River, Sasco Brook, and Saugatuck River

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Key terms and information about this report:

Acronyms:

- CT DEEP: Connecticut Department of Energy and Environmental Protection
- CFU/100 mL: Colony forming units per 100 mL. This is a unit of measurement for bacteria concentrations. A colony is raised from a single bacterium to a visible colony for counting by providing the preferred heat range and media for 24 hours.

Study Site Naming:

- Sites are numbered with the lowest number (1) being closest to the mouth of the river where it meets a larger body of water or Long Island Sound. Sites with the highest numbers are located furthest upstream.
- Site names that include “SD” indicate that the sample location is a storm drain outfall rather than an instream location. These sites are not held to the same pass/fail assessment standards as instream sites and were not included in the figures.

Terms in Tables:

- No Sample: Indicates that a sample was not taken at that time for reasons including broken or lost sample bottle, stagnant water, inaccessibility due to construction or other factors, or dry river bed.
- TNTC: The colonies on the petri dish were too numerous to count.
- N/A: Indicates data not available because the site was added to the sampling plan for that river at a later date.
- Wet: Rainfall is indicated as “Wet” if >0.1 inches of rain fell within 2 days prior to sampling.
- Dry: Rainfall is indicated as “Dry” if <0.1 inches of rain fell within 2 days prior to sampling.

Introduction

The mission of Harbor Watch is to provide the people of Connecticut with the data, knowledge, and field expertise necessary to safeguard our waterways, educate our communities about watershed issues, and train volunteers and student interns through hands-on research. Here, we present a study of water quality in rivers throughout Fairfield County, Connecticut. The objective of this monitoring was to assist in the location of sources of sewage pollution from point and non-point sources, using *Escherichia coli* (*E. coli*) as an indicator.

Harbor Watch has been conducting monitoring projects throughout Fairfield County for 30 years. With the help of dedicated municipal partners, we have been able to identify and remediate numerous sources of sewage pollution to our rivers and Long Island Sound. The 2016 monitoring season was the largest range in geography in the history of the Harbor Watch program; the furthest east waterway tested was the Rooster River in Bridgeport, the furthest west was the Byram River in Greenwich, and the farthest north was the Saugatuck River in Redding. In this report, we present the data that we collected in 10 rivers throughout 14 towns.

This report focuses on the results of three water quality indicators; *E. coli*, dissolved oxygen, and conductivity. *E. coli* was selected for study because it is the indicator bacteria of choice for the Environmental Protection Agency and Connecticut Department of Energy and Environmental Protection (CT DEEP) for sewage pollution in freshwater systems. Its presence in high concentrations suggests that there are likely also more harmful pathogens present. Dissolved oxygen is an important water quality indicator because many aquatic species rely on dissolved oxygen for survival, similarly to how land animals rely on oxygen in the air. When dissolved oxygen is not available, species like fish and macroinvertebrates will relocate to higher quality waters, or die due to the lack of oxygen. Conductivity is a measure of how easily the water can carry an electrical current by measuring the ionic strength of the water. It can quantify the intrusion of salt water or other sources of salts and other compounds into a waterway.

Methods

Each river was visited approximately twice per month from May through September for a total of 10 sampling days per river. Sites were selected based on access and representativeness of the river, with effort made to space sites evenly throughout the length of the river. Monitoring was carried out under Quality Assurance Project Plans approved by the CT DEEP (RFA #14102, #16080, #16079, #16081, #16082, #16044, #16083, and #16084).

Monitoring teams left Earthplace in Westport, CT in the mid-morning to begin sampling and would return within 2-3 hours. Each team was comprised of fully-trained Harbor Watch employees, sometimes accompanied by volunteers. At each site, a water sample was collected and kept on ice. Water temperature, dissolved oxygen, and conductivity were measured at each site using a YSI Pro2030 meter.

Upon return to the Harbor Watch laboratory, the water samples were analyzed for fecal coliform and *E. coli* using membrane filtration methods set forth in Standard Methods (SM9222D and SM9222G). *E. coli* concentrations were evaluated using the criteria published in the CT DEEP Surface Water Quality Standards on 10/10/13 (Table 1). Because the rivers we tested do not contain designated swim areas, the "all other recreational uses" criteria will apply.

Table 1. CT DEEP criteria for *E. coli* levels as applied to recreational use, effective 10/10/13.

Designated Use Recreation	Class	Indicator	Criteria
Designated Swimming	AA, A, B	*Escherichia coli*	Geomean less than 126 CFU/100 mL; Single Sample Maximum 235 CFU/100 mL
Non-designated Swimming	AA, A, B	*Escherichia coli*	Geomean less than 126 CFU/100 mL; Single Sample Maximum 410 CFU/100 mL
All Other Recreational Uses	AA, A, B	*Escherichia coli*	Geomean less than 126 CFU/100 mL; Single Sample Maximum 576 CFU/100 mL

Results and Discussion

A. Fairfield County Summary

From May through September 2016, Harbor Watch monitored 10 waterways, many of which were new to the roster of waterways we have previously monitored. There were 104 unique sampling locations that were sampled 10 times each. We found that many of these rivers did not meet the state criteria for bacteria (Table 1) and may be a conduit for sewage pollution to Long Island Sound. 62% of sites failed the CT DEEP geomean criterion of <126 CFU/100 mL (Figure A1 Left). One third of these sites were double the state criterion. In addition, 47% of sites failed the CT DEEP secondary single sample maximum criterion of <10% of *E. coli* samples at each site >576 CFU/100 mL (Figure A1 Right). The Mianus River, which flows through Stamford and Greenwich, had the fewest exceedances of the CT DEEP criteria. The Rooster River, which traverses the Bridgeport/Fairfield line, had the most exceedances of the CT DEEP criteria (Figure A1).

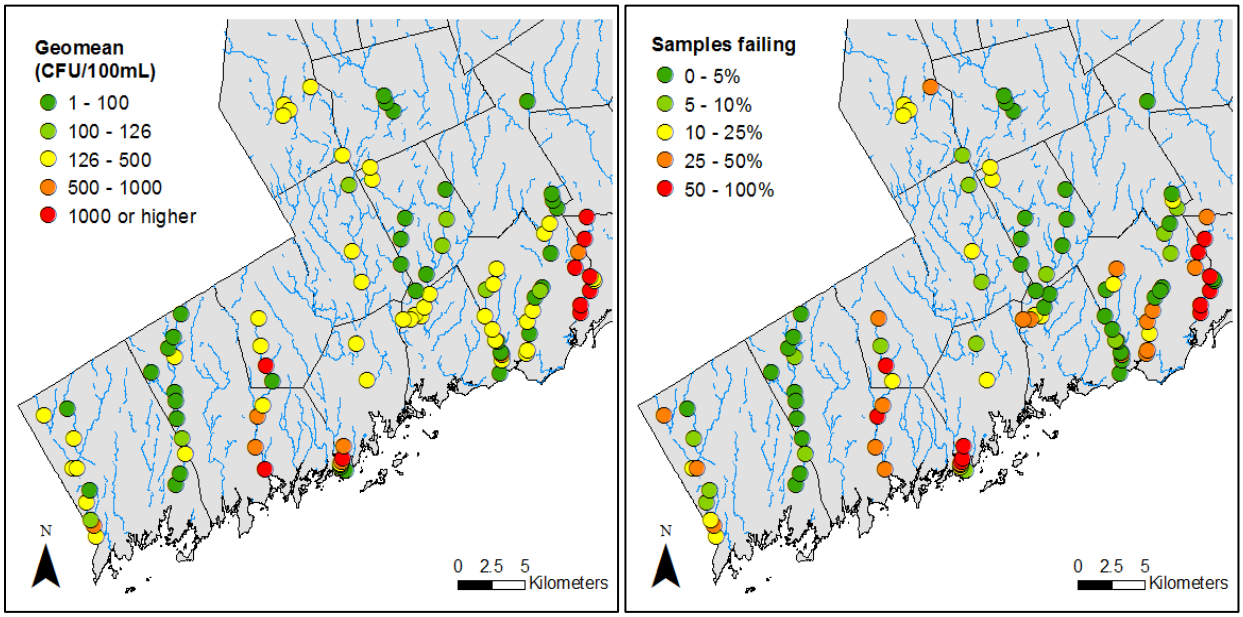

Figure A1. Map of 2016 sampling locations and *E. coli* concentrations. (Left) *E. coli* geomean for each site. The bacteria level for each site was compared to the state criteria for recreational waters. Passing sites have a geomean less than 126 CFU/100 mL. (Right) *E. coli* single sample maximums for each site. The bacteria level for each sample was compared to the state criteria for recreational waters. Passing sites have less than 10% of their samples exceeding 576 CFU/100 mL.

The state has also set the criterion for dissolved oxygen levels at a minimum of 5 mg/L. While many of the sampling sites met this criterion, a number of sites had mean dissolved oxygen values which fell below 5 mg/L (Figure A2). Prolonged events of low dissolved oxygen conditions can be harmful to aquatic and marine organisms. Dissolved oxygen values can be attributed to a number of different factors such as low flow, decomposition of organic matter,

and warm water temperature, many of which we observed over the course of the sampling season.

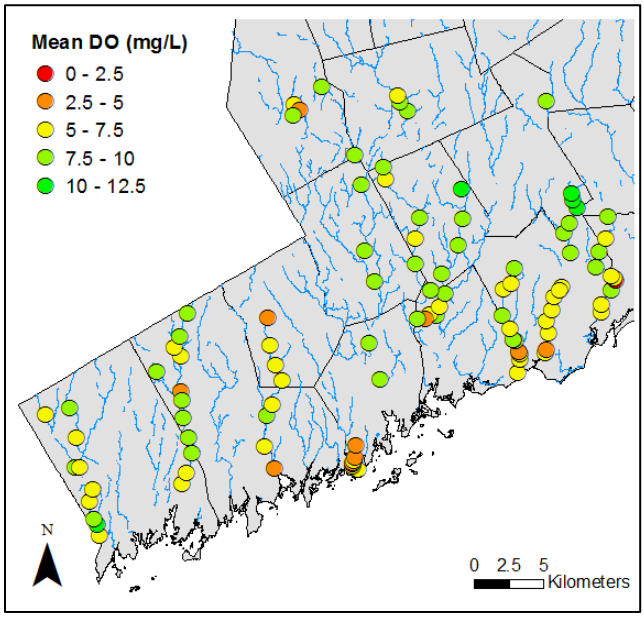

Figure A2. Map of 2016 river sampling locations and mean dissolved oxygen values. The dissolved oxygen level for each sample was compared to the state criterion of a minimum of 5 mg/L.

During the 2016 monitoring season very little rain fell from May through September. July had the largest precipitation totaling 4.8 inches and June had the least amount totaling 1.26 inches (Figure A3; Weather Underground-KBDR). Rainfall can help improve water quality by pushing a larger volume of water through the river bed. This in turn can alleviate low flow problems such as decreased dissolved oxygen levels which tend to occur during droughts. However, rainfall can also push runoff from yards, forests, and impervious surfaces into the waterway, impacting bacteria concentration and conductivity values.

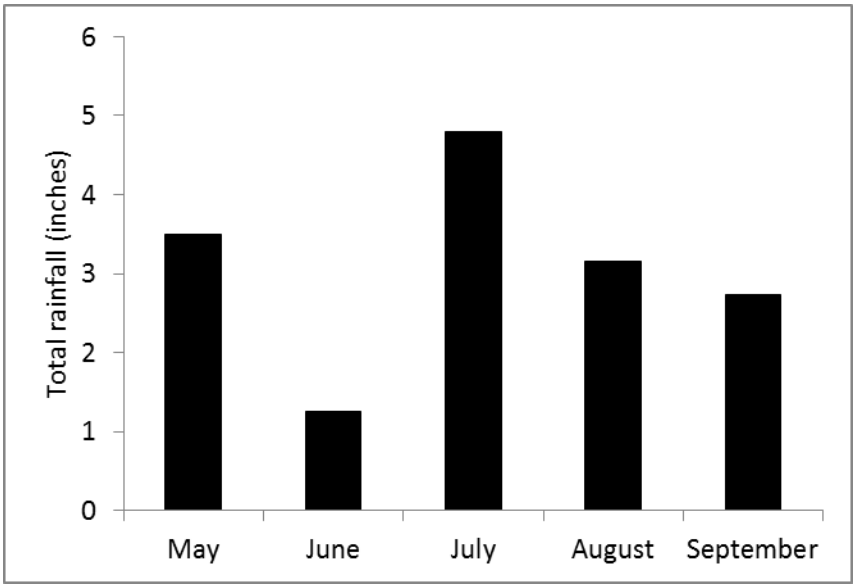

Figure A3. Monthly rainfall totals for 2016 (Weather Underground-KBDR).

Harbor Watch collects data on Fairfield County waterways for a number of different reasons. One goal is to better understand the ecological health of our watersheds by monitoring dissolved oxygen, conductivity, water temperature, and bacteria levels. Another goal is to use data that we collect to inform where pollution sources may be so that they can be remediated. This data can focus our efforts on areas that are in need of further investigations. During 2016, we conducted 4 pollution track-down surveys in Darien, Norwalk, and Fairfield storm water systems. These pollution track-down surveys are ongoing and will continue year-round. Our process has been successful in identifying point sources of pollution such as leaking sanitary sewer lines, broken sewer laterals, and pipes illegally hooked into the storm water system. By partnering with municipalities to fix these problems, we have seen up to 95% reductions in bacteria concentrations entering our waters from previously observed sources! However, the prevalence of failing bacteria concentrations observed this year (Figure A1) indicate that there is still much work to be done to protect and restore our rivers and Long Island Sound.

In the chapters that follow, we present the detailed results of the water quality monitoring conducted in the 10 waterways studied by Harbor Watch in 2016 (Byram River, Farm Creek, Mianus River, Mill River, Noroton River, Norwalk River, Poplar Plains Brook, Rooster River, Sasco Brook, and Saugatuck River).

B. Byram River

The Byram River watershed encompasses portions of four communities whose political boundaries fall within the states of Connecticut and New York. The majority of the river is located in Greenwich, CT. The three towns in New York through which the river runs are New Castle, Purchase, and Port Chester, which fall within Westchester County. The Watershed is approximately 12,000 acres or 18.7 square miles and defined by 2 main drainage basins, the Byram River and the East Branch of the Byram River. The main stem of the Byram River is approximately 14 miles long. The river begins at the Byram River reservoir and flows south, ultimately discharging to Long Island Sound through Port Chester Harbor. The land use in the watershed is predominantly residential.

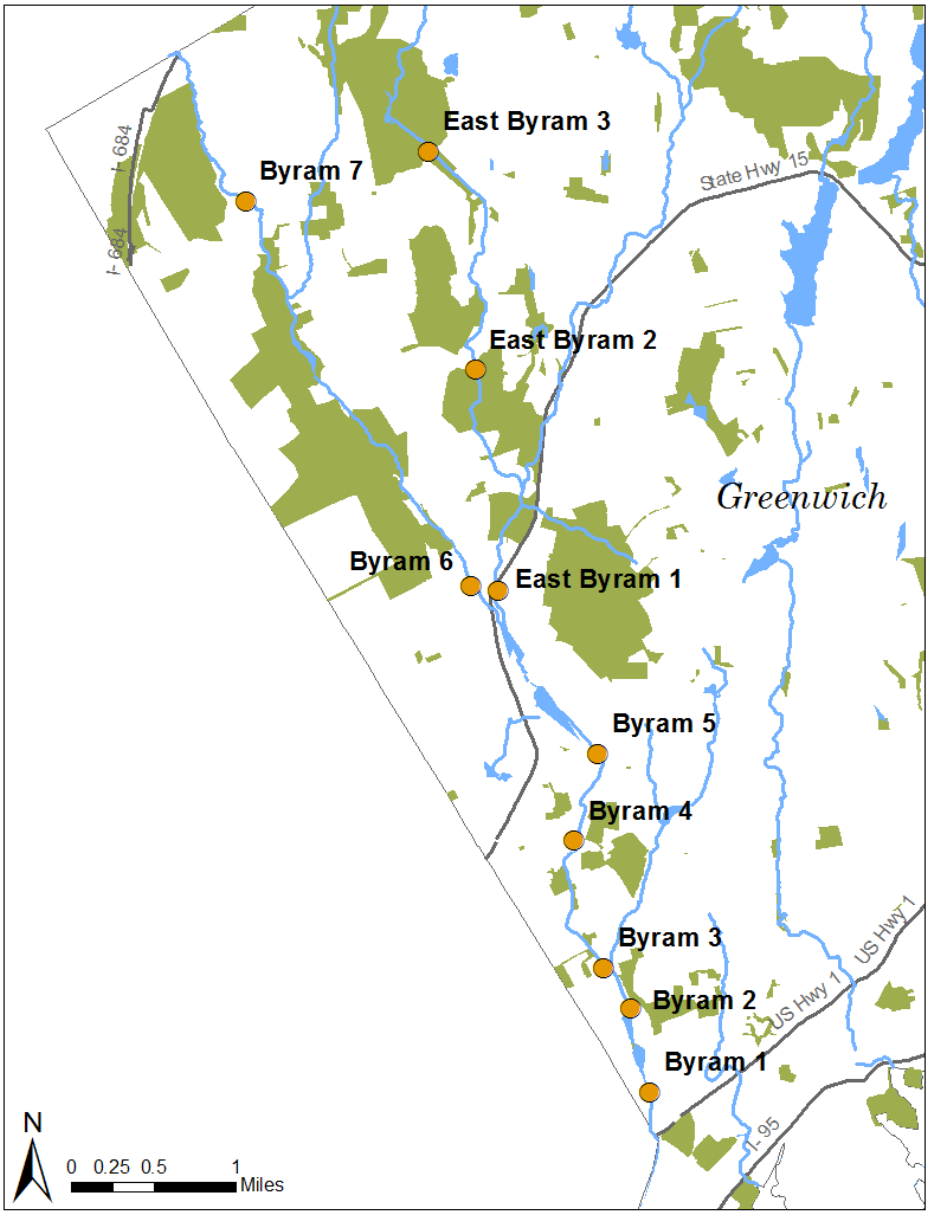

Figure B1. Sample locations for 10 sites on the Byram River.

This was the first year that Harbor Watch collected data on the Byram River. Site locations were chosen to complement ongoing sampling conducted by the Town of Greenwich. We found that the Byram River was not meeting the state criteria for *E. coli*, but was exceeding the minimum criterion for dissolved oxygen. We suggest further investigation of the watershed in the coming monitoring seasons to identify what sources may be contributing to the elevated bacteria levels observed in the river.

Of the 10 sites on the Byram River, only one site, East Byram 3, met both CT DEEP criteria for *E. coli* (Figure B2, Table B1). The remaining nine sites exceeded the geomean criterion (<126 CFU/100 mL) for *E. coli*, the single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL), or both criteria (Figure B2, Table B1). Elevated bacteria concentrations were observed on sampling dates during which more than 0.1 inches of rain fell during the collection or within the prior two days of sampling. Byram 1 was also known to be an area where geese and other water fowl congregated, which can be a contributing factor to elevated bacteria concentrations during all weather conditions.

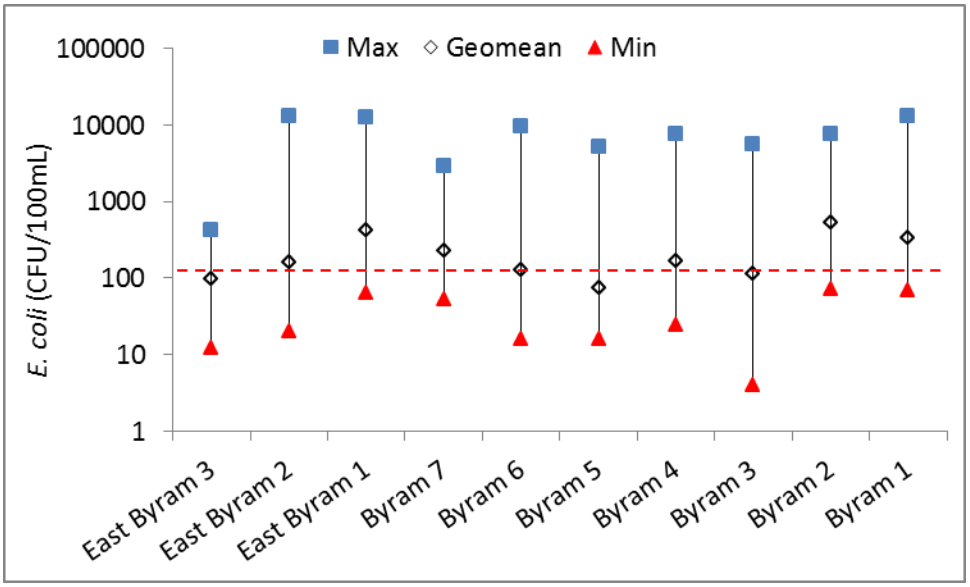

Figure B2. Byram River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table B1. Byram River *E. coli* concentrations and relation to CT DEEP water quality criteria (rainfall data: M. Long, personal communication, Oct 26, 2016)

	5/16	6/6	6/23	6/30	7/12	7/27	8/7	8/30	9/6	9/19	Geomean	% >576
East Byram 3	12	160	350	420	50	212	236	48	28	No Sample	99	0%
East Byram 2	160	460	20	130	72	160	320	56	24	13300	162	10%
East Byram 1	64	770	620	320	290	280	300	144	400	12700	421	30%
Byram 7	52	2900	No Sample	130	80	208	800	64	52	2200	232	33%
Byram 6	16	1506	60	140	24	140	68	28	84	9500	126	20%
Byram 5	16	490	20	110	28	76	76	28	16	5200	76	10%
Byram 4	24	490	110	140	120	92	380	24	148	7700	171	10%
Byram 3	52	900	30	190	80	176	72	64	4	5500	114	20%
Byram 2	72	2700	400	590	150	620	460	300	380	7500	528	40%
Byram 1	76	3600	150	160	68	240	440	96	TNTC	12900	339	22%
Rainfall	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Dry	Dry	Wet		

All average dissolved oxygen values exceeded 5 mg/L which is the CT DEEP minimum criterion (Figure B3). Individual values fell below 5 mg/L at East Byram 2 on 9/6, Byram 7 on 9/19, and Byram 1 on 6/30, 7/27, 8/7, and 8/30. Low dissolved oxygen levels can be attributed to low flow and organic matter decay. Byram 1 in particular was shallow in depth and the river was slow moving due to drought conditions experienced during the monitoring season.

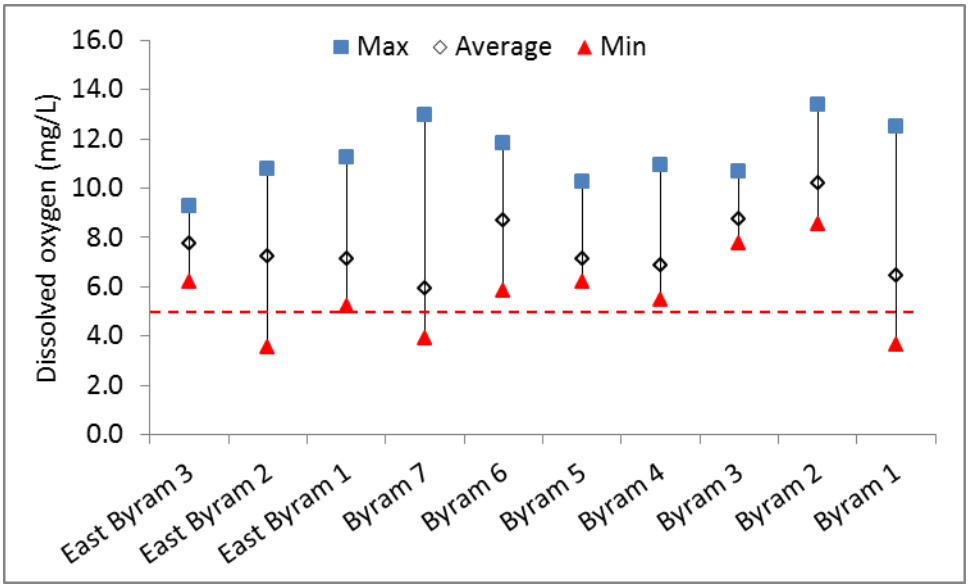

Figure B3. Byram River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Conductivity values were stable across the majority of the sites. Conductivity value ranges at Byram 7 and Byram 6 were large and elevated relative to the rest of the sites (Figure B4). Fluctuating conductivity values at these sites may be related to runoff from the country clubs just upstream of the sampling location. Lower amounts of rainfall may be responsible for the stability of conductivity values in the other sampling locations by reducing the amount of ions entering the water through runoff.

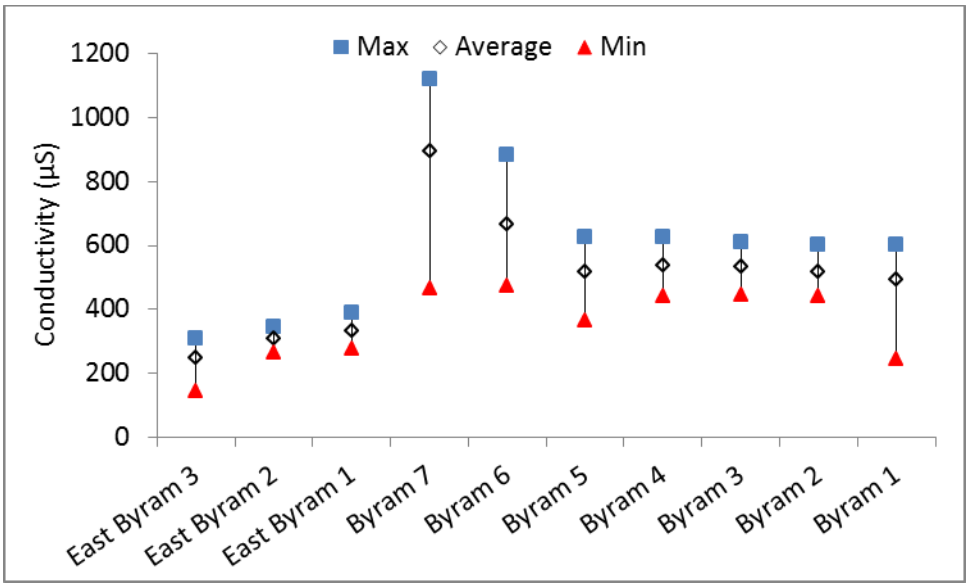

Figure B4. Byram River conductivity values. Maximum, average, and minimum for each site.

Table B2. GPS coordinates and site locations for the Byram River

Station Number	Latitude	Longitude	Town	Comments
Byram 1	41.01649	-73.65623	Greenwich	Den Lane, end of road
Byram 2	41.02383	-73.65859	Greenwich	2 Upland Street East
Byram 3	41.02740	-73.66169	Greenwich	Comly Avenue and Pemberwick Road
Byram 4	41.03858	-73.66530	Greenwich	Glenville Street
Byram 5	41.04627	-73.66265	Greenwich	7 Bailiwick Road
Byram 6	41.06092	-73.67760	Greenwich	Sherwood Avenue
Byram 7	41.09460	-73.70437	Greenwich	111 Bedford Road
East Byram 1	41.06051	-73.67454	Greenwich	329 Riversville Road
East Byram 2	41.07998	-73.67743	Greenwich	105 Porchuck Road
East Byram 3	41.09915	-73.68308	Greenwich	88 John Street

C. Farm Creek

Farm Creek is a small tributary to Long Island Sound located entirely in Norwalk, CT. The creek begins north of Roton Middle School, flows south to where the creek opens up to an estuary surrounded by salt marsh, and ultimately discharges to Wilson Cove. Most of the watershed is residential with a few school campuses which include large sports fields.

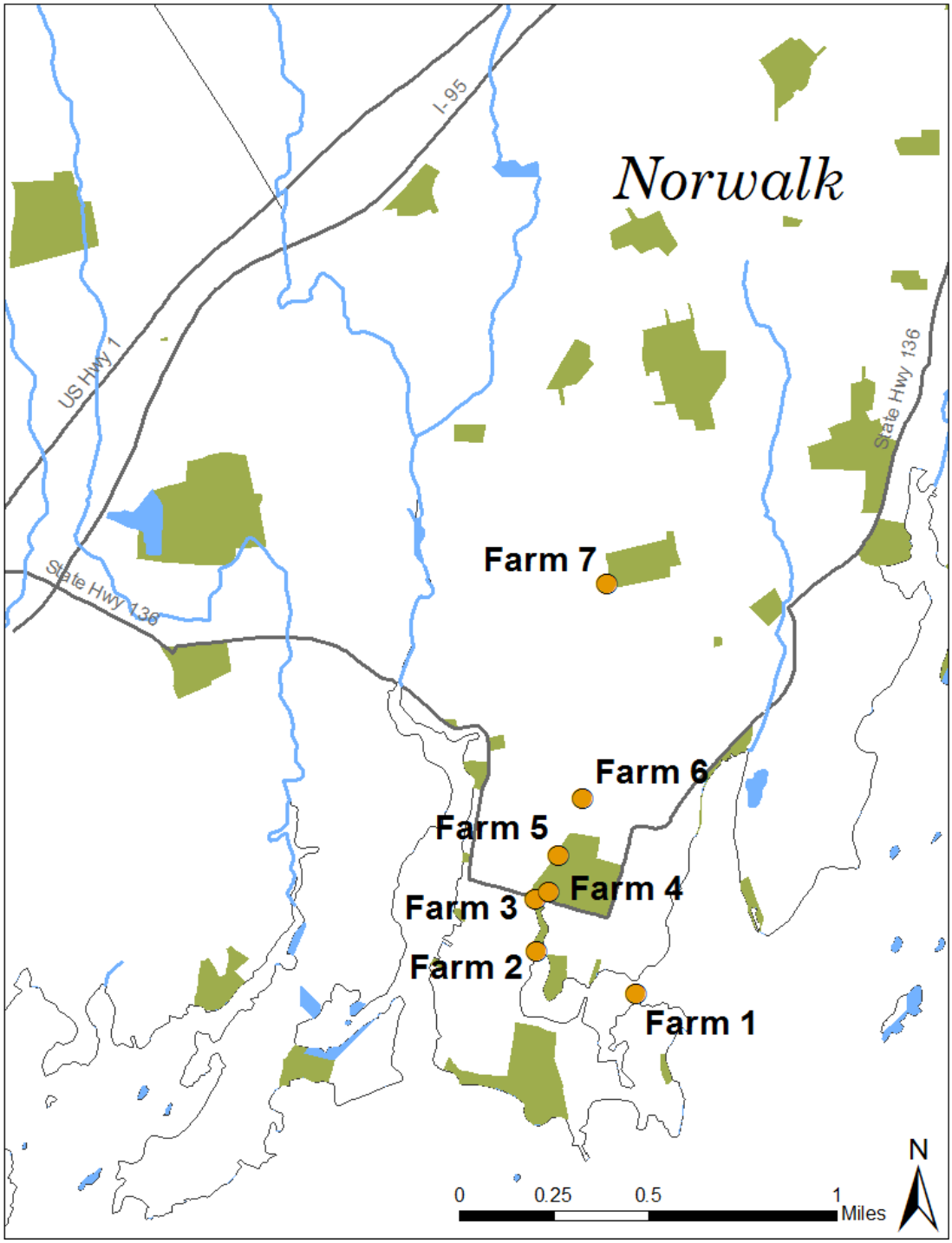

Figure C1. Sample locations for 7 sites on the Farm Creek.

While we have monitored Farm Creek since 2014, most of the sampling took place in the late fall to early spring. This is the first year in which we sampled during the May through September monitoring season. Farm Creek did not meet the CT DEEP criteria for *E. coli* and often fell below the minimum criterion levels for dissolved oxygen. Bacteria concentration geomean failures in 2016 occurred more often than in 2015 (Figure C2). We suggest further investigation to identify areas where sewage pollution may be entering the creek. We have begun working with the City of Norwalk Conservation Department to create a plan for adding additional monitoring sites.

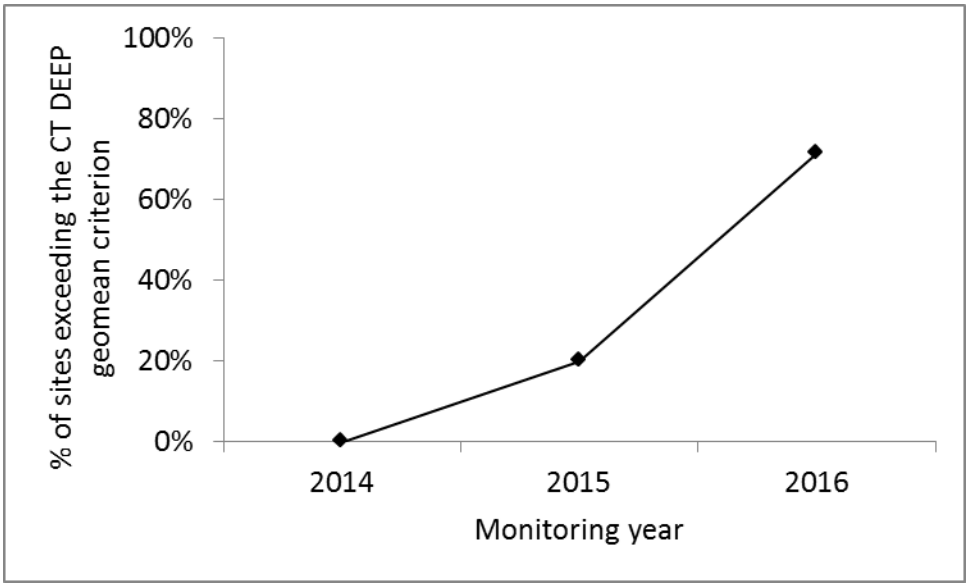

Figure C2. Historic look at Farm Creek CT DEEP geomean criterion exceedances.

The five upstream sites exceed both the geomean criterion (<126 CFU/100 mL) and the single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL; Figure C2, Table C1). The two sites closest to the mouth exceeded only the single sample maximum criterion (Table C1). Farm Creek is tidally influenced up to Farm 3, and Farm 1 is inundated with brackish water regardless of the tide cycle. Since sample collection was conducted regardless of the tides, the low geomean at Farm 2 and Farm 1 could be associated with dilution when samples were collected at high tide. The causes for the elevated bacteria counts throughout the length of the creek are unknown at this time, but may be influenced by the large number of water fowl that congregate at a few of the sampling sites.

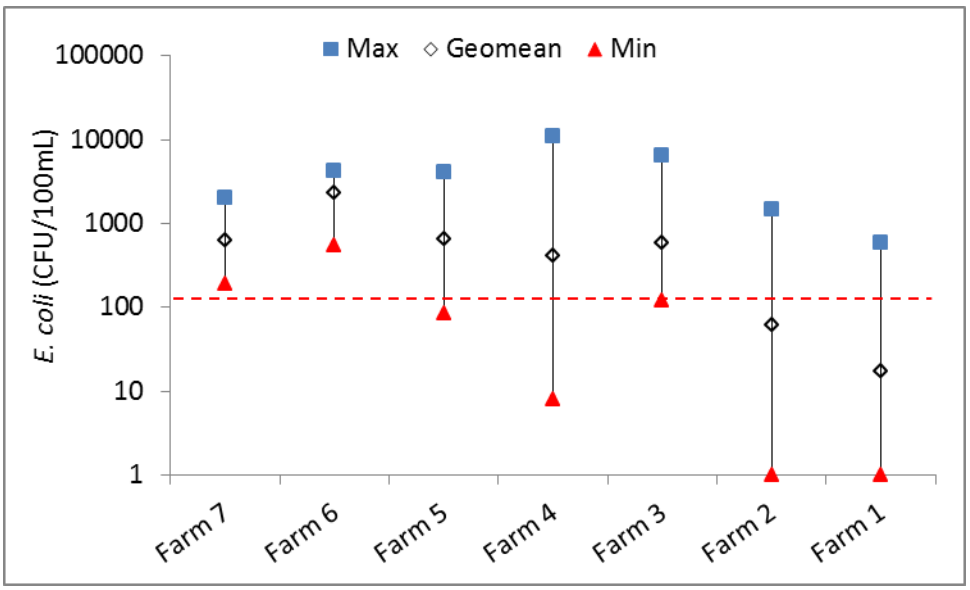

Figure C3. Farm Creek *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table C1. Farm Creek *E. coli* concentrations and relation to CT DEEP water quality criteria. Blue cells represent actual *E. coli* count of 0 CFU/100mL, but were changed to calculate geomean (rainfall data: P. DiPietro, personal communication, Oct 26, 2016)

	5/18	5/31	6/13	7/5	7/13	7/26	8/15	8/29	9/12	9/27	Geomean	% >576
Farm 7	N/A	N/A	N/A	N/A	N/A	2000	660	190	dry	TNTC	631	67%
Farm 6	N/A	N/A	N/A	N/A	N/A	4000	3300	550	2280	4320	2349	80%
Farm 5	940	980	204	N/A	1000	4100	1400	430	84	TNTC	667	63%
Farm 4	8	TNTC	184	TNTC	11000	480	650	No Sample	No Sample	960	411	50%
Farm 3	120	TNTC	420	6400	250	500	1500	250	900	740	600	44%
Farm 2	52	TNTC	72	1500	30	500	10	1	28	640	63	22%
Farm 1	1	250	8	600	1	60	10	20	20	8	17	10%
Rainfall	Dry	Wet	Wet	Wet	Dry	Wet	Wet	Dry	Dry	Wet		

Mean dissolved oxygen values at sites Farm 7, Farm 6, Farm 4, and Farm 3 fell below the CT DEEP minimum criterion of 5 mg/L and all sites had individual readings which fell below the minimum as well (Figure C3). Farm Creek is shallow and has very low flow upstream of the intertidal areas which could be contributing to the low dissolved oxygen levels. Farm 4 is located downstream of a pond which gets clogged with plant growth such as duckweed throughout the summer months. The wide range of dissolved oxygen may be caused by the fluctuating plant life and decomposition throughout the monitoring season.

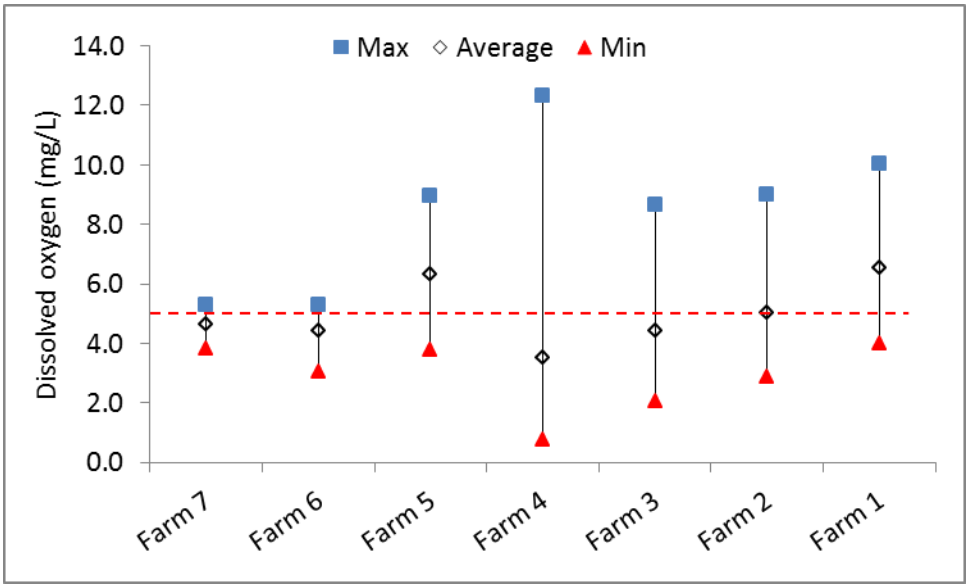

Figure C4. Farm Creek dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Conductivity ranges above the area of tidal incursion vary, with Farm 5 having the greatest range (Figure C4, left). While the cause of this is unknown, the site is located just downstream of a parking lot which may be a conduit for runoff directly into the creek. Conductivity values at the tidally influenced sites vary greatly due to the intrusion of salt water (Figure C4, right).

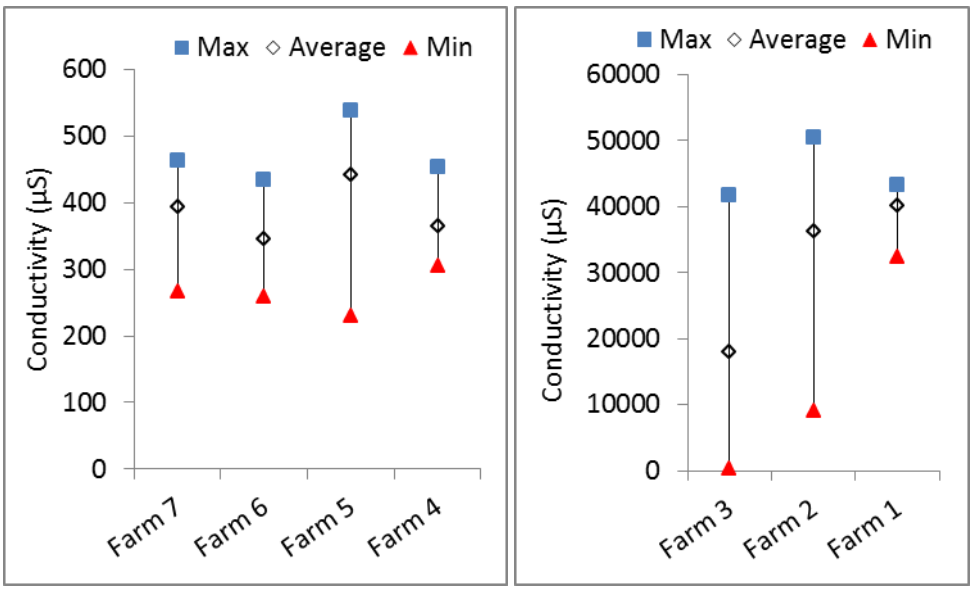

Figure C5. Farm Creek conductivity values. Maximum, average, and minimum for each site that is (left) above the area of tidal incursion and (right) tidally influenced.

Table C2. GPS coordinates and site locations for Farm Creek

Station Number	Latitude	Longitude	Town	Comments
Farm 1	41.06118	-73.43543	Norwalk	86 Bluff Avenue
Farm 2	41.06279	-73.44051	Norwalk	7 Sammis Street
Farm 3	41.06478	-73.44056	Norwalk	25 McKinley Street
Farm 4	41.06506	-73.43994	Norwalk	29 McKinley Street
Farm 5	41.06646	-73.43946	Norwalk	8 Roton Avenue
Farm 6	41.06866	-73.43821	Norwalk	3 Indian Spring Road
Farm 7	41.07687	-73.43706	Norwalk	55 Crooked Trail

D. Mianus River

The Mianus River watershed encompasses portions of four communities whose political boundaries fall within the states of Connecticut and New York. The two towns in Connecticut are Stamford and Greenwich, which fall within Fairfield County. The two towns in New York are New Castle, and Bedford, which fall within Westchester County. The watershed is approximately 18,300 acres or 28.7 square miles and defined by 2 main drainage basins: the Mianus River and the East Branch of the Mianus River. The main stem of the Mianus River is approximately 20 miles long. The river begins in New Castle, NY and flows northeast into Bedford, NY where it begins to flow south into the Mianus Reservoir and Stamford, CT. The river discharges into Long Island Sound through Cos Cob Harbor in Greenwich, CT. The land use along the river is a mixture of preserves (Mianus River Gorge), state parks (Mianus River Park), and residential.

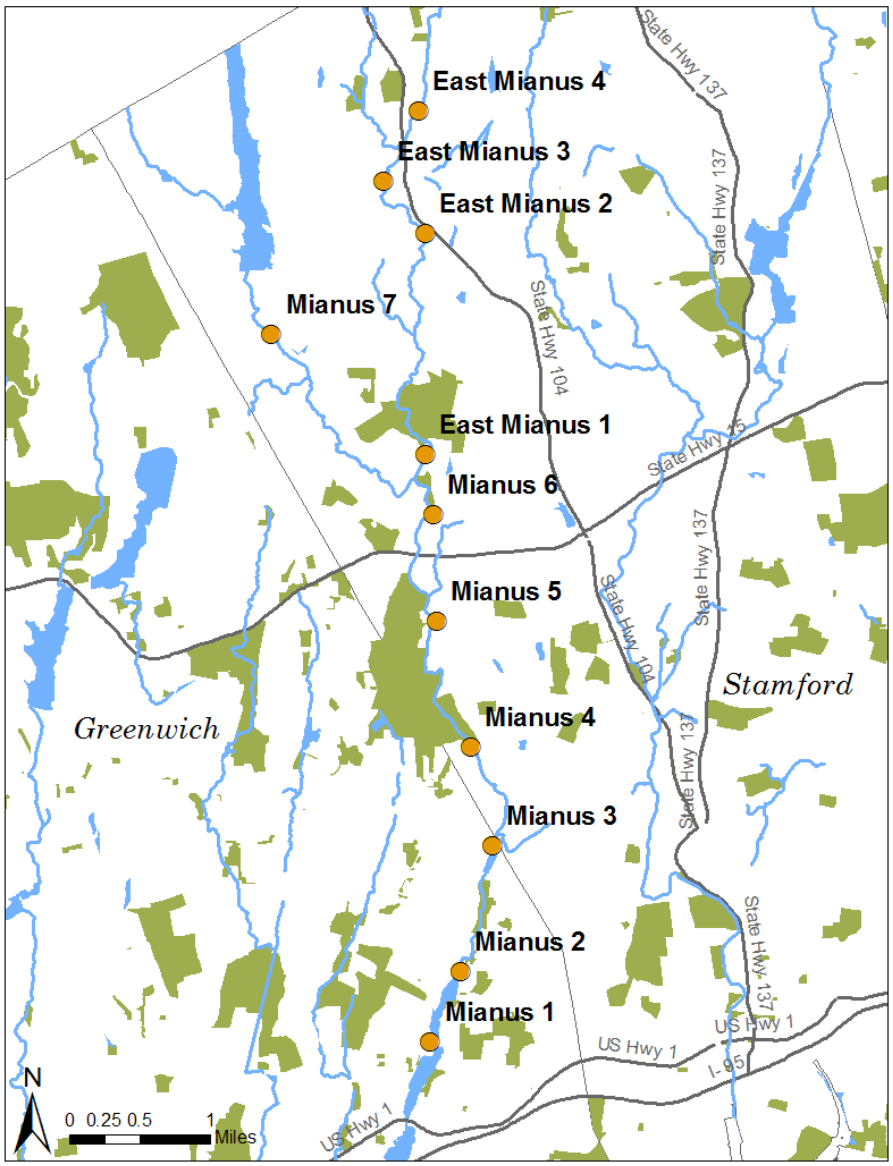

Figure D1. Sample locations for 11 sites on the Mianus River.

This was the first year that Harbor Watch collected data on the Mianus River. The water quality in the Mianus River was good and met CT DEEP criteria at almost all of the sites for both *E. coli* and dissolved oxygen. We suggest continuing monitoring in the 2017 monitoring season to ensure these results are not an anomaly due to drought conditions observed in 2016.

Two sites on the Mianus River, East Mianus 2 and Mianus 3, exceeded both the geomean criterion (<126 CFU/100mL) and the single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL) set by the CT DEEP (Figure D2, Table D1). The remaining nine sites met both the state criteria for *E. coli* (Figure D2, Table D1).

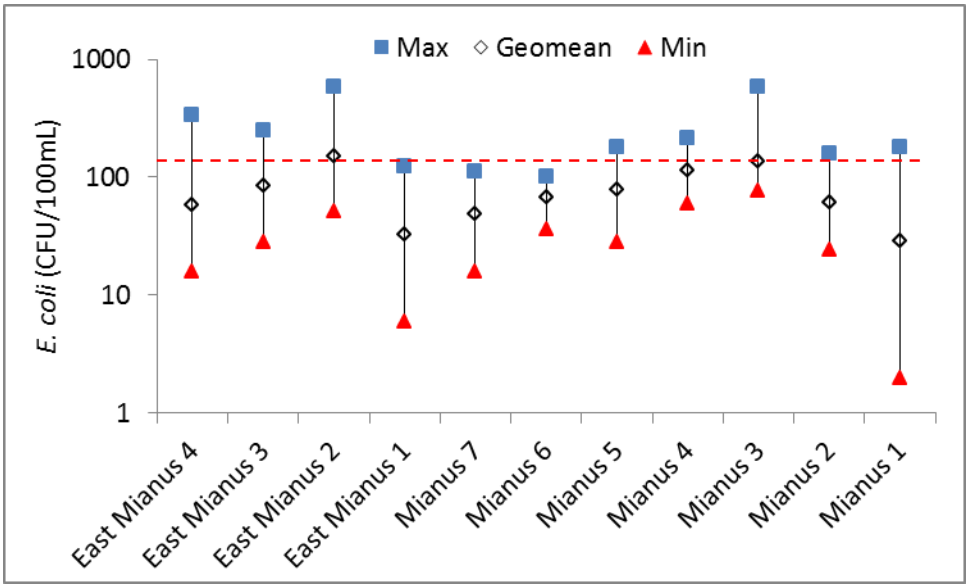

Figure D2. Mianus River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table D1. Mianus River *E. coli* concentrations and relation to CT DEEP water quality criteria (rainfall data: M. Long, personal communication, Oct 26, 2016)

	5/23	6/2	6/22	7/7	7/11	8/3	8/11	8/31	9/15	9/21	Geomean	% >576
East Mianus 4	24	56	16	340	52	48	280	20	18	240	58	0%
East Mianus 3	248	124	132	28	64	28	148	156	42	92	84	0%
East Mianus 2	268	68	52	120	92	136	580	104	310	250	152	10%
East Mianus 1	20	24	44	64	56	20	124	40	6	32	33	0%
Mianus 7	76	40	44	76	72	28	16	24	112	88	49	0%
Mianus 6	84	68	92	No sample	76	100	64	36	46	64	67	0%
Mianus 5	56	48	116	96	28	84	84	76	180	100	78	0%
Mianus 4	88	92	112	100	60	160	212	No sample	No sample	156	114	0%
Mianus 3	88	76	136	112	104	100	248	132	112	580	137	10%
Mianus 2	48	42	72	24	68	160	136	64	40	TNTC	62	0%
Mianus 1	N/A	N/A	32	56	60	100	20	12	2	180	31	0%
Rainfall	Dry	Dry	Dry	Wet	Wet	Dry	Wet	Dry	Dry	Wet		

The lowest observed dissolved oxygen values met CT DEEP minimum criteria of 5 mg/L at the majority of sites, and 10 of the 11 sites had mean dissolved oxygen levels above 5 mg/L (Figure D3). However, individual readings fell below 5 mg/L at multiple sites (Table D2). These low dissolved oxygen values may have been due to low flow through the large ponds along river and specifically above East Mianus 3, and Mianus Pond where Mianus 2 and Mianus 1 sites are located. Many of these ponds became choked with duckweed and other algae throughout the summer months.

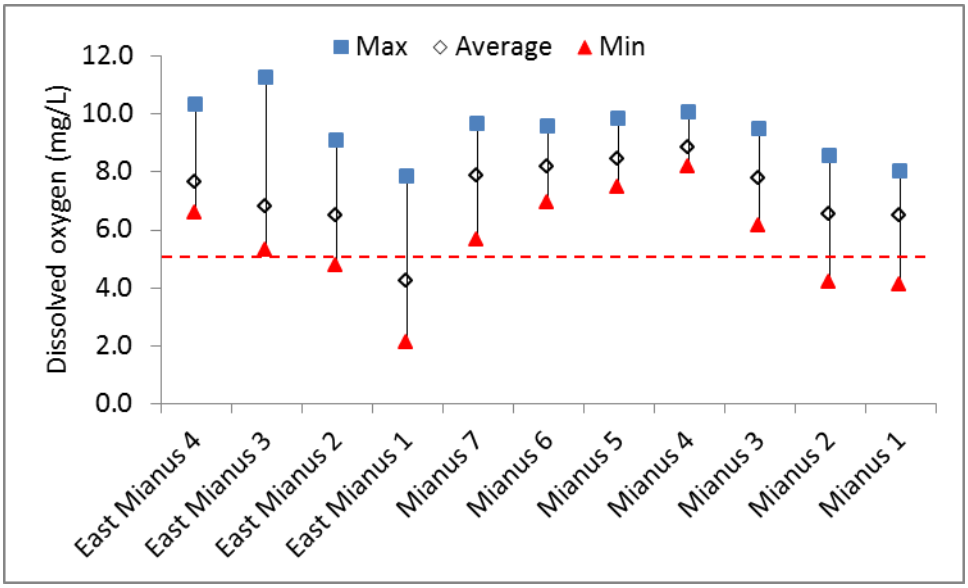

Figure D3. Mianus River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Table D2. Days during which dissolved oxygen levels fell below 5 mg/L

Site	Date	Value (mg/L)
East Mianus 2	8/11/2016	4.7
East Mianus 1	6/22/2016	4.5
	7/7/2016	4.5
	7/11/2016	3.9
	8/3/2016	4.0
	8/11/2016	3.5
	8/31/2016	3.7
	9/15/2016	2.1
	9/21/2016	2.6
Mianus 2	8/3/2016	4.9
	8/11/2016	4.2
Mianus 1	7/11/2016	4.5
	8/3/2016	4.1

Conductivity values along the length of the Mianus River remained stable with narrow ranges (Figure D4). This can be credited to the fact that river sampling begins below the Mianus Reservoir followed by sparsely populated residential areas and long stretches of river flowing through wooded parks. This allows for limited inputs from human contaminants which may enter the river during rainfall events.

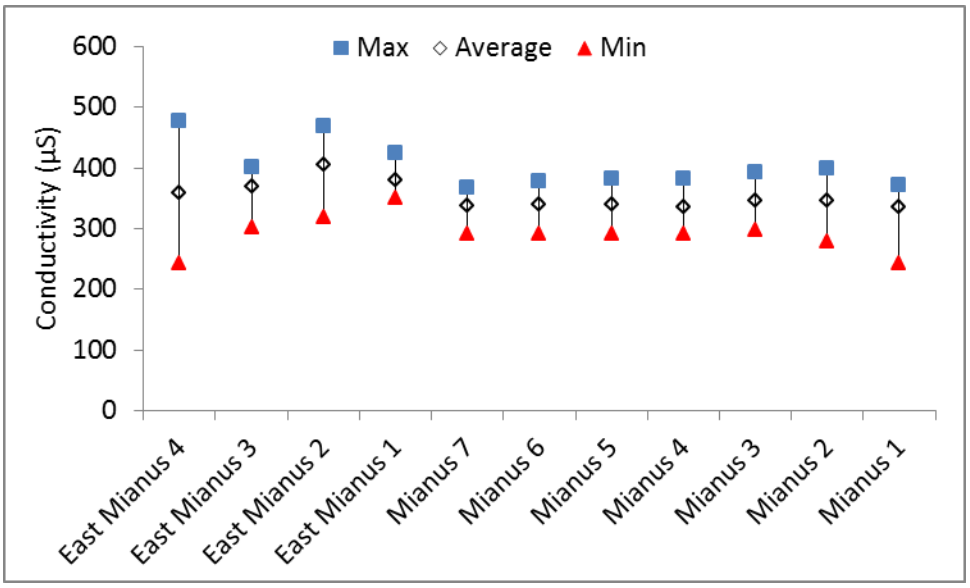

Figure D4. Mianus River conductivity values. Maximum, average, and minimum for each site.

Table D3. GPS coordinates and site locations for the Mianus River

Station Number	Latitude	Longitude	Town	Comments
Mianus 1	41.05034	-73.58622	Greenwich	179 Valley Road
Mianus 2	41.05760	-73.58222	Greenwich	Palmer Hill Road and Valley Road
Mianus 3	41.07069	-73.57806	Greenwich	499 Valley Road
Mianus 4	41.08076	-73.58111	Stamford	Mianus River Park trail head parking
Mianus 5	41.09368	-73.58594	Stamford	121 Old Mill Lane
Mianus 6	41.10473	-73.58652	Stamford	2 June Road
Mianus 7	41.12319	-73.60880	Stamford	215 Farms Road
East Mianus 1	41.11091	-73.58770	Stamford	365 Riverbank Road
East Mianus 2	41.13368	-73.58800	Stamford	180 Wildwood Road
East Mianus 3	41.13906	-73.59377	Stamford	1501 Riverbank Road
East Mianus 4	41.14636	-73.58899	Stamford	137 Old Long Ridge Road

E. Mill River

The Mill River watershed encompasses portions of six communities whose political boundaries fall within the state of Connecticut. The six Connecticut towns, all located in Fairfield County, are Redding, Easton, Monroe, Trumbull, Fairfield, and Bridgeport. The watershed is approximately 16,000 acres or 25.8 square miles. There are two large dams on the river which create reservoirs (Easton Reservoir and Swamp Mortar Reservoir) for drinking water and downriver flow control. The Mill River begins in the north-east corner of Easton and travels south into Southport Harbor in Fairfield.

This was the first year that Harbor Watch collected data on the Mill River. The Mill River did not meet the CT DEEP criteria for *E. coli* at approximately half the sampling locations. Mean dissolved oxygen values at all sites met the CT DEEP minimum. We suggest continued monitoring during the 2017 monitoring season to identify potential causes of the elevated bacteria counts.

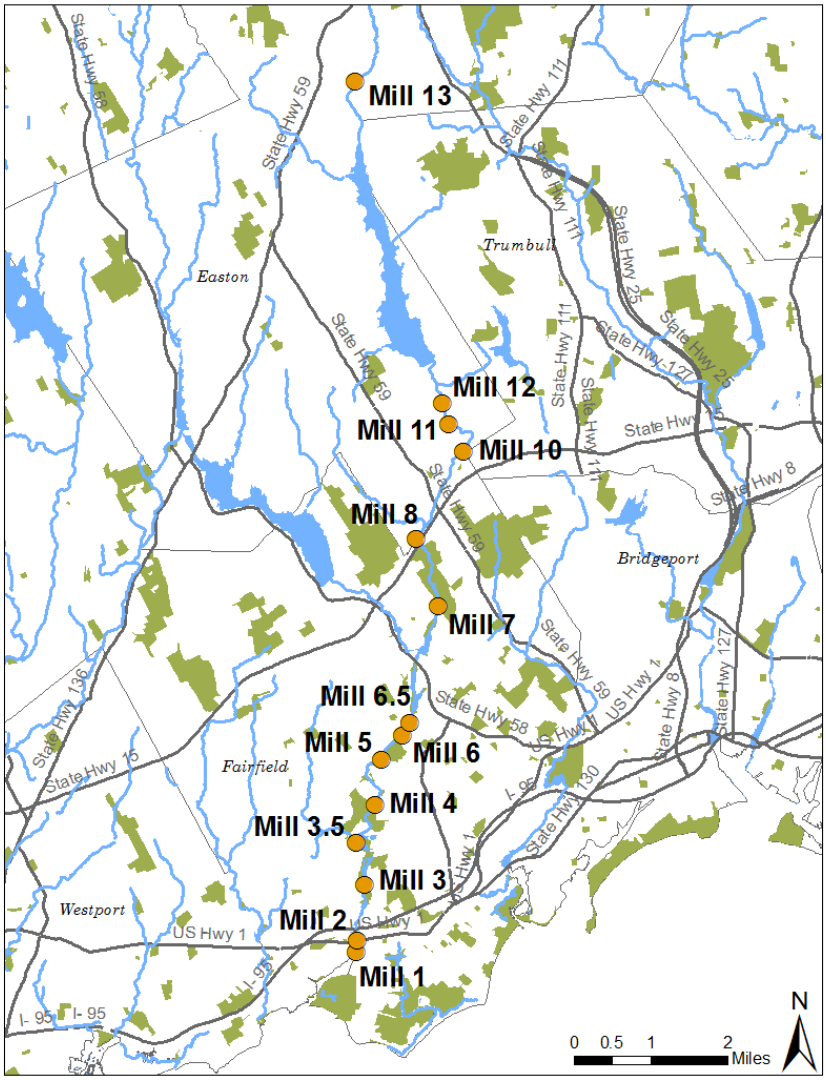

Figure E1. Sample locations for 14 sites on the Mill River.

Five sites, Mill 8, Mill 4, Mill 3.5, Mill 2, and Mill 1 exceeded both the geomean criterion (<126 CFU/100 mL) and the single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL) set by the CT DEEP (Figure E2, Table E1). Four additional sites, Mill 11, Mill 10, Mill 7, and Mill 3, exceeded the single sample maximum criterion (Table E1). Elevated concentrations at Mill 2 and Mill 1 are concerning because sampling was conducted regardless of tide cycles which traditionally dilute concentrations at high tide. Water fowl were observed upstream of these sites during a few of the sampling days, but the cause of these elevated bacteria counts is unknown at this time.

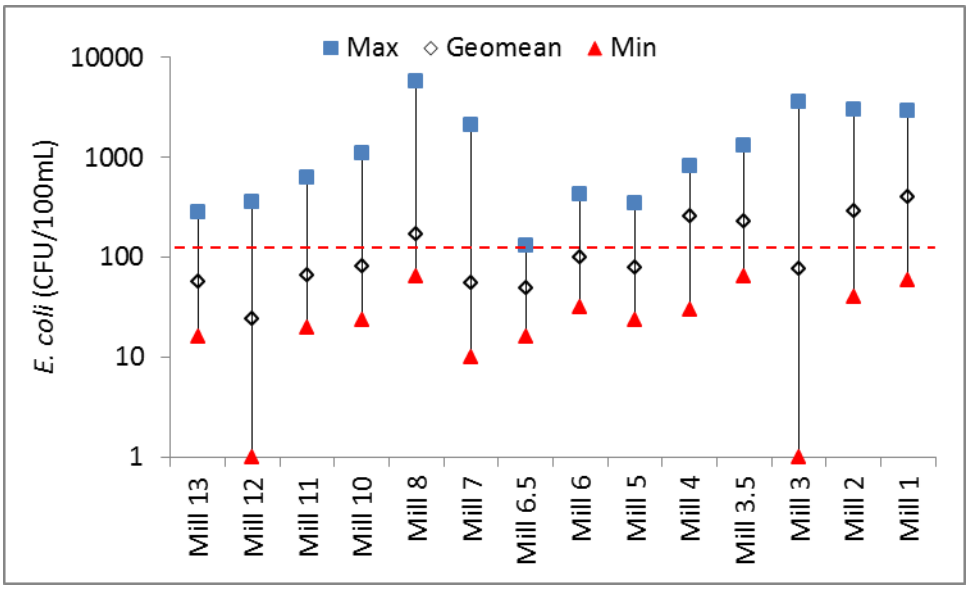

Figure E2. Mill River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table E1. Mill River *E. coli* concentrations and relation to CT DEEP water quality criteria. Blue cells represent actual *E. coli* count of 0 CFU/100 mL, but were changed to calculate geomean (rainfall data: Weather Underground-Fairfield Town Hall)

	5/26	6/8	6/21	6/27	7/20	8/1	8/16	8/22	9/7	9/20	Geomean	%>576
Mill 13	52	52	16	No Sample	40	140	68	280	90	16	57	0%
Mill 12	16	64	32	40	20	92	8	360	10	1	24	0%
Mill 11	No Sample	No Sample	52	32	140	144	24	630	40	20	67	13%
Mill 10	28	24	76	72	148	160	44	1100	70	52	83	10%
Mill 8	64	64	132	76	64	520	108	5800	150	172	172	10%
Mill 7	28	40	16	28	28	244	20	2100	10	204	56	10%
Mill 6.5	N/A	N/A	N/A	56	132	16	36	40	30	132	49	0%
Mill 6	92	92	100	48	52	164	32	430	80	288	101	0%
Mill 5	68	64	168	24	No Sample	36	40	350	60	240	80	0%
Mill 4	128	224	292	30	80	300	700	820	530	700	258	30%
Mill 3.5	N/A	N/A	N/A	76	72	600	64	1300	140	840	228	43%
Mill 3	136	60	208	28	28	72	20	3600	1	1180	78	20%
Mill 2	232	260	900	70	40	520	56	3000	300	1180	293	30%
Mill 1	124	196	900	2900	60	680	144	1800	230	780	406	50%
Rainfall	Wet	Dry	Wet	Dry	Wet	Wet	Wet	Wet	Dry	Wet		

Mean dissolved oxygen values at all eleven sites met the CT DEEP minimum criterion of 5 mg/L (Figure E3). Individual readings fell below 5 mg/L at multiple sites (Table E2). The most concerning site, Mill 2, had multiple days during which the dissolved oxygen was below 5 mg/L. At its lowest, this dissolved oxygen was observed to be only 0.76 mg/L (Figure E3). This site sits at the outlet of a small pond north of the Route 1 corridor. It is believed that the pond does not flush well and could be causing the low levels of dissolved oxygen. There was also construction occurring around the pond which utilized booms that may have impeded flow through the pond.

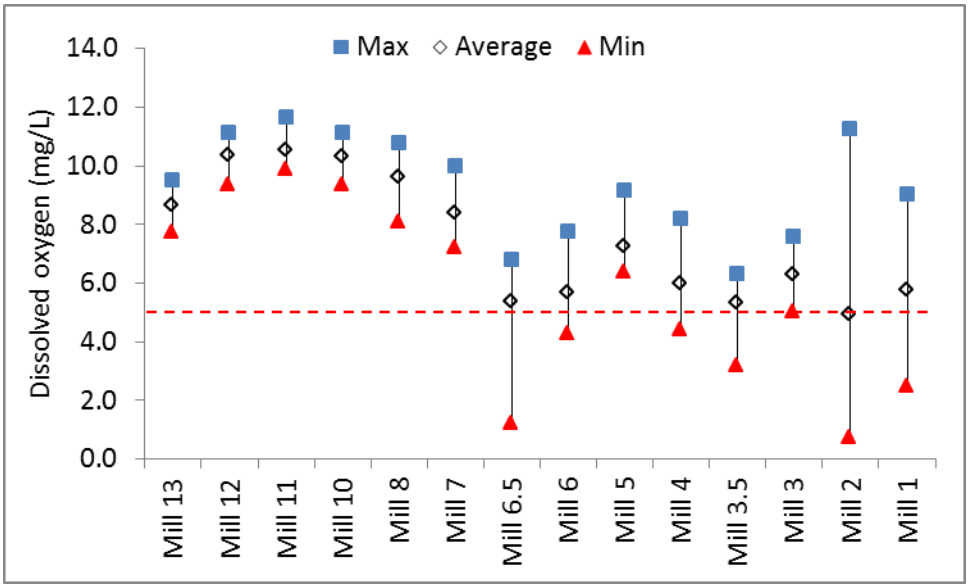

Figure E3. Mill River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Table E2. Days during which dissolved oxygen levels fell below 5 mg/L

Site	Date	Value (mg/L)
Mill 6.5	6/27/2016	1.2
	8/16/2016	4.9
Mill 6	6/27/2016	4.9
	8/1/2016	4.9
	8/22/2016	4.3
Mill 4	8/16/2016	4.4
Mill 3.5	7/20/2016	3.2
	8/16/2016	4.1

Site	Date	Value (mg/L)
Mill 2	6/27/2016	0.8
	7/20/2016	3.2
	8/16/2016	1.3
	8/22/2016	4.1
	9/7/2016	4.6
	9/20/2016	4.5
Mill 1	6/27/2016	4.5
	7/20/2016	3.8
	8/1/2016	3.5
	8/16/2016	2.5

Conductivity values above the area of tidal incursion had narrow ranges indicating stability at each site (Figure E4, left). The wider ranges at sites Mill 2 and Mill 1 were due to the tidal influence (Figure E4, right). Sampling was conducted regardless of the tide cycle. It should be noted that on a few sampling days, Mill 2 had higher conductivity values than Mill 1, which may be caused by poor flushing under the Route 1 Bridge or runoff from any ongoing construction at Mill 2.

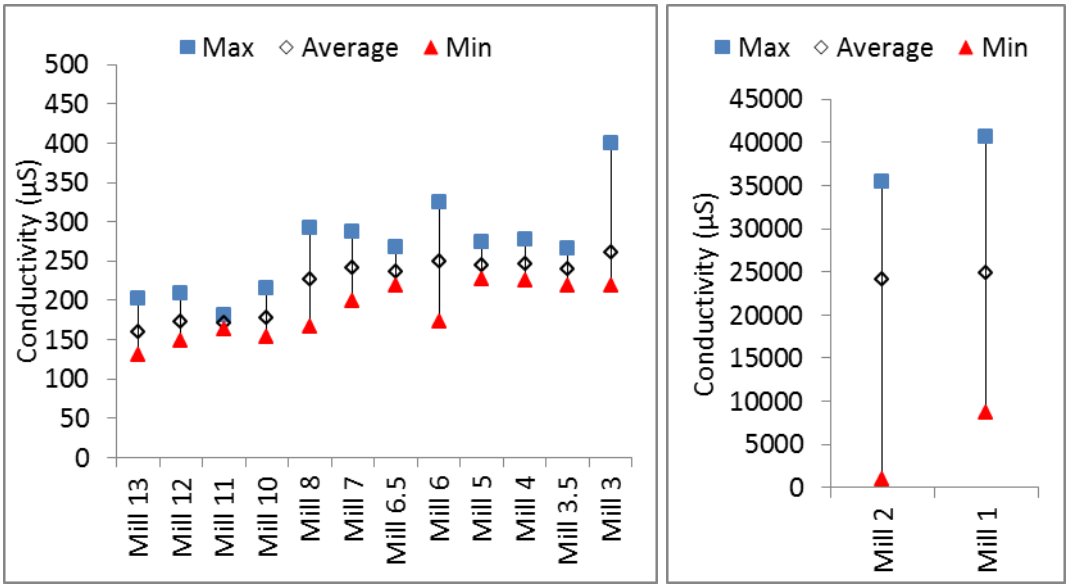

Figure E4. Mill River conductivity values. Maximum, average, and minimum for each site that is (left) above the area of tidal incursion and (right) tidally influenced.

Table E3. GPS coordinates and site locations for the Mill River

Station Number	Latitude	Longitude	Town	Comments
Mill 1	41.137579	-73.274603	Fairfield	70 Harbor Road
Mill 2	41.139772	-73.274176	Fairfield	Near Martel Bistro and Bar
Mill 3	41.150400	-73.272600	Fairfield	Big stone bridge on Sturges Road
Mill 3.5	41.158205	-73.274665	Fairfield	Twin Brooks Lane at bend in road
Mill 4	41.165412	-73.270046	Fairfield	165 Duck Farm Road
Mill 5	41.173800	-73.268400	Fairfield	Bridge on Mill Plain Road (where changes to Burr Street)
Mill 5.5	41.180788	-73.261608	Fairfield	Intersection of Samp Mortar Drive and Brookside Drive
Mill 6	41.178466	-73.263413	Fairfield	61 Mountain Laurel Road
Mill 7	41.202727	-73.254708	Fairfield	Bridge on Morehouse Highway (near Canterbury Lane)
Mill 8	41.215454	-73.260199	Fairfield	427 Congress Street
Mill 10	41.231978	-73.248555	Easton	South Park Avenue
Mill 11	41.237067	-73.252174	Easton	South Park Avenue near Riverside Drive
Mill 12	41.241082	-73.253928	Easton	South Park Avenue between Buck Hill Road and Marich Drive
Mill 13	41.301489	-73.276127	Monroe	Judd Road and Velvet Street

F. Noroton River

The Noroton River watershed encompasses portions of three communities whose political boundaries fall within the state of Connecticut. The three towns in Connecticut are Stamford, Darien, and New Canaan, which fall within Fairfield County. The watershed is approximately 7,000 acres or 11 square miles. The river begins in New Canaan and flows south between the border of Stamford and Darien. The river discharges into Long Island Sound through Holly Pond on the border of Stamford and Darien. The land use along the river is a mixture of residential and light commercial.

This is the first year that we collected data on the Noroton River. The river exceeded the CT DEEP *E. coli* criteria at all sites. Some sites did not meet the CT DEEP criterion for dissolved oxygen. We suggest continued testing in the Noroton River to identify sources that may be contributing to the elevated bacteria in the river.

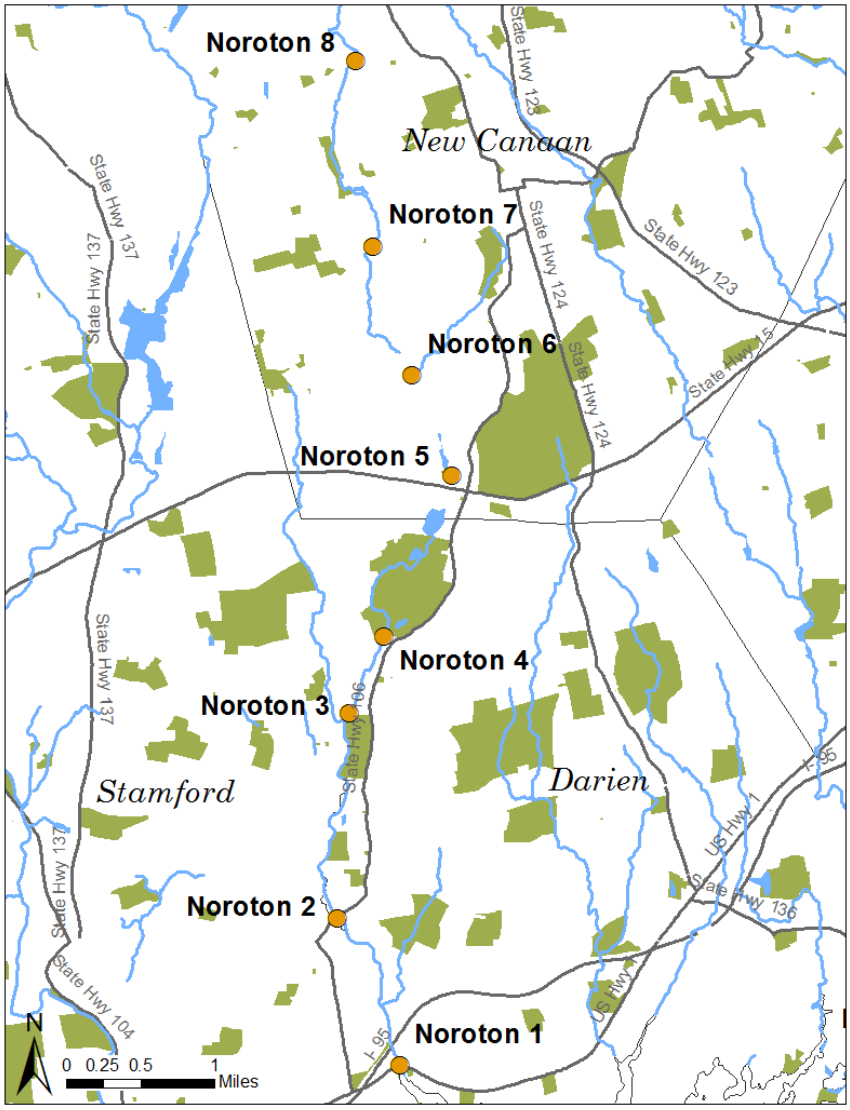

Figure F1. Sample locations for 8 sites on the Noroton River.

All sites except for Noroton 5 exceeded the CT DEEP geomean criterion of <126 CFU/100mL (Figure F2, Table F1). All 8 sites exceeded the CT DEEP single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL; Table F1). Elevated bacteria concentrations occurred on sampling dates when more than 0.1 inches fell during collection or within the prior two days of sampling (Table F1). Possible causes of the elevated bacteria concentrations are unknown at this time.

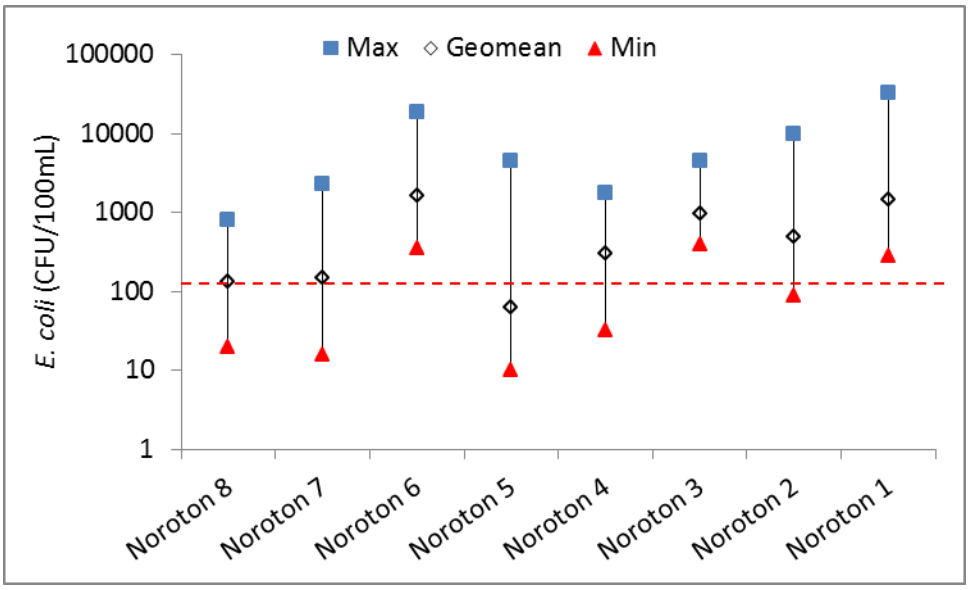

Figure F2. Noroton River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table F1. Noroton River *E. coli* concentrations and relation to CT DEEP water quality criteria (rainfall data: Weather Underground-KHPN)

	5/24	6/7	6/15	7/5	7/13	8/4	8/18	9/1	9/8	9/20	Geomean	%>576
Noroton 8	760	40	116	800	70	40	30	20	780	530	135	30%
Noroton 7	380	110	16	2300	110	30	120	80	250	440	149	10%
Noroton 6	1300	350	480	18700	500	5000	3400	2800	770	2000	1650	70%
Noroton 5	48	60	28	4500	20	10	30	30	10	1700	64	20%
Noroton 4	620	32	980	No Sample	140	150	140	1800	270	800	304	44%
Noroton 3	1120	650	400	3000	680	430	650	4600	610	1600	971	80%
Noroton 2	1520	300	156	9900	290	90	970	90	160	4100	504	40%
Noroton 1	2980	520	540	11300	450	280	360	32500	680	5200	1477	50%
Rainfall	Wet	Wet	Dry	Wet	Dry	Dry	Dry	Wet	Dry	Wet		

Mean dissolved oxygen values met the 5 mg/L CT DEEP minimum criterion at 6 of the 8 sites. Noroton 8 and Noroton 1 frequently fell below 5 mg/L. Additional sites also had individual readings which fell below 5 mg/L (Table F2). The low dissolved oxygen levels may be caused by low flow, warm temperatures, and drought conditions throughout the summer months.

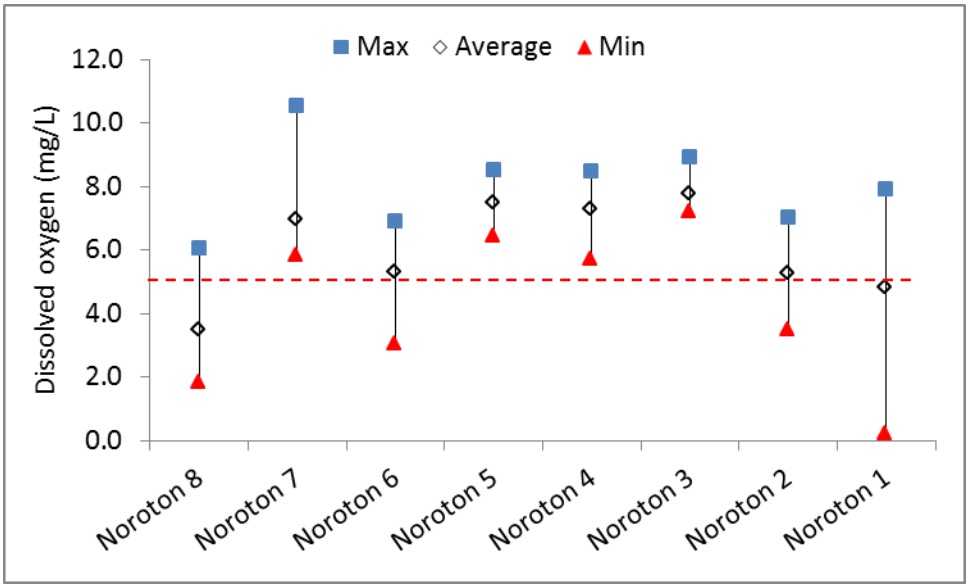

Figure F3. Noroton River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Table F2. Days during which dissolved oxygen levels fell below 5 mg/L

Site	Date	Value (mg/L)
Noroton 8	6/7/2016	2.4
	6/15/2016	2.0
	7/13/2016	3.7
	8/18/2016	3.8
	9/1/2016	1.9
	9/8/2016	1.9
	9/20/2016	4.0
Noroton 6	7/13/2016	4.2
	8/4/2016	3.0
	8/18/2016	3.2
	9/1/2016	4.4
Noroton 2	8/4/2016	4.7
	8/18/2016	3.5
	9/1/2016	4.0
	9/8/2016	4.7
Noroton 1	6/15/2016	4.9
	7/13/2016	0.2
	8/4/2016	2.9
	8/18/2016	0.4
	9/1/2016	4.8

Conductivity values had narrow ranges at the upper 6 sampling locations. Noroton 2 had a wide range in conductivity (Figure 4, left). The reason for this is unknown, but a possible cause may

have been the rainfall that fell during sampling on 9/1 creating runoff from the road into the river. Noroton 1 is a tidally influenced site, and samples were collected regardless of the tide cycle which contributed to the wide range in conductivity observed (Figure F4, right).

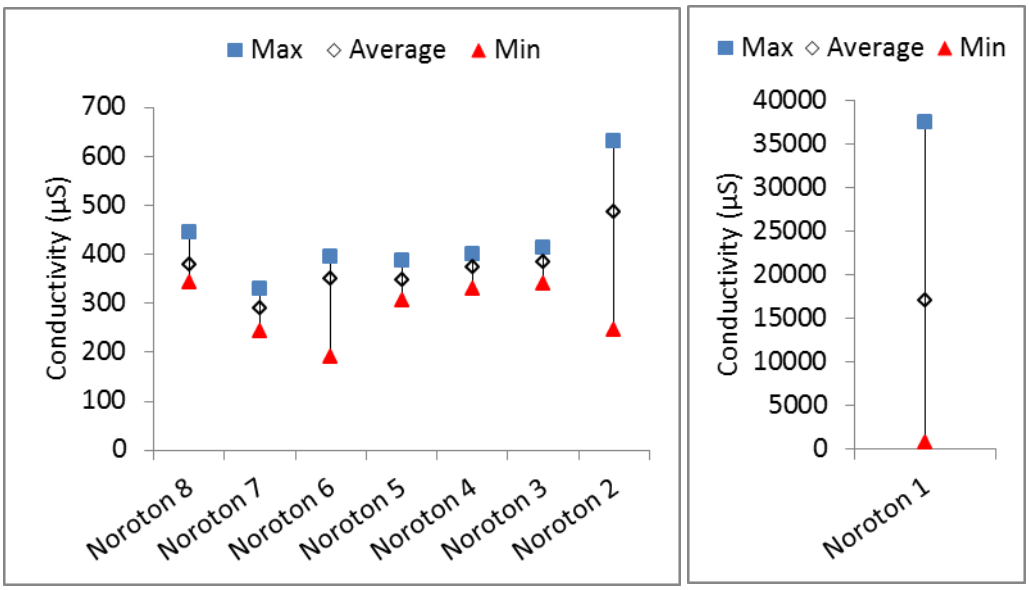

Figure F4. Noroton River conductivity values. Maximum, average, and minimum for each site that is (left) above the area of tidal incursion and (right) tidally influenced.

Table F3. GPS coordinates and site locations for the Noroton River

Station Number	Latitude	Longitude	Town	Comments
Noroton 1	41.06093	-73.50735	Stamford	1308 East Main Street
Noroton 2	41.07530	-73.51550	Stamford	668 Connecticut 106
Noroton 3	41.09540	-73.51430	Stamford	Springdale Athletic Club
Noroton 4	41.10290	-73.50982	Stamford	137 Woodway Road
Noroton 5	41.11868	-73.50130	New Canaan	47 Jellif Mill Road
Noroton 6	41.12845	-73.50648	New Canaan	Knapp Lane
Noroton 7	41.14108	-73.51167	New Canaan	209 Frogtown Road
Noroton 8	41.15925	-73.51421	New Canaan	West Road and Greenley Road intersection

G. Norwalk River

The Norwalk River watershed encompasses portions of seven communities whose political boundaries fall within the states of Connecticut and New York. The six Connecticut towns, all located in Fairfield County, are New Canaan, Norwalk, Redding, Ridgefield, Weston and Wilton. The seventh town is Lewisboro, New York, in Westchester County (NRWI, 1998). The watershed is roughly 40,000 acres or 64.1 square miles. Approximately 64 percent of the watershed land use is developed by commercial/light industry uses, residential neighborhoods, and roads (NRWI, 1998). The remaining 36 percent is comprised of woodland, open lands, water, and wetlands (NRWI, 1998). The main stem of the Norwalk River is approximately 20 miles in length, beginning in the Great Swamp in Ridgefield. From there the river runs north approximately a mile, before turning south discharging in Norwalk Harbor where the last three miles are a tidal estuary (NRWI, 1998).

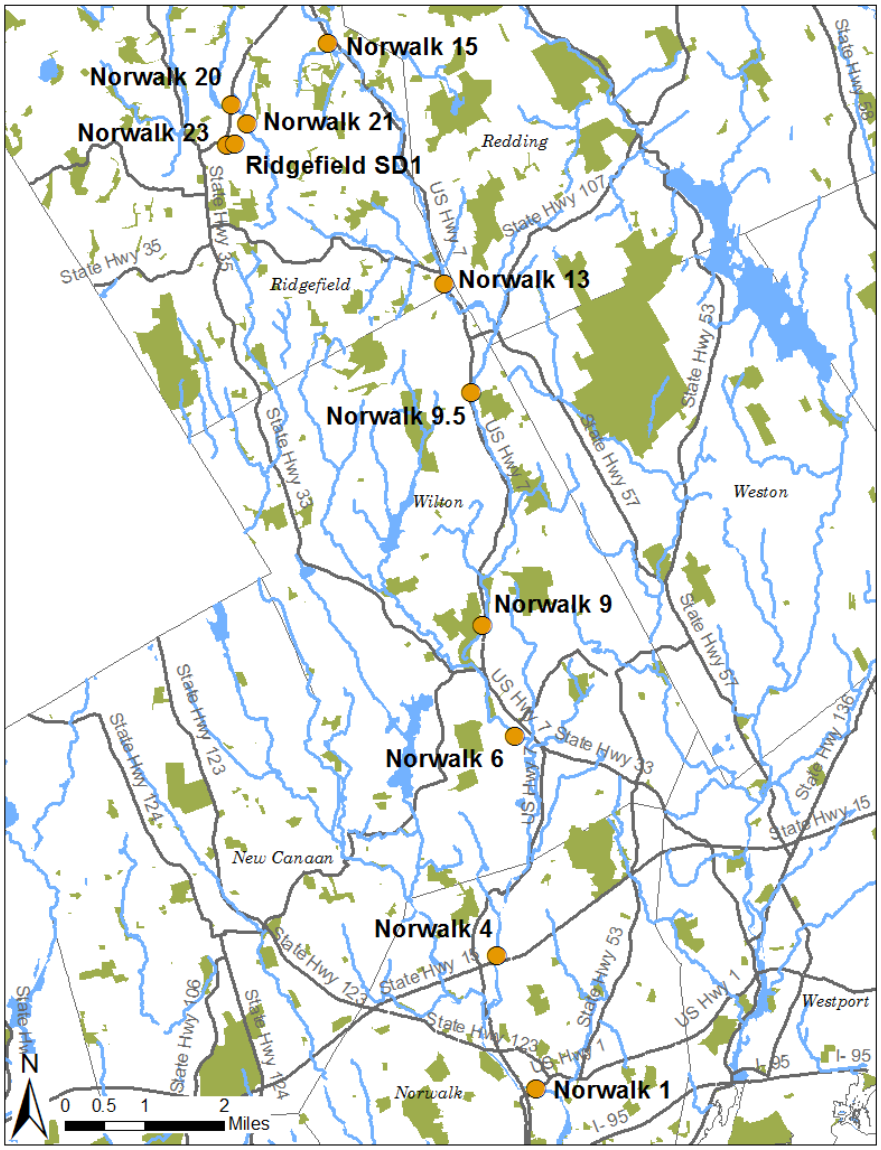

Figure G1. Sample locations for 11 sites on the Norwalk River.

We have monitored the Norwalk River year-round for 18 years, with the highest frequency of sampling during the May through September monitoring season. Our results indicate that water quality conditions in the river during 2016 were worse than 2015, but better than 2014 (Figure G2). Currently the river exceeded the CT DEEP criteria for *E. coli*, but dissolved oxygen values did meet the minimum CT DEEP criterion.

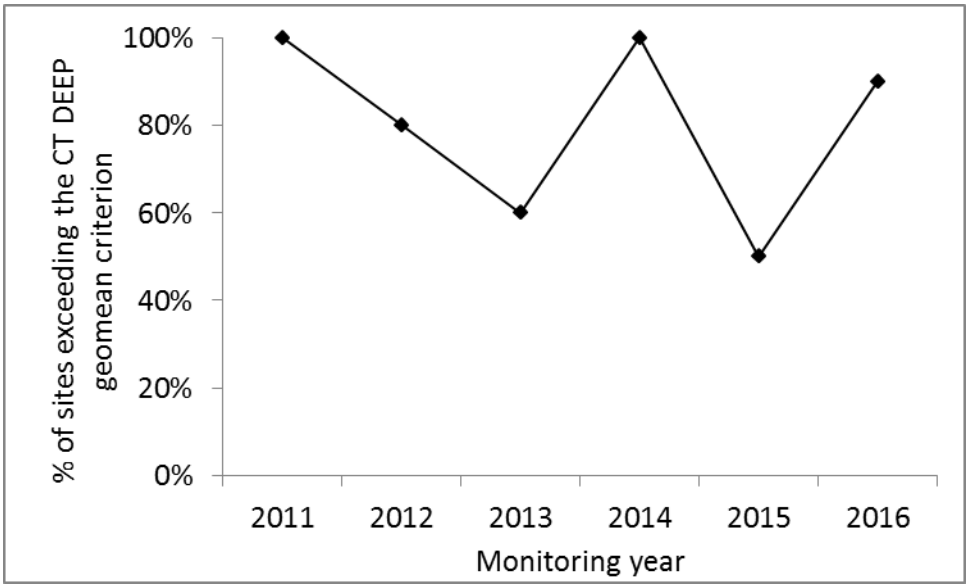

Figure G2. Historic look at Norwalk River CT DEEP geomean criterion exceedances.

In 2016, site Norwalk 9.5 was the only site that passed the CT DEEP *E. coli* geomean criterion of <126 CFU/100 mL (Figure G3, Table G1). All 11 sites on the Norwalk River exceeded the CT DEEP single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL; Table G1). Elevated bacteria counts were observed on sampling days which had at least 0.1 inches of rain fall during sample collection and/or within the two days prior to sample collection. Site Ridgefield SD1 in Table G1 is the Ridgefield Wastewater Treatment Plant effluent pipe where it enters the Norwalk River. From April through October, the plant utilizes ultra-violet lights which the treated wastewater flows past for a final bacteria elimination process. The bacteria counts were very low at this site, and were frequently 0 CFU/100 mL (shown in blue cells in Table G1). These data show that the plant was not discharging untreated water to the Norwalk River during the study period.

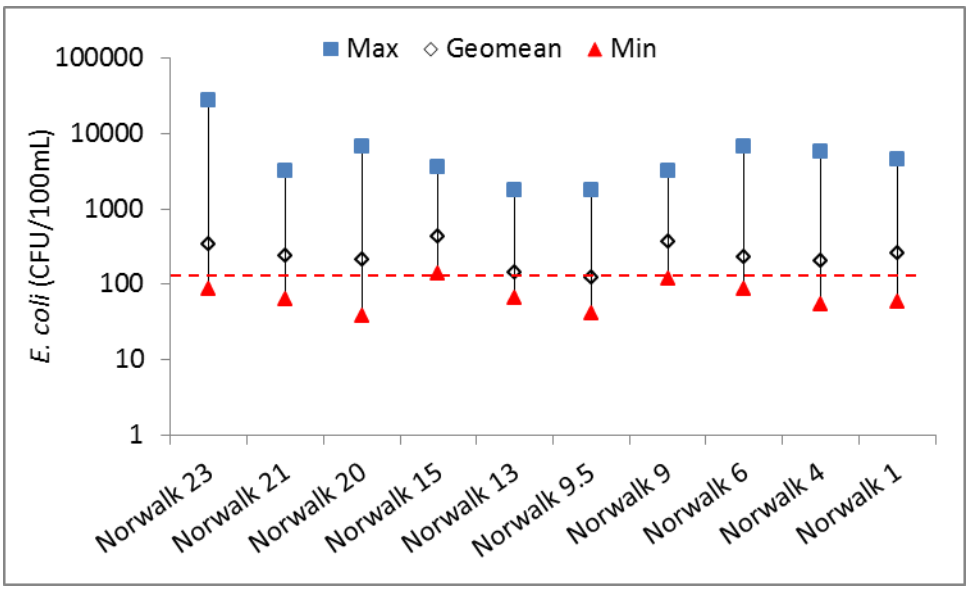

Figure G3. Norwalk River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table G1. Norwalk River *E. coli* concentrations and relation to CT DEEP water quality criteria. Blue cells represent actual *E. coli* count of 0 CFU/100mL, but were changed to calculate geomean (rainfall data: P. DiPietro, personal communication, Oct 26, 2016)

	5/24	6/7	6/15	7/8	7/13	8/4	8/18	9/1	9/8	9/19	Geomean	% >576
Norwalk 23	3860	240	116	96	116	164	152	84	196	28100	327	20%
Ridgefield SD1	1	1	1	1	1	1	1	1	1	4	1	0%
Norwalk 21	2220	176	104	164	60	88	72	340	140	3200	228	20%
Norwalk 20	1360	252	260	36	64	44	60	284	140	6700	207	20%
Norwalk 15	680	356	132	3660	212	540	TNTC	240	170	700	417	33%
Norwalk 13	96	188	136	140	116	80	84	92	64	1800	140	10%
Norwalk 9.5	60	64	128	96	120	72	140	124	40	1800	118	10%
Norwalk 9	320	268	188	280	420	116	220	760	340	3200	363	20%
Norwalk 6	380	160	164	116	132	140	140	184	84	6900	224	10%
Norwalk 4	440	212	116	148	124	88	88	196	52	5700	197	10%
Norwalk 1	420	228	244	136	120	240	76	580	56	4600	252	20%
Rainfall	Wet	Wet	Dry	Wet	Dry	Dry	Dry	Wet	Wet	Wet		

Dissolved oxygen averages at all sites pass the CT DEEP minimum criterion of 5 mg/L (Figure G4). Individual readings fell below 5 mg/L at Norwalk 21 and Norwalk 20 on multiple days over the course of the monitoring season (Table G2). Flow through these sites was slow as the river courses through the Great Swamp in Ridgefield, CT.

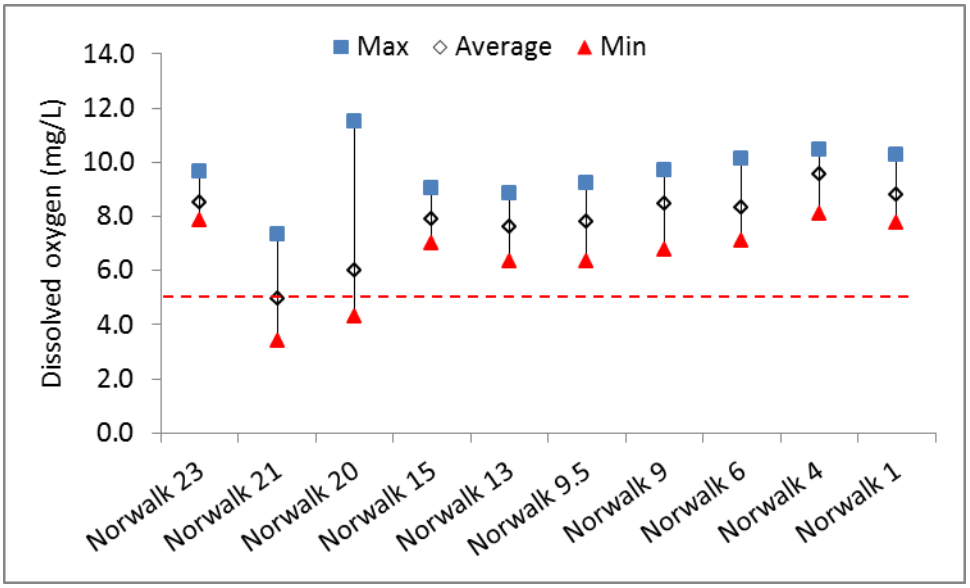

Figure G4. Norwalk River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Table G2. Days during which dissolved oxygen levels fell below 5 mg/L

Site	Date	Value (mg/L)
Norwalk 21	7/8/2016	4.3
	7/13/2016	4.1
	8/4/2016	3.4
	8/18/2016	3.4
	9/1/2016	4.1
Norwalk 20	8/4/2016	4.6
	9/1/2016	4.3
	9/19/2016	4.7

Conductivity values in the upper Norwalk River had wider ranges than sites located in the lower portion of the Norwalk River. This may be attributed to the geology in Ridgefield, CT and the prevalence of limestone beds that increase conductivity from runoff and erosion. Ranges in conductivity begin to stabilize at Norwalk 9.5 which is below where two tributaries, Comstock Brook and Cooper Brook, converge with the river. These tributaries add an influx of low conductivity freshwater to the system.

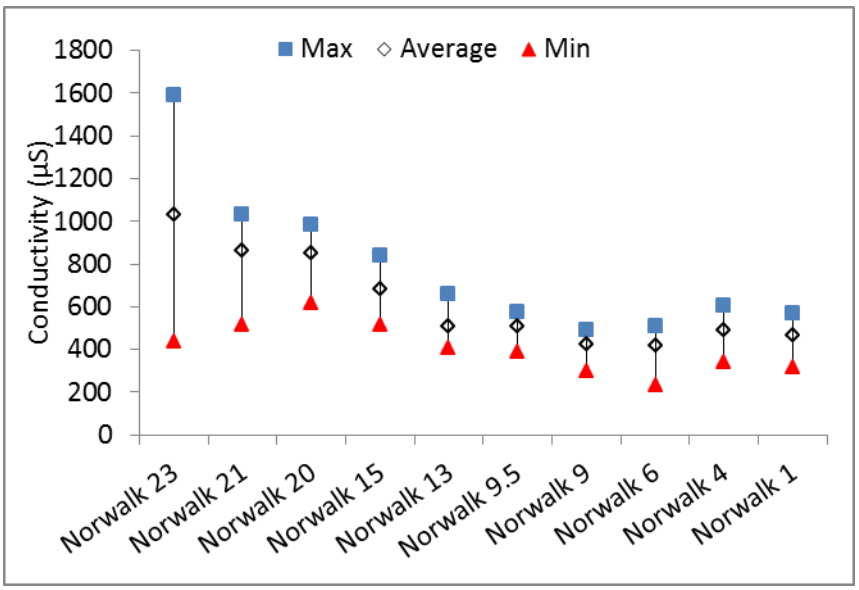

Figure G5. Norwalk River conductivity values. Maximum, average, and minimum for each site.

Table G3. GPS coordinates and site locations for the Norwalk River

Station Number	Latitude	Longitude	Town	Comments
Norwalk 1	41.11938	-73.41724	Norwalk	40 Cross Street
Norwalk 4	41.14349	-73.42669	Norwalk	10 Glover Avenue
Norwalk 6	41.18341	-73.42276	Wilton	187 Danbury Road
Norwalk 9	41.20354	-73.43094	Wilton	School Road, trail head across from Cider Mill School
Norwalk 9.5	41.24590	-73.43409	Wilton	Old Mill Road park
Norwalk 13	41.26550	-73.44079	Ridgefield	787 Branchville Road
Norwalk 15	41.30909	-73.46931	Ridgefield	30 Stonehenge Road
Norwalk 20	41.29787	-73.49232	Ridgefield	195 Danbury Road
Norwalk 21	41.29444	-73.48843	Ridgefield	68 Farmingville Road
Ridgefield SD1	41.29077	-73.49155	Ridgefield	Ligi's Way. Wastewater Treatment Plant effluent discharge
Norwalk 23	41.29055	-73.49337	Ridgefield	22 South Street

H. Poplar Plains Brook

Poplar Plains Brook is located entirely in Westport, CT. It is a small tributary that flows into the Saugatuck River at the north end of Lee's Pond. Beginning at the Merritt Parkway, the brook flows south into Partrick Wetlands, and turns northeast until it travels under Route 33 where it flows due east and meets the Saugatuck River. The land use along the river is a mixture of residential, preserve (Partrick Wetlands), and light commercial.

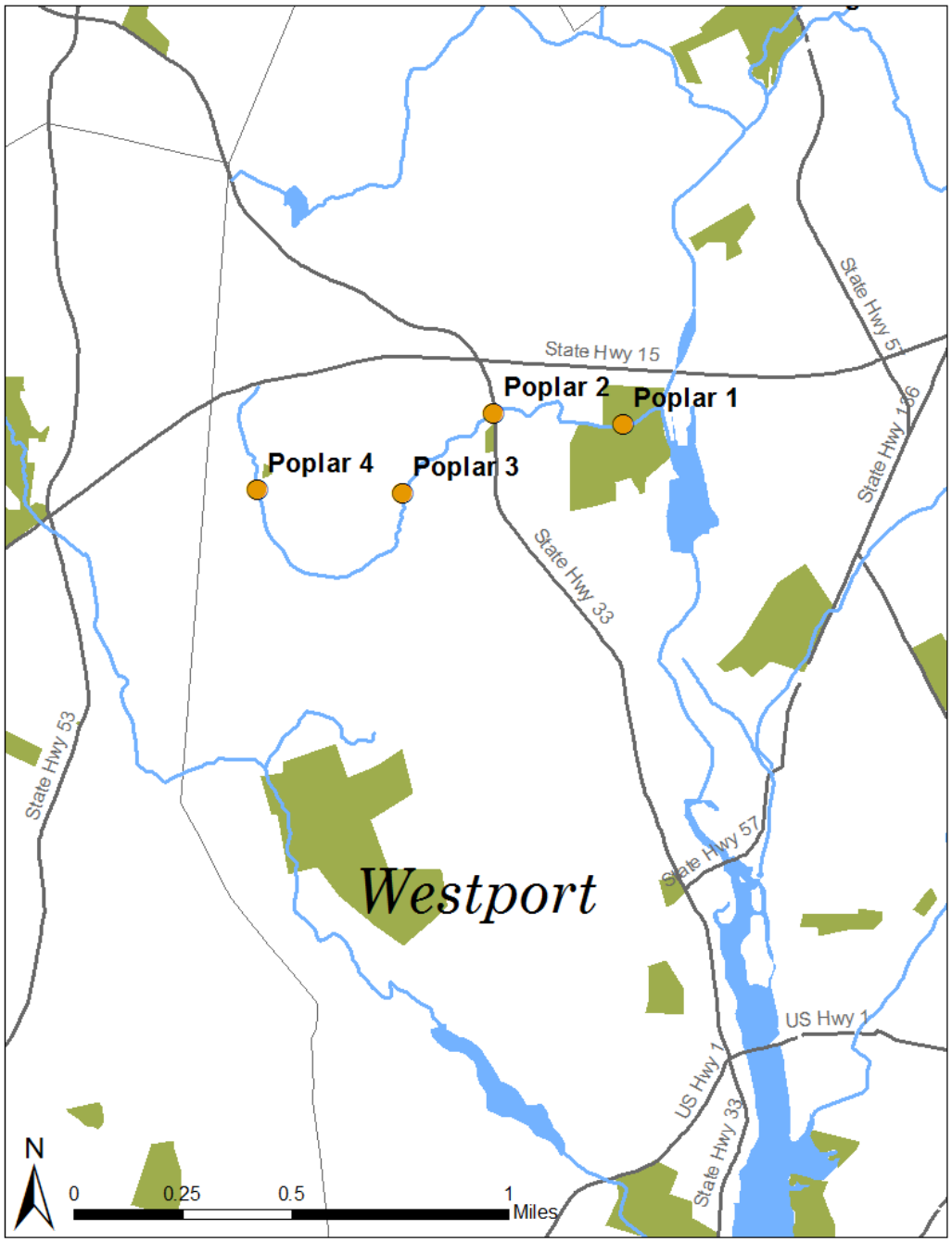

Figure H1. Sample locations for 4 sites on the Poplar Plains Brook.

Harbor Watch had monitored Poplar Plains in the past, but had not collected data on the brook in 5 years. From 2009 through 2011, Poplar Plains was monitored periodically during each season and was meeting the state criterion for *E. coli* (Figure H2). In 2016, the results were very different, with all of the sites failing the state criterion. The cause of this difference in bacteria concentrations is unknown at this time and warrants further study. We suggest continued monitoring of Poplar Plains Brook to work on identifying pollution sources.

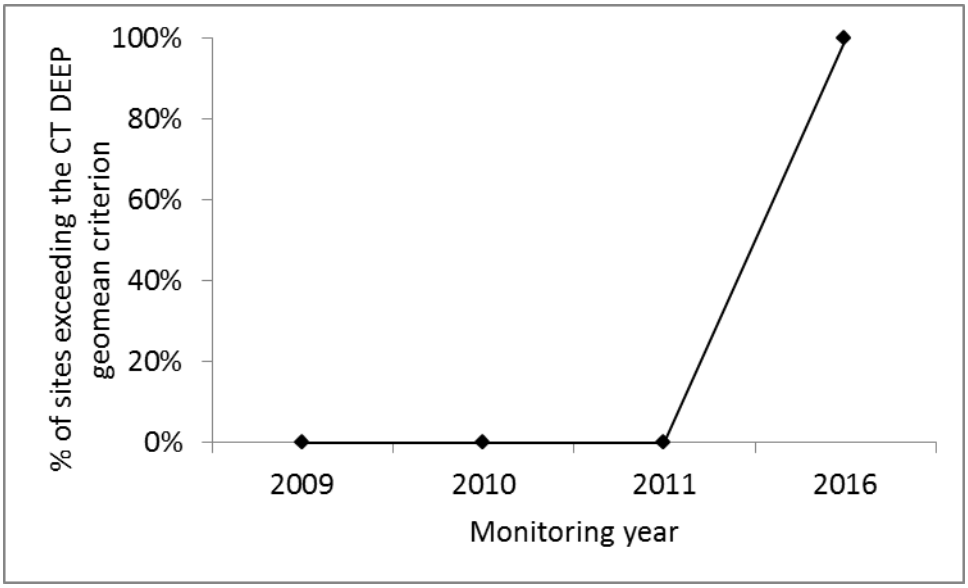

Figure H2. Historic look at Popular Plains CT DEEP geomean criterion exceedances.

In 2016, all four sites exceeded both CT DEEP geomean (<126 CFU/100 mL) and single sample maximum (<10% of *E. coli* samples at each site >576 CFU/100 mL) criteria for *E. coli* (Figure H3, Table H1). Elevated bacteria concentrations occurred on sample collections days that had rain within 2 days prior to sampling (Table H1).

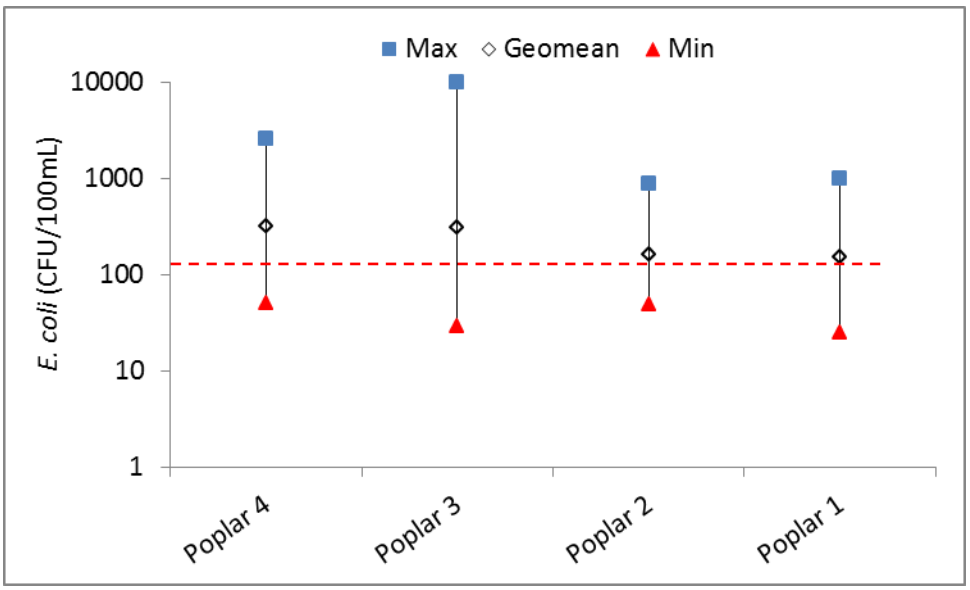

Figure H3. Poplar Plains Brook *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table H1. Poplar Plains Brook *E. coli* concentrations and relation to CT DEEP water quality criteria (rainfall data: E. Long, personal communication, Sept 30, 2016)

	5/18	5/31	6/13	7/5	7/13	7/26	8/15	8/29	9/12	9/27	Geomean	%>576
Poplar 4	80	380	52	2400	80	1400	560	50	No Sample	2600	315	33%
Poplar 3	64	270	108	10000	60	3900	360	40	28	3620	302	30%
Poplar 2	48	330	68	270	270	900	110	50	No Sample	No Sample	158	13%
Poplar 1	24	230	52	800	90	1000	220	60	188	100	148	20%
Rainfall	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Dry	Dry	Wet		

Mean dissolved oxygen levels at Poplar 4, Poplar 2, and Poplar 1 met the CT DEEP minimum criterion of 5 mg/L (Figure H4). Poplar 3 had a mean value below 5 mg/L. This site is located within Partrick Wetlands where there is very low flow through the wetland. Also, decomposing organic matter is present on the brook bottom at this site. These factors may have negatively impacted the dissolved oxygen values. Individual readings did drop below 5 mg/L at Poplar 2 on 7/13, 7/26, and 8/29. Poplar 2 was not sampled after that for the rest of the season due to the fact that the site turned into a small pool of standing water as a result of drought conditions.

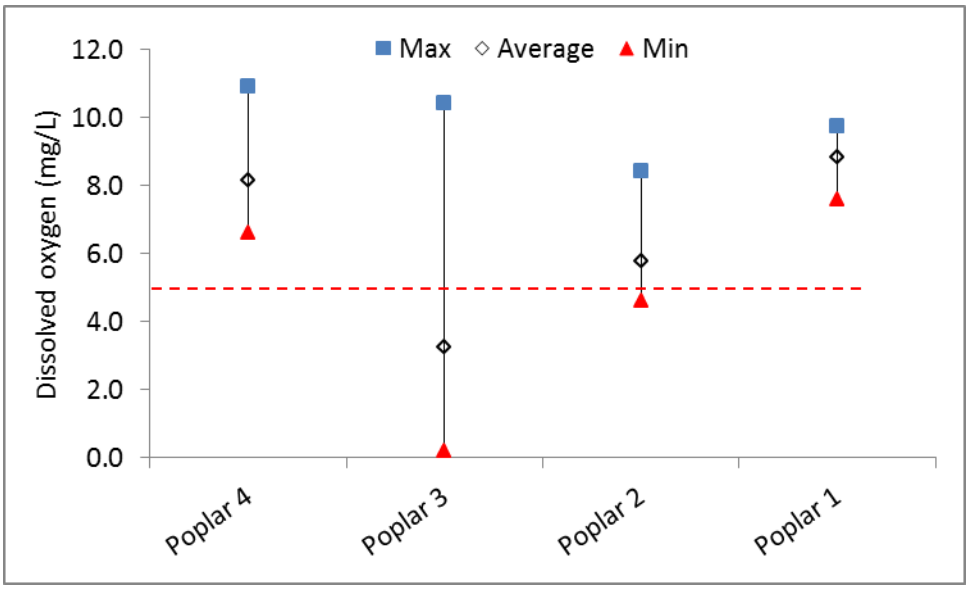

Figure H4. Poplar Plains Brook dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Conductivity values throughout the brook were stable. Mean values were close to each other with Poplar 3 having the highest mean value and Poplar 2 having the lowest (Figure H5).

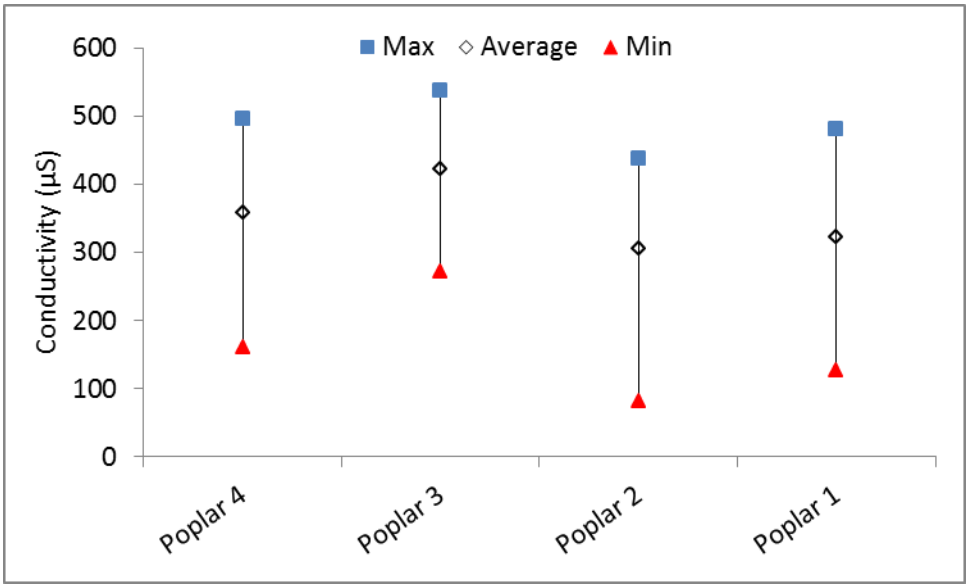

Figure H5. Poplar Plains Brook conductivity values. Maximum, average, and minimum for each site.

Table H2. GPS coordinates and site locations for Poplar Plains Brook

Station Number	Latitude	Longitude	Town	Comments
Poplar 1	41.16173	-73.36938	Westport	Bridge on Westport Weston YMCA property
Poplar 2	41.16205	-73.37512	Westport	Route 33 at the old Red Barn restaurant.
Poplar 3	41.15937	-73.37910	Westport	Partrick Wetlands. Follow trail along ridge to brook
Poplar 4	41.15946	-73.38549	Westport	Newtown Turnpike at Twin Oaks Lane

I. Rooster River (Ash Creek)

The Rooster River watershed encompasses portions of four communities whose political boundaries fall within the state of Connecticut. The four Connecticut towns, all located in Fairfield County, are Fairfield, Bridgeport, Trumbull, and Easton. The watershed is approximately 9,800 acres or 15.3 square miles. The Rooster River begins on the west side of Trumbull and travels south, traversing the Bridgeport/Fairfield town boundary before discharging to Ash Creek. Rooster River is also known as Ash Creek and Horse Tavern Brook.

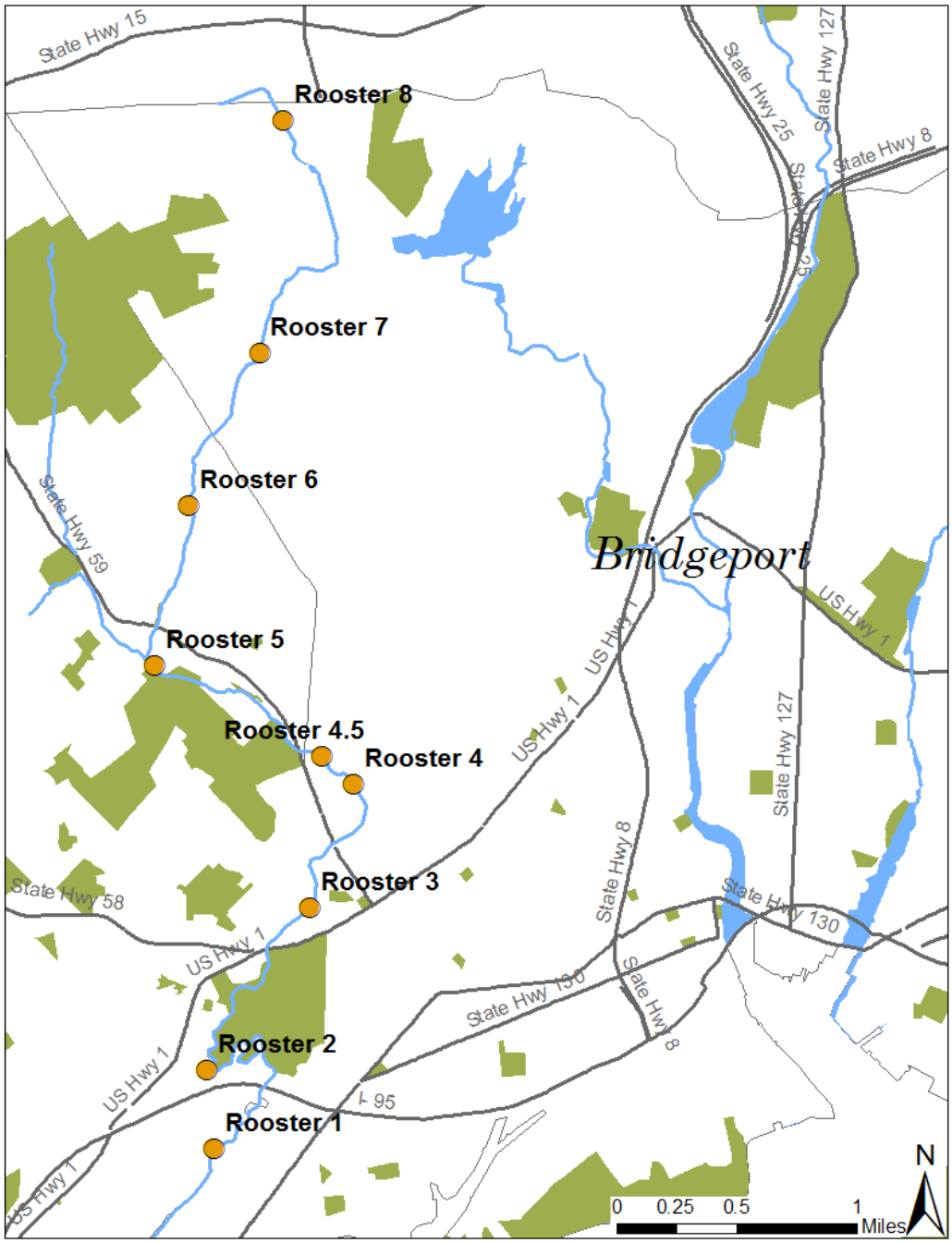

Figure I1. Sample locations for 9 sites on the Rooster River.

This was the first year that Harbor Watch monitored the Rooster River. Bacteria concentrations were elevated above CT DEEP maximum criteria at all sampling locations. We found that the river had been previously diverted underground for an extended section, reducing flow in the original riverbed, effectively drying it up. Due to the poor water quality observed during this study, we plan to conduct another season of monitoring in 2017 to gain a better understanding of the river, its flow, and how the watershed may be impacting the water quality.

All sites exceeded both CT DEEP geomean (<126 CFU/100 mL) and single sample maximum (<10% of *E. coli* samples at each site >576 CFU/100 mL) criteria for *E. coli* (Figure I2, Table I1). Elevated bacteria counts were observed on sampling days regardless of rainfall conditions, although when sampling occurred during a rain event the highest bacteria concentrations were observed, such as on 9/27 (Table I1). Rooster 4 quickly dried up after the start of the monitoring season, which only allowed sampling to occur on the first two sampling days. This site was located in the middle section of the natural riverbed which was below the diversion point located north of Rooster 4.5 (at Laurel Avenue in Bridgeport).

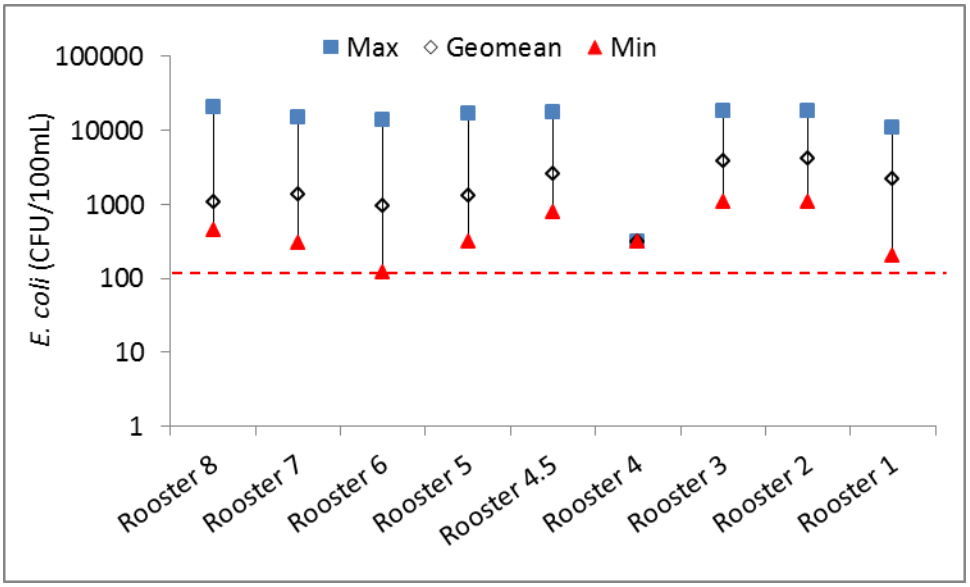

Figure I2. Rooster River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table I1. Rooster River *E. coli* concentrations and relation to CT DEEP water quality criteria. Rainfall data not available for 48 hours prior to 6/1/16 sampling (rainfall data: Weather Underground-Fairfield Town Hall)

	5/25	6/1	6/16	7/6	7/19	7/25	8/9	8/25	9/15	9/27	Geomean	%>576
Rooster 8	500	500	560	600	10800	480	770	710	450	21000	1084	50%
Rooster 7	420	6000	460	1060	5700	300	340	1800	1200	14900	1368	60%
Rooster 6	420	540	730	900	6000	1100	660	550	120	14000	950	60%
Rooster 5	1000	520	2100	1300	14500	540	560	480	310	16600	1314	50%
Rooster 4.5	N/A	N/A	N/A	N/A	N/A	N/A	2000	1700	800	17700	2634	100%
Rooster 4	TNTC	310	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	No Sample	310	0%
Rooster 3	2800	TNTC	5900	4200	16000	2000	TNTC	1100	1200	18100	3896	100%
Rooster 2	1640	4700	7500	3900	15000	1300	TNTC	1100	5200	18300	4258	100%
Rooster 1	TNTC	2400	200	4000	TNTC	4600	6200	3600	290	11100	2240	75%
Rainfall	Wet	N/A	Dry	Wet	Wet	Dry	Dry	Dry	Dry	Wet		

All sites had average dissolved oxygen values above the CT DEEP minimum criterion of 5 mg/L (Figure I3). Individual readings fell below 5 mg/L at Rooster 4 on 6/1, Rooster 2 on 9/15, and Rooster 1 on 7/19. The cause of the low readings may have been due to low flow resulting from the drought conditions observed during the monitoring season.

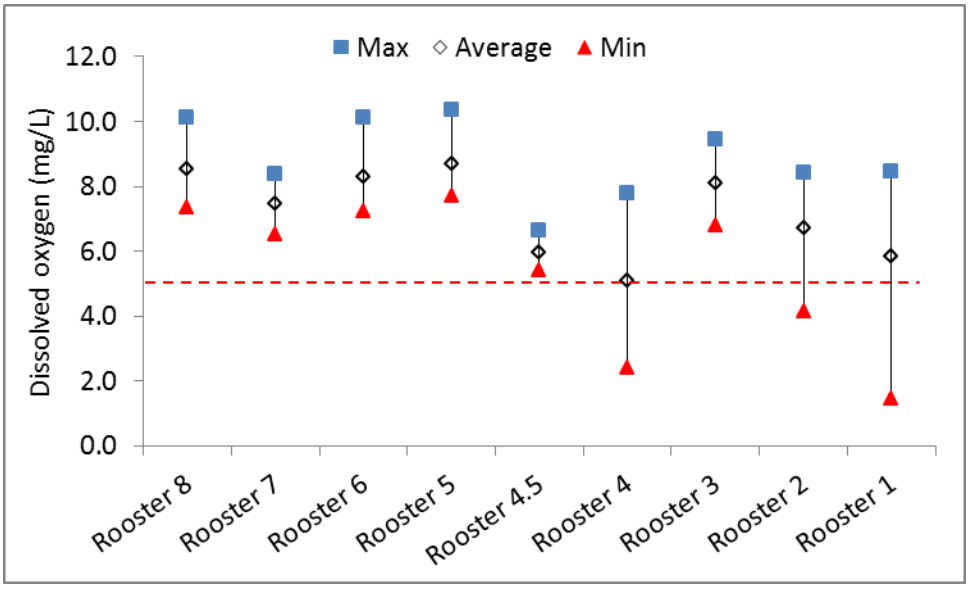

Figure I3. Rooster River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Conductivity value ranges at each site were wide, indicating large variability in the system from day to day (Figure I4, left). Rooster 1 had the widest range in conductivity due to sampling occurring regardless of the tidal cycle (Figure I4, right).

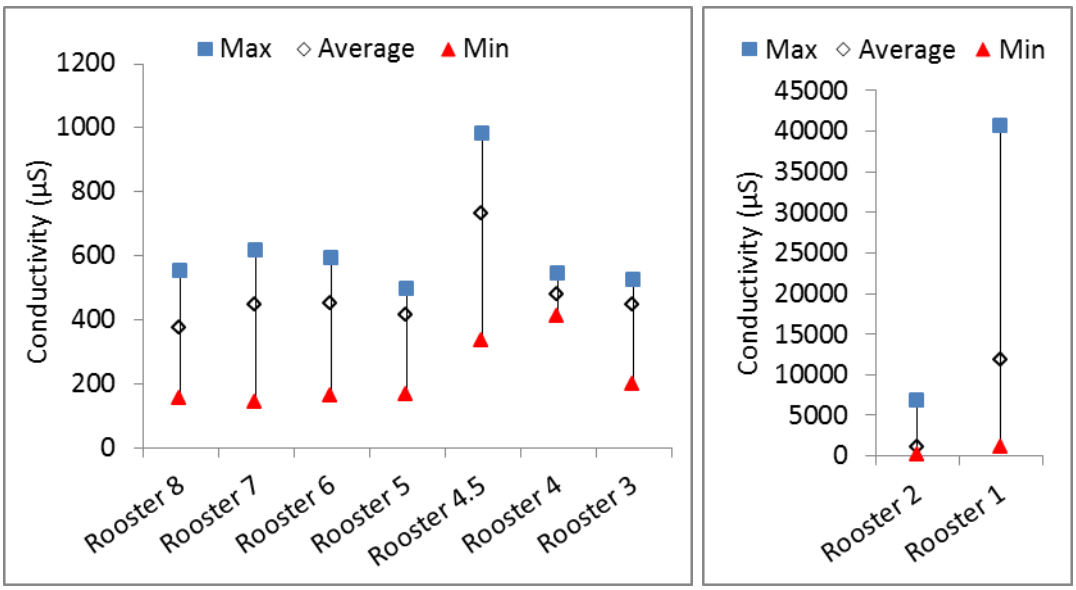

Figure I4. Rooster River conductivity values. Maximum, average, and minimum for each site that is (left) above the area of tidal incursion and (right) tidally influenced.

Table I2. GPS coordinates and site locations for the Rooster River

Station Number	Latitude	Longitude	Town	Comments
Rooster 1	41.16432	-73.22708	Fairfield	398 Scofield Avenue - by Audi.
Rooster 2	41.16910	-73.22773	Fairfield	Fairchild Avenue
Rooster 3	41.17889	-73.21954	Bridgeport	Cartright Street, end of road
Rooster 4	41.18642	-73.21613	Bridgeport	41 Astoria Avenue
Rooster 4.5	41.18807	-73.21872	Bridgeport	1675 Capitol Avenue
Rooster 5	41.19351	-73.23204	Fairfield	131 Westwood Road
Rooster 6	41.20316	-73.22940	Fairfield	263 Wilson Street
Rooster 7	41.21243	-73.22382	Bridgeport	Vinvellette Street next to abandoned old Stop and Shop building
Rooster 8	41.22641	-73.22206	Bridgeport	2825 Old Town Road

J. Sasco Brook

The Sasco Brook watershed falls entirely within the state of Connecticut. The Connecticut towns, all located in Fairfield County, are Westport, Fairfield, and Easton. The watershed is approximately 6,600 acres. The land use consists of residential housing on 2+ acres of land, private farms (horses, sheep, llamas), a golf course (Patterson Country Club), wildlife preserves (Brentwood Park, Audubon Society), and the Fairfield County Hunt Club. Residential housing at the southern end of the watershed near the Route 1 corridor is on smaller properties consisting of 0.5 acres, and is on the municipal sewer system. Most of the housing in the Sasco Brook watershed, however, is on septic systems. Sasco Brook begins in northwest Fairfield and flows south, following the border between Fairfield and Westport and discharging to Long Island Sound at Southport Beach.

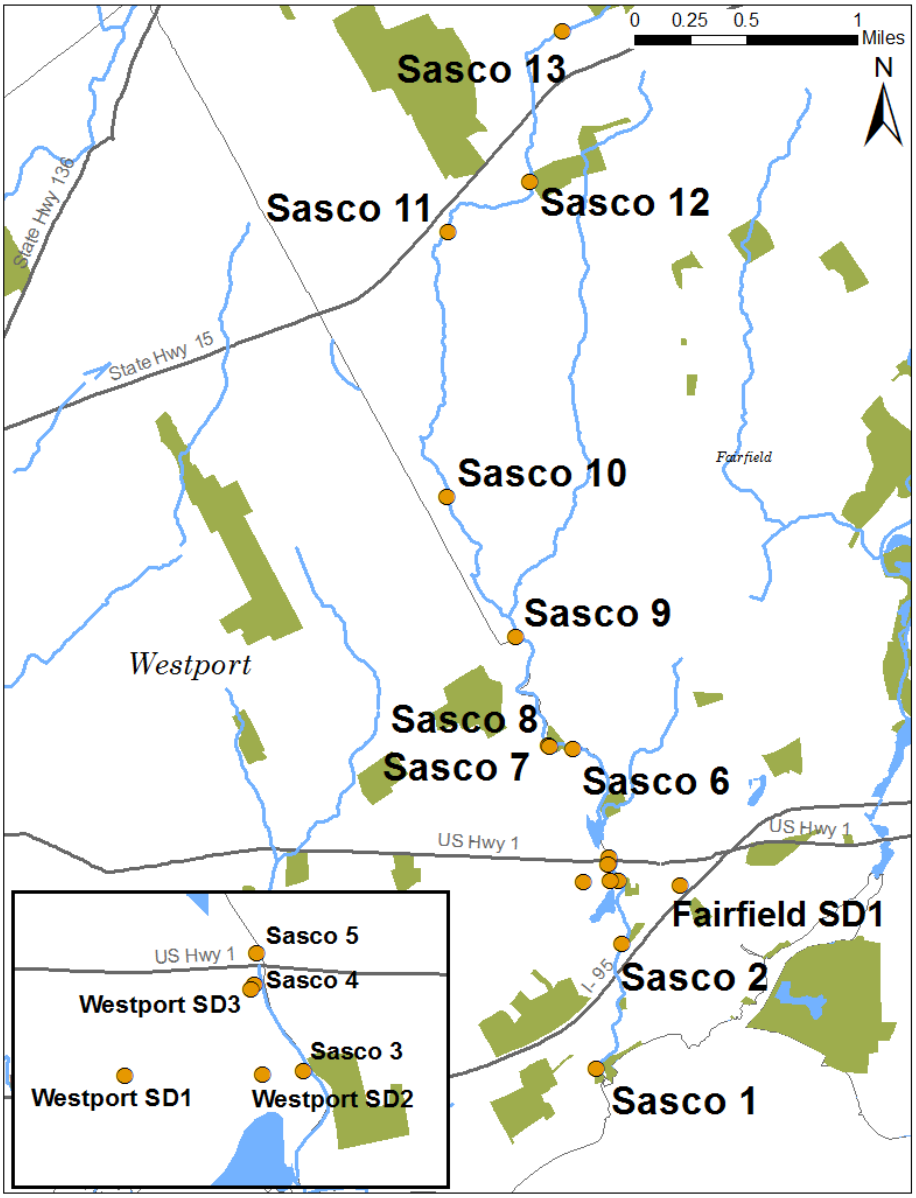

Figure J1. Sample locations for 17 sites on Sasco Brook.

Sasco Brook has been monitored by Harbor Watch for many years, and a different subset of sampling locations has been monitored each year. Sasco Brook had fewer CT DEEP geomean criterion exceedances in 2016 than 2014 (Figure J2). With the exception of 2012, where the majority of testing was conducted during the winter and fall months, historic data show little change in the bacteria criterion exceedances over the last five years. We suggest continued monitoring of Sasco Brook during the coming monitoring seasons to identify any sources of suspected pollution inputs.

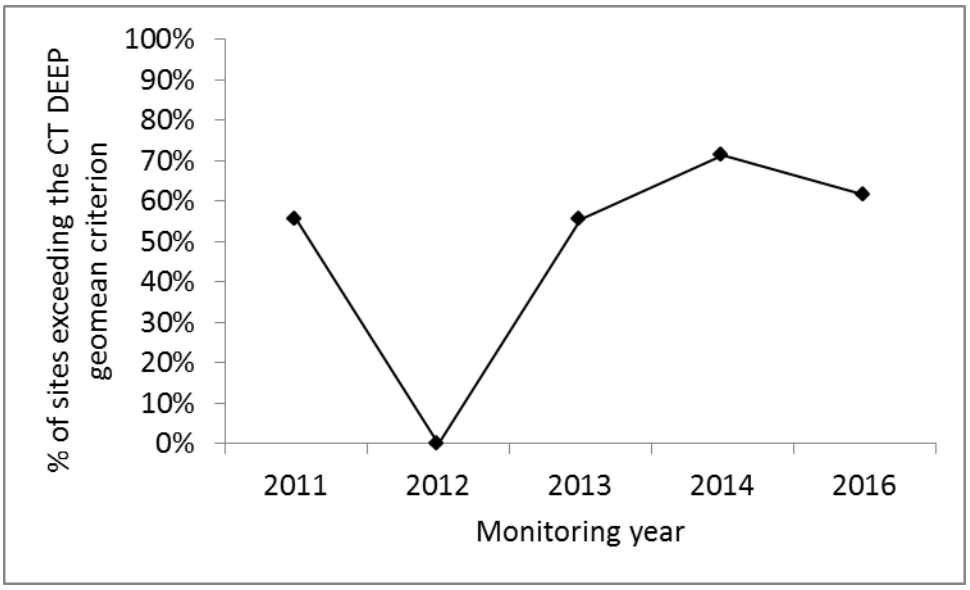

Figure J2. Historic look at Sasco Brook CT DEEP geomean criterion exceedances.

In 2016, eight of the 13 sites on Sasco Brook exceeded the CT DEEP *E. coli* geomean criterion (<126 CFU/100 mL; Figure J3, Table J1). Five of these sites also exceeded the CT DEEP single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL; Table J1).

Four stormwater discharges were also monitored along the lower portion of Sasco Brook. These discharges should typically be dry except during rainfall events, but these locations are instead continuously flowing and often observed with a large volume of flow. The volume of flow observed suggested that the flow could have been from a stream that was diverted underground for development purposes, but could also have input of sump pump discharges or sewage.

On July 26th, a sanitary sewer bypass occurred in the Stop and Shop parking lot in Westport, CT. Evidence of this bypass was observed at site Westport SD1, which is the discharge of the stormwater pipe that collects runoff from the Stop and Shop parking lot, on 7/28 and 8/8 when the pipe was still flushing out the sewage (Table J1). Sites downstream, such as Sasco 3 and Sasco 2 also had elevated bacteria counts on these days which may have been due to the sanitary bypass. The elevated bacteria concentrations prior to the bypass may have been an

indicator of the pipe breaking and leaching through the soil into the stormwater system (Table J1). Site Fairfield SD1 is another stormwater discharge that had elevated bacteria concentrations throughout the monitoring season. We began investigating possible sources of pollution by working upstream through the stormwater system, taking samples in catch basins to track the bacteria concentrations. This investigation is still underway at the time of publication of this report.

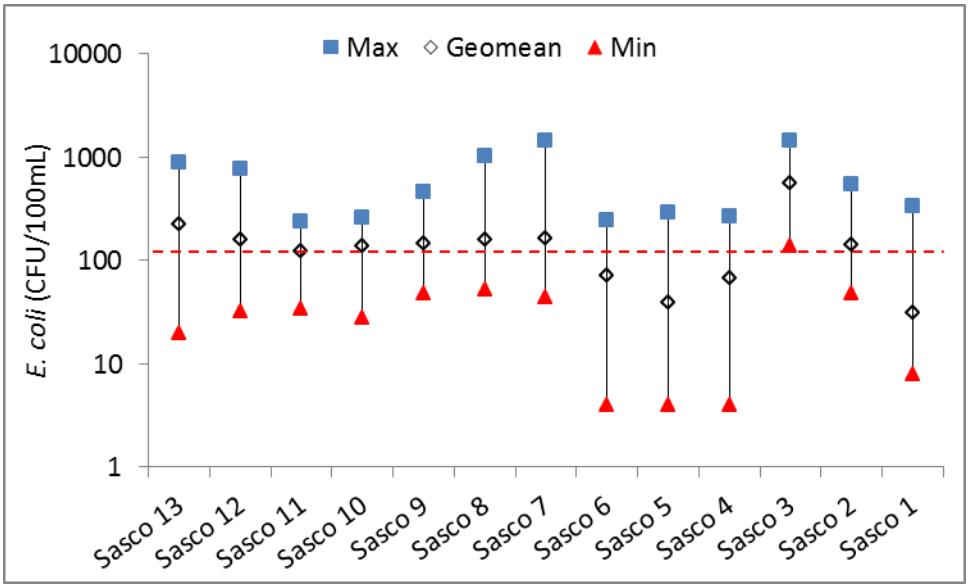

Figure J3. Sasco Brook *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100mL.

Table J1. Sasco Brook *E. coli* concentrations and relation to CT DEEP water quality criteria. Blue cells represent actual *E. coli* count of 0 CFU/100mL, but were changed to calculate geomean. Red cells represent results reported in fecal coliform, not *E. coli* because *E. coli* data are not available (rainfall data: E. Long, personal communication, Sept 30, 2016)

	5/19	6/1	6/14	6/29	7/18	7/28	8/8	8/29	9/12	9/26	Geomean	% > 576
Sasco 13	20	140	80	880	700	620	128	212	No Sample	560	222	33%
Sasco 12	32	140	132	280	76	260	780	148	No Sample	No Sample	157	13%
Sasco 11	100	216	34	180	240	208	144	100	116	60	121	0%
Sasco 10	28	208	260	92	244	232	108	64	212	92	127	0%
Sasco 9	48	224	140	212	460	156	108	60	132	236	147	0%
Sasco 8	84	268	112	168	420	120	52	1040	120	76	159	10%
Sasco 7	44	580	88	124	252	164	64	1460	228	60	165	20%
Sasco 6	64	248	152	172	128	84	4	24	120	64	71	0%
Sasco 5	48	288	96	84	28	100	24	No Sample	4	8	40	0%
Sasco 4	56	264	80	66	136	88	32	4	4	230	51	0%
Westport SD3	1	72	4	1	84	76	4	12	4	230	12	0%
Westport SD1	1	96	16	TNTC	90	720	1300	1	No Sample	No Sample	39	29%
Westport SD2	1	100	20	32	56	108	32	No Sample	1	56	21	0%
Sasco 3	140	460	252	640	540	680	840	1340	1460	540	566	50%
Fairfield SD1	52	240	TNTC	460	TNTC	500	TNTC	800	540	980	383	29%
Sasco 2	56	260	148	440	156	148	540	48	96	72	144	0%
Sasco 1	12	76	16	60	16	104	340	16	16	8	32	0%
Rainfall	Dry	Wet	Dry	Wet	Dry	Dry	Dry	Dry	Dry	Dry		

Mean dissolved oxygen values at all sites, with the exception of Sasco 5, were above the CT DEEP minimum criterion of 5 mg/L (Figure J4). Sasco 5 is located just above the dam at the lower end of Bulkley Pond. The pond did not have much water movement through it which may have been a cause of the low dissolved oxygen readings. Multiple sites had individual readings fall below 5 mg/L on multiple sampling days (Table J2).

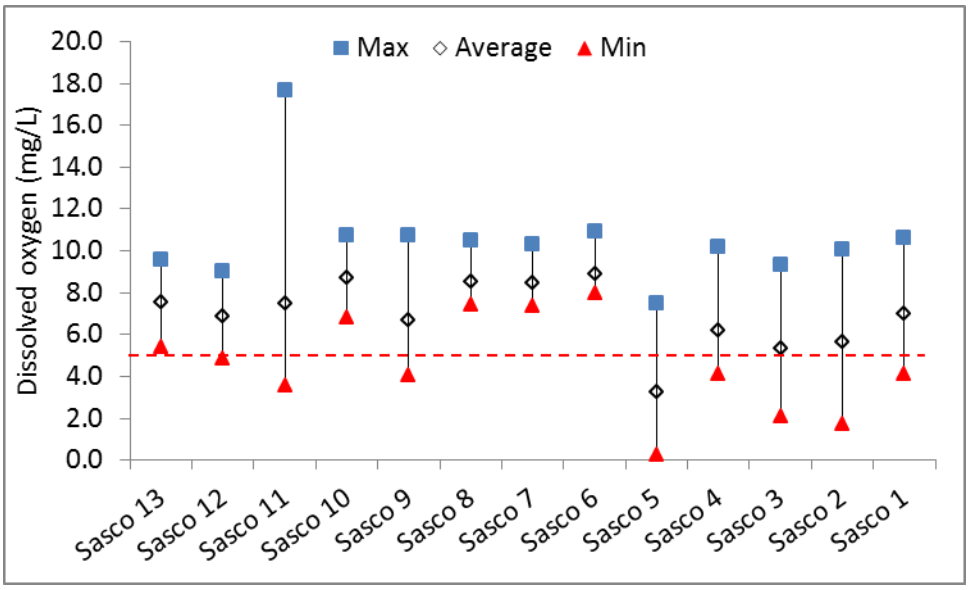

Figure J4. Sasco Brook dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Table J2. Days during which dissolved oxygen levels fell below 5 mg/L

Site	Date	Value (mg/L)
Sasco 12	6/29/2016	4.9
Sasco 11	7/18/2016	3.6
	9/12/2016	4.6
Sasco 9	7/18/2016	4.0
	8/8/2016	4.7
Sasco 5	6/29/2016	0.8
	7/18/2016	2.9
	7/28/2016	1.2
	8/8/2016	0.2
	9/12/2016	0.6
	9/26/2016	4.3
Sasco 4	7/28/2016	4.6
	8/8/2016	4.4
	8/29/2016	4.1
	9/12/2016	4.4

Site	Date	Value (mg/L)
Sasco 3	6/29/2016	4.6
	7/18/2016	4.0
	7/28/2016	4.8
	8/8/2016	4.5
	8/29/2016	4.1
	9/12/2016	2.1
Sasco 2	6/29/2016	1.7
	7/18/2016	3.9
	7/28/2016	4.1
	9/12/2016	4.7
Sasco 1	6/29/2016	5.0
	8/8/2016	4.1

Conductivity values in the upper Sasco Brook had narrow ranges (Figure J5 Left). The variability observed in the lower 3 sites was due to tidal incursion and sampling occurred regardless of the tide cycle (Figure J5 Right).

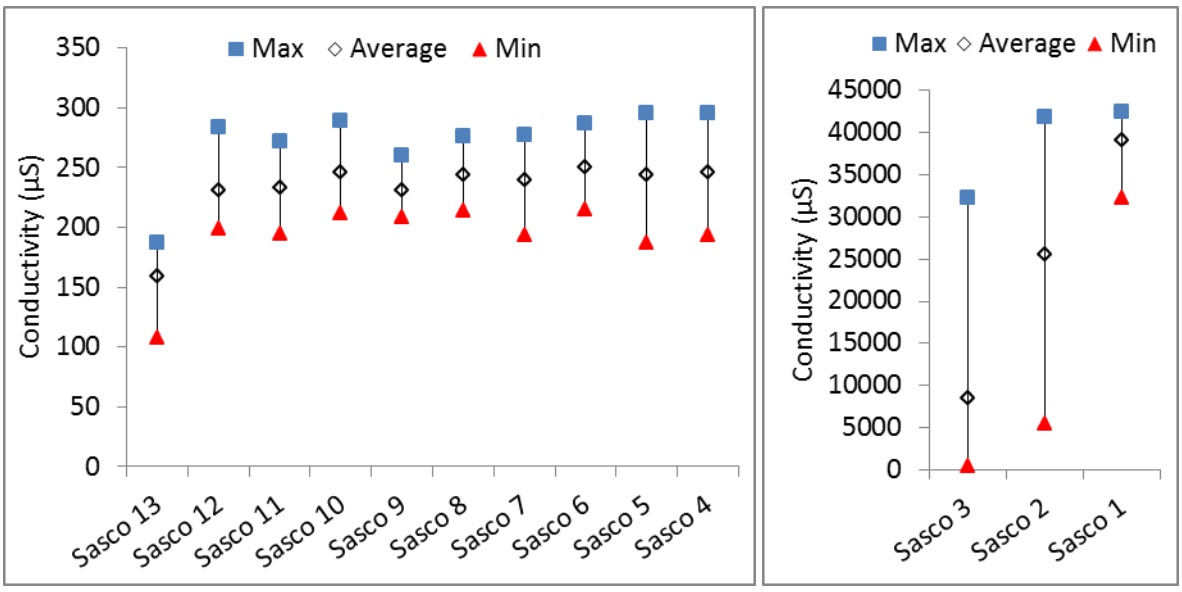

Figure J5. Sasco Brook conductivity values. Maximum, average, and minimum for each site that is (left) above the area of tidal incursion and (right) tidally influenced.

Table J2. GPS coordinates and site locations for Sasco Brook

Station Number	Latitude	Longitude	Town	Comments
Sasco 1	41.12478	-73.29888	Westport	1505 Pequot Avenue
Sasco 2	41.13293	-73.29675	Westport	32 Westway Road
Fairfield SD1	41.13674	-73.29183	Fairfield	Discharges near I-95 onramp at exit 19
Sasco 3	41.13702	-73.29708	Westport	408 Greens Farm Road
Westport SD2	41.13697	-73.29779	Westport	408 Greens Farm Road
Westport SD1	41.13694	-73.30014	Westport	19 Bulkley Ave South.
Westport SD3	41.13807	-73.29799	Westport	Panera and Home Goods Shopping Center
Sasco 4	41.13813	-73.29793	Westport	Upstream side of Route 1 bridge
Sasco 5	41.13853	-73.29790	Fairfield	Bulkley Pond before dam
Sasco 6	41.14556	-73.30111	Westport	Intersection on Old Road and Wakeman Lane
Sasco 7	41.14573	-73.30314	Westport	8 Ulbrick Lane. Downstream of confluence
Sasco 8	41.14579	-73.30318	Westport	8 Ulbrick Lane. Upstream of confluence
Sasco 9	41.15280	-73.30605	Fairfield	210 Hulls Farm Road
Sasco 10	41.16192	-73.31209	Fairfield	105 Ingleside Road
Sasco 11	41.17913	-73.31210	Fairfield	1260 Merwins Lane
Sasco 12	41.18243	-73.30508	Fairfield	1701 Redding Road
Sasco 13	41.19223	-73.30241	Fairfield	4375 Congress Street

K. Saugatuck River

The Saugatuck River watershed encompasses portions of nine communities whose political boundaries fall within the state of Connecticut. The Connecticut towns, all located in Fairfield County, are Danbury, Ridgefield, Bethel, Redding, Wilton, Weston, Easton, Westport, and Norwalk. The watershed is approximately 38,704 acres or 60.5 square miles and is defined by two main drainage basins and a tributary: the Saugatuck River, the West Branch of the Saugatuck River, and Poplar Plains Brook (presented in section H of this report). The land use is a combination of protective preserve around the Saugatuck Reservoir, residential, and light commercial. The Saugatuck River begins in Redding and flows southeast into Weston, and then south into Westport discharging to Long Island Sound through the Saugatuck Harbor. The West Branch of the Saugatuck River is located primarily in Weston, with a small portion traveling southwest into Westport.

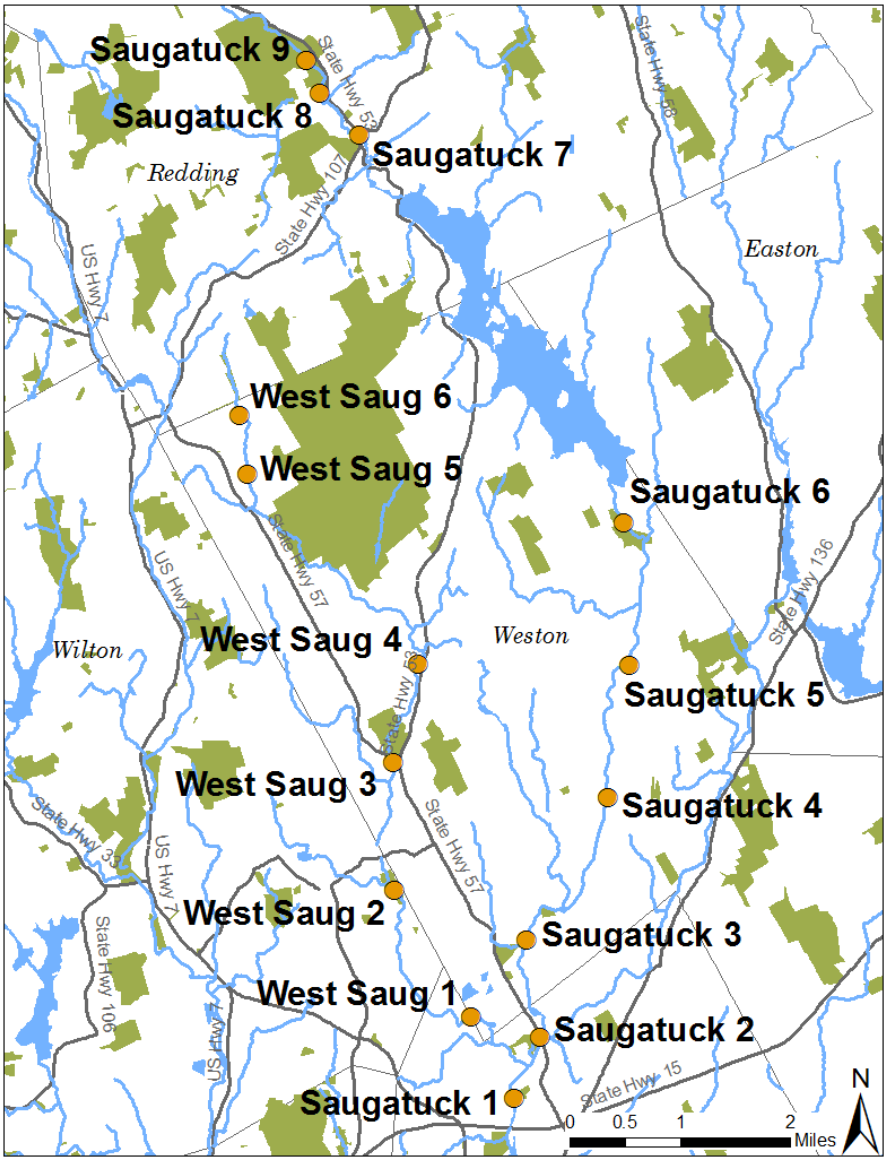

Figure K1. Sample locations for 15 sites on the Saugatuck River.

Harbor Watch has been monitoring the Saugatuck River for approximately 10 years. While the percentage of sites exceeding the CT DEEP geomean criterion has fluctuated through the years, overall the percentage has remained relatively low (Figure K2). More sites exceeded the criterion in 2016 than 2015, but the 2015 samples were only collected in October and November when we tend to observe lower bacteria concentrations due to the colder temperatures. We suggest continued monitoring of the river to identify any sources of sewage pollution for remediation, though overall water quality in the river was good in 2016.

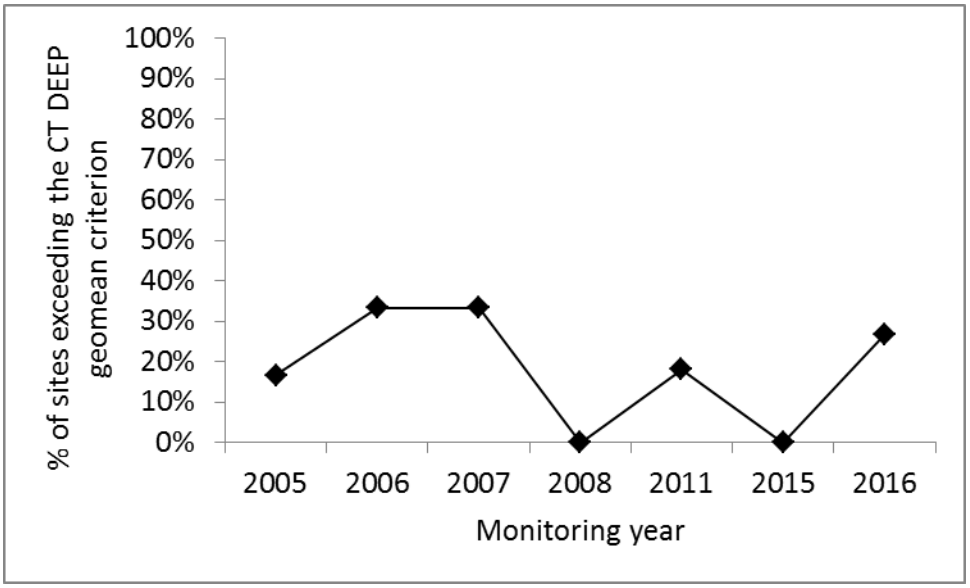

Figure K2. Historic look at Saugatuck River CT DEEP geomean criterion exceedances.

In 2016, four sites, West Saugatuck 6, West Saugatuck 5, Saugatuck 2 and Saugatuck 1, exceeded the CT DEEP *E. coli* geomean criterion (<126 CFU/100 mL; Figure K3, Table K1). Three sites, West Saugatuck 6, West Saugatuck 5, and Saugatuck 3, exceeded the single sample maximum criterion (<10% of *E. coli* samples at each site >576 CFU/100 mL; Table K1). The samples collected during wet weather conditions tended to have elevated bacteria counts (Table K1).

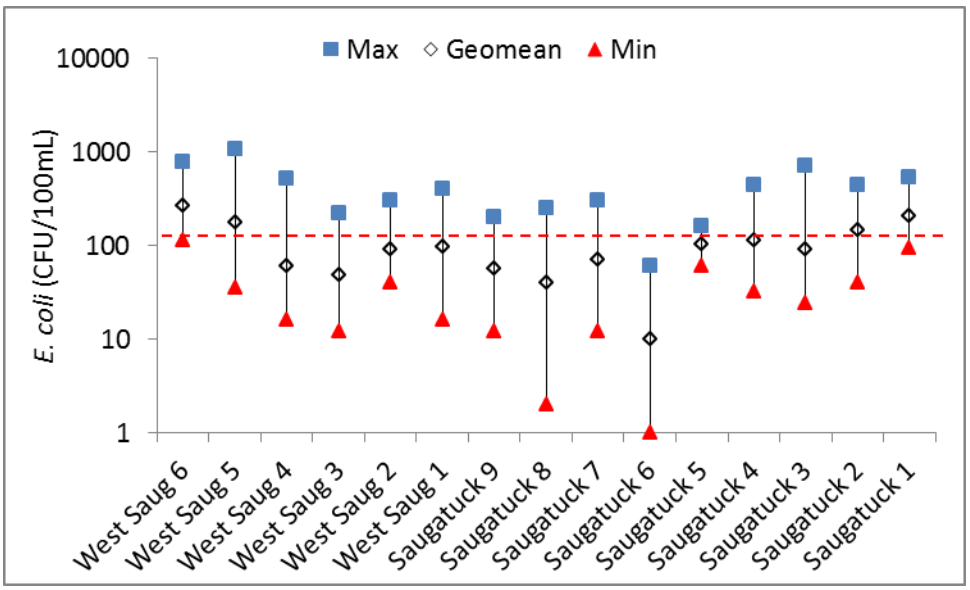

Figure K3. Saugatuck River *E. coli* concentrations. Maximum, geomean, and minimum for each site. Dotted line represents the CT DEEP geomean maximum of 126 CFU/100 mL.

Table K1. Saugatuck River *E. coli* concentrations and relation to CT DEEP water quality criteria. Blue cells represent actual *E. coli* count of 0 CFU/100mL, but were changed to calculate geomean (rainfall data: E. Long, personal communication, Sept 30, 2016)

	5/25	6/2	6/16	7/6	7/19	7/27	8/9	8/25	9/13	9/26	Geomean	%>576
West Saugatuck 6	172	116	176	316	780	520	224	268	No Sample	No Sample	269	13%
West Saugatuck 5	172	80	36	176	84	700	176	1080	No Sample	No Sample	177	25%
West Saugatuck 4	340	76	28	240	16	520	16	92	16	18	60	0%
West Saugatuck 3	184	48	No Sample	180	12	220	36	36	20	14	49	0%
West Saugatuck 2	168	72	132	300	52	200	40	68	68	48	92	0%
West Saugatuck 1	120	64	116	160	68	400	144	240	36	16	97	0%
Saugatuck 9	200	64	48	64	148	100	36	64	20	12	56	0%
Saugatuck 8	248	20	28	56	100	128	32	40	48	2	41	0%
Saugatuck 7	184	24	40	80	304	188	60	116	12	50	71	0%
Saugatuck 6	20	1	12	60	20	16	20	4	8	4	10	0%
Saugatuck 5	68	60	104	88	100	164	124	156	128	88	103	0%
Saugatuck 4	80	32	56	440	76	260	176	160	100	106	114	0%
Saugatuck 3	192	24	68	116	52	720	88	92	60	54	90	10%
Saugatuck 2	288	120	440	224	140	292	68	108	100	40	145	0%
Saugatuck 1	480	540	160	320	120	400	96	176	144	112	211	0%
Rainfall	Wet	Dry	Dry	Wet	Wet	Wet	Dry	Dry	Dry	Dry		

Each of the sites on the Saugatuck River had a mean dissolved oxygen value above the CT DEEP minimum criterion of 5 mg/L (Figure K4). However, individual readings fell below 5 mg/L at West Saugatuck 5 on 8/9 and 8/25, West Saugatuck 3 on 7/19, and Saugatuck 9 on 7/6, 7/19, 8/9, and 9/13.

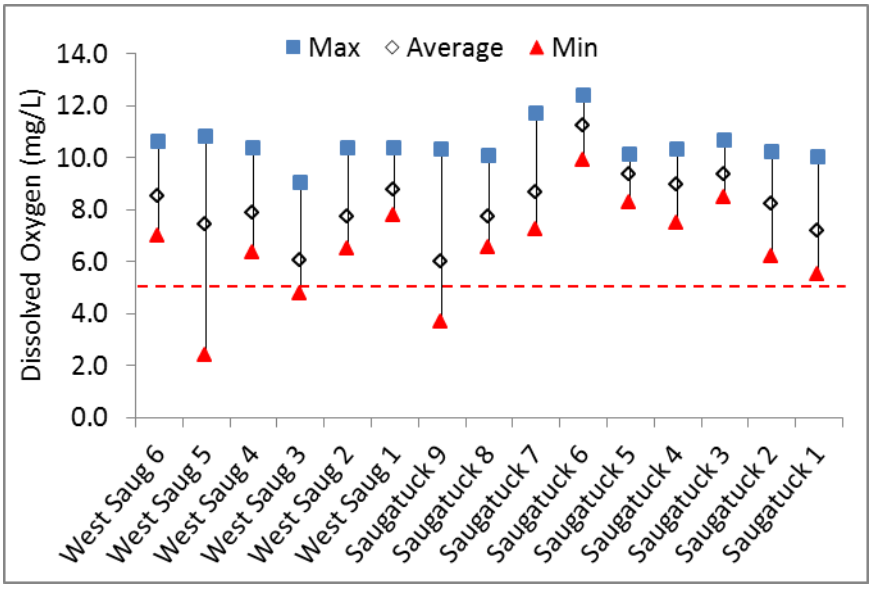

Figure K4. Saugatuck River dissolved oxygen concentrations. Maximum, average, and minimum for each site. Dotted line represents the CT DEEP minimum of 5 mg/L.

Ranges in conductivity throughout the river were narrow (Figure K5). Mean conductivity values increased in the West Branch of the Saugatuck at sites closer to the confluence with the Saugatuck River (Figure K5). There was a drop in mean conductivity values between Saugatuck 7 and Saugatuck 6, which may have been attributed to the Saugatuck Reservoir, which is located in between the sites. The area around the reservoir is protected land which acts as a buffer between the roads and the water.

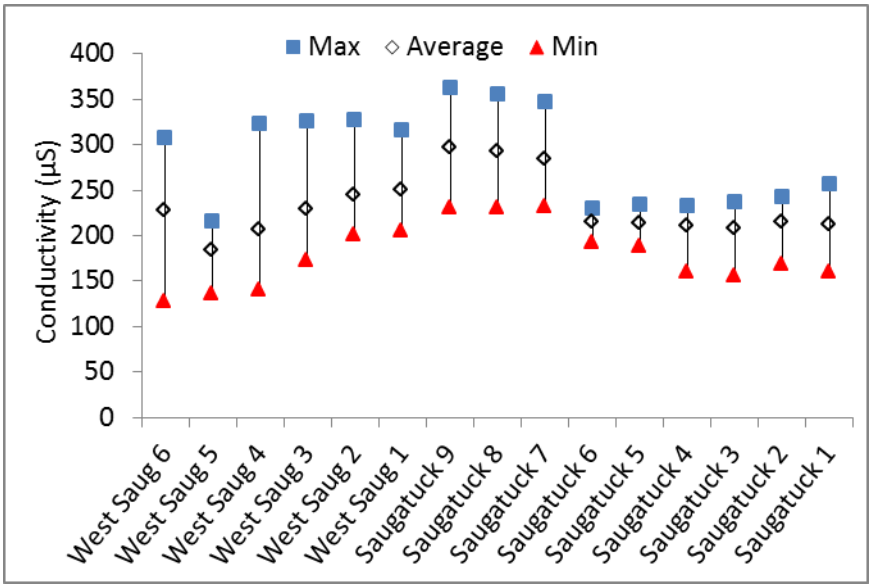

Figure K5. Saugatuck River conductivity values. Maximum, average, and minimum for each site.

Table K2. GPS coordinates and site locations for the Saugatuck River

Station Number	Latitude	Longitude	Town	Comments
Saugatuck 1	41.16748	-73.36647	Westport	Michele Lane on Clinton Avenue
Saugatuck 2	41.17553	-73.36193	Westport	Weston Road by Glendinning Place
Saugatuck 3	41.18830	-73.36441	Weston	27 River Road
Saugatuck 4	41.20722	-73.35043	Weston	1 Cartbridge Road
Saugatuck 5	41.22469	-73.34670	Weston	18 Davis Hill Road
Saugatuck 6	41.24343	-73.34785	Weston	153 Valley Forge Road
Saugatuck 7	41.29439	-73.39480	Redding	Route 53 and Route 107 intersection
Saugatuck 8	41.29987	-73.40161	Redding	Diamond Hill Road by Mark Twain Library
Saugatuck 9	41.30420	-73.40415	Redding	Saugatuck Falls Trail
West Saugatuck 1	41.17809	-73.37404	Weston	21 Cavalry Road
West Saugatuck 2	41.19480	-73.38763	Wilton	23 Stonebridge Road
West Saugatuck 3	41.21162	-73.38800	Weston	Intersection of Georgetown Road and Old Mill Road
West Saugatuck 4	41.22465	-73.38366	Weston	3 Michaels Way
West Saugatuck 5	41.24954	-73.41377	Weston	20 Indian Valley Road
West Saugatuck 6	41.25730	-73.41533	Weston	86 Old Farm Road

Citations

1. State of Connecticut Department of Energy and Environmental Protection. "Connecticut Water Quality Standards." (2013): 22-90. Eregulations.ct.gov. Web. Accessed: 28 Nov. 2016.
2. The Norwalk River Watershed Initiative Committee. *The Norwalk River Watershed Action Plan*. 1998. 38 pp.
3. "Weather History for KBDR." *Weather Underground*. The Weather Company, LLC. Web. Accessed: 28 November 2016.
4. "Fairfield Town Hall KCTFAIRF27." *Weather Underground*. The Weather Company, LLC. Web. Accessed: 04 November 2016.
5. "Weather History for KHPN." *Weather Underground*. The Weather Company, LLC. Web. Accessed: 04 November 2016.