

NON-POINT SOURCES OF BACTERIA AT THE BEACHES

Rainfall and Bacteria, an Eight Year Correlation of Data, 1989 to 1996

An eight year survey of enterococcus bacteria at Stamford's beaches on Long Island Sound show values which can be directly related to rainfall and is statistically significant. The increases in the number enterococcus bacteria were found primarily in samples taken where the flowing natural and man-made drainage basins connect with the areas of Long Island Sound. The amount of rain needed to influence the bacteria levels varied according to several factors.

The enterococcus bacteria group was adopted by the State of Connecticut in 1990, as the primary standard to evaluate beach water quality. The Stamford Health Department Laboratory began evaluating the standard using the membrane filtration method in 1988. Evaluations using enterococcus bacteria were more sensitive to the influence of rainfall than previous tests using total and fecal coliform bacteria. Also observed was a rapid decrease in the bacterial density over time. Twenty four hours after a significant rain elevated bacteria levels would usually return to levels below the limit established by the State of Connecticut(61 colonies/100 mL) for bathing waters. The amount of rain which could trigger counts greater than the established limit was usually at levels at or greater than one inch.

The following factors were reviewed and compared to the incidence of high bacteria readings and found to be insignificant; wind direction and speed, surf conditions, bather load, average water temperature and routine tidal variance at sampling time.

Other factors, which were found to influence individual readings, were the occurrence of abnormal events. These special events were specifically small to moderate sewage spills (no large spills occurred during the monitoring period), the presence of floatable materialⁱ, characterized as grease from sewage treatment plant bypasses or overflows, and excessively high tides, either due to storms or in the natural cycle of the summer months, but the effects were not found to be significant when the individual events were compared with cumulative data.

Surveys of various individual areas of potential contamination(i.e. ... boat docks, neighboring homes and businesses and pumping stations) have not identified any direct sources of the bacteria elevations. Storm water drainage does contribute significantly to bacteria increases, even though the storm drains are mostly free from improper sanitary sewer connections or seepageⁱⁱ. This is normal runoff from the streets and yards of an urban area with a significant domestic and wild animal population.

Each beach has different topographical characteristics, with West and Southfield Beaches being the most similar. Cove Island Beach had four sampling points, three on the main beach which is bordered on the east side by the outlet of the Noroton River and one in a sheltered cove to the west of the main beach. Cummings Beach has three test points with an outlet from a man-made drainage basin and a marina to the west separated by a jetty.

West Beach is to the west of the same drainage and marina. Southfield Beach is in a protected harbor and to the west of the sewage treatment plant discharge and the outlet of the Mill River.

As each beach has different characteristics, each is affected differently by rain according to how storm water would pass the area. The east and mid sample points at Cummings Beach and the Horseshoe Beach at Cove Island are generally protected from a direct influence by natural and/or made-made barriers and show little increase after significant rain. The other portion of Cove Island Beach is directly affected by run-off from the Noroton River. West Beach is influenced by the man-made drainage of storm water at Soundview Pond and Southfield Beach has a several man-made and natural drainage areas flowing by it.

Tests taken over the years at the Soundview pond, which is a depository of drainage for Westcott Cove at West Beach, has shown consistent enterococcus values in the thousands per 100 mL. Surveys at the Pulaski Street bridge, which is the outlet for the Mill River at Southfield Beach, showed an increase in enterococcus levels in samples taken after rain. Refer to tables 1 & 2.

Statistically, the data accumulated shows a very significant correlation between the amount of rain before sampling and the number of samples with elevated bacteria counts, (the Chi Squared p value being much less than 0.00001).

Variances exist on the amount of rain which causes these high values. For most years any rain of one inch or greater would cause a significant number of samples to be elevated. Exceptions to this rule occurred in 1993 and 1995, where the total amount of rain during the beach season was very light and rain greater than 1.00" did not occur during the months of June, July and August. Bacterial counts were influenced by storm water runoff significantly with a rain of 0.7", and some areas were affected with as little as a half an inch of rain. The effects caused by lower amounts of rain is not as widespread and predictable as for those greater than an inch, but it does prove to be significant in times of decreased rain during the summer months. The summer weather patterns are shown in figure #R1.

A map of the Stamford Area beaches with an illustration of the consequence of significant rain is seen in samples taken several hours after a significant rain at low tide (Figures #1 to #3). The results of tests taken three days after the initial profile, show all areas with no significant bacteria counts.

The geometric meanⁱⁱⁱ was used to evaluate each beach and the effect rainfall had on bacteria levels. The geometric mean's limit for beach closure in Connecticut is 33. Table #1 is a summary of this evaluation showing increased values for the geometric mean with increased rain events the day before sampling.

This summarized data and shows the sheltered nature of Cummings Beach, the exposed character of Cove Island and West Beach and the extreme sensitivity of Southfield Beach with respect to runoff after significant rain.

Southfield Beach is the most affected beach with elevated bacteria samples occurring not only after direct rainfall, but also for several days after a significant rain event. As little as a quarter inch of rain caused the geometric mean to be above the limit for safe bathing. When the number and sizes of the sources of runoff are considered, this is supportive of our conclusion that it is urban runoff that is the primary cause of elevated bacteria levels at the beaches.

West Beach is similarly sensitive to considerable rain, with most of the high quantities of bacteria being found after an inch of rain. With the influence of Soundview pond, the geometric mean was elevated with as little as half an inch of rain mostly under conditions of drought or near drought.

Cove Island Beach was the next most responsive to rainfall, but only to amounts greater than 1.00 inch. Cove Island Beaches did show sensitivity to rain greater than a half an inch when conditions of drought or near drought existed.

Cummings Beach exhibited the least influence from rain and is established as the bacteriologically cleanest of the four beaches. The sampling points at Cummings Park showed some affect from rain in drought conditions, but problems were significantly moderated compared to the other beaches.

How a beach is affected when there has been little rain previously in the season by rain between 0.5 to 0.99 inches the day before collection is shown in table #2. The effects of abnormal events have been removed from this table.

The beach at Southfield is the only beach that does not show a dramatic change due to a drought or near drought condition. All other beaches show a significant change in the geometric mean of the enterococcus values when there is little rain for the season.

In summary, runoff after a significant rain event affects the quality of water at the recreational beaches in Stamford. What constitutes significant rain may vary, according to the drainage surrounding each beach, and according to the rainfall pattern for the season. The more sources of drainage around a beach or the occurrence of drought or near drought conditions, the less rain needed to influence the water quality. Under normal or above rain amounts for a season and a single source of storm water influx, one inch of rain is generally needed to obtain elevated bacteria levels. Under near drought or drought conditions, a half an inch of rain is all that is needed to affect the amount of bacteria found in the recreational water area. If multiple sources of storm runoff exist, as little as a quarter inch of rain can have a significantly effect on water quality.

Table #1 Enterococcus bacteria levels from samples at the Pulaski Street Bridge

Collection Date	Previous days rain	Enterococcus/100 mL
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10/19/94	0.001 "	25
03/08/95	0.350 "	100
03/22/95	0.060 "	70
04/12/95	0.760 "	180
04/19/95	0.070 "	< 10

Table #2 Enterococcus bacteria levels from samples at the outfall of Soundview Pond to Cummings Lagoon

Collection Date	Previous days rain	Enterococcus/100 mL
06/24/87	0.001 "	400
06/29/87	0.860 "	1,400
07/06/87	0.000 "	40
07/13/87	0.000 "	100
07/27/87	0.860 "	4,300
06/09/89	0.280 "	1,500
07/03/90	0.430 "	490
05/08/91	2.120 "	2,000
10/07/92	0.000 "	250

Table #3 Geometric Mean of Enterococcus bacteria compared to the amount of rain occurring the previous day

Beach	Previous rain amount	total samples	Enterococcus/100 mL Geometric mean
Cove Island with four sampling points	no rain	383	2.7
	trace to 0.249"	140	2.4
	0.25" to 0.499"	47	5.3
	0.5" to 0.99"	29	9.9
	over 1.00"	31	73.8
Cummings with three sampling points	no rain	301	3.1
	trace to 0.249"	105	3.4
	0.25" to 0.499"	42	6.1

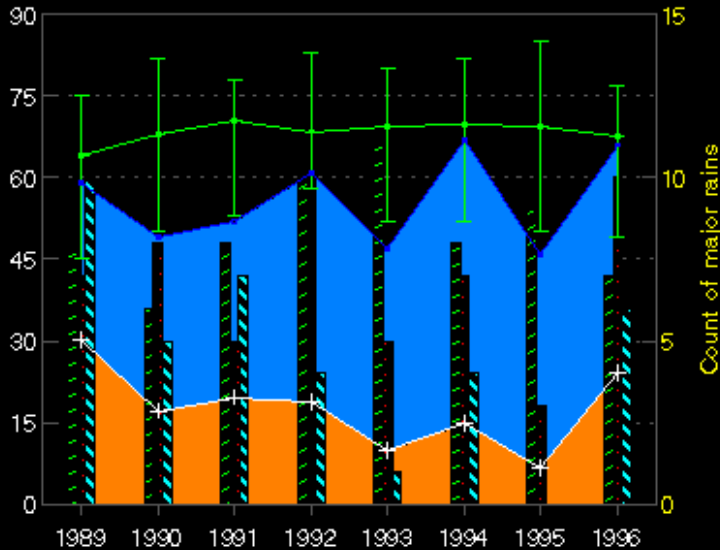
	0.5" to 0.99"	20	24.1
	over 1.00"	23	29.0
West with two sampling points	no rain	194	3.0
	trace to 0.249"	69	3.6
	0.25" to 0.499"	26	7.7
	0.5" to 0.99"	14	52.2
	over 1.00"	14	65.8
Southfield with two sampling points	no rain	107	6.7
	trace to 0.249"	36	13.0
	0.25" to 0.499"	13	54.6
	0.5" to 0.99"	6	180.3
	over 1.00"	7	824.1

Table #4 Geometric Mean of Enterococcus bacteria in "Normal to High" summer rain patterns compared to "Low" summer rain patterns in samples taken one day after a half inch of rain

Beach	Summer Rain Amounts	Samples after 0.5" to 0.99"	Enterococcus/100 mL Geometric mean
Cove Island	Normal	21	8.4
	Drought	8	29.1
Cummings	Normal	14	11.5
	Drought	6	54.3
West	Normal	8	26.6
	Drought	4	399.8
Southfield	Normal	4	265.0
	Drought	2	96.4

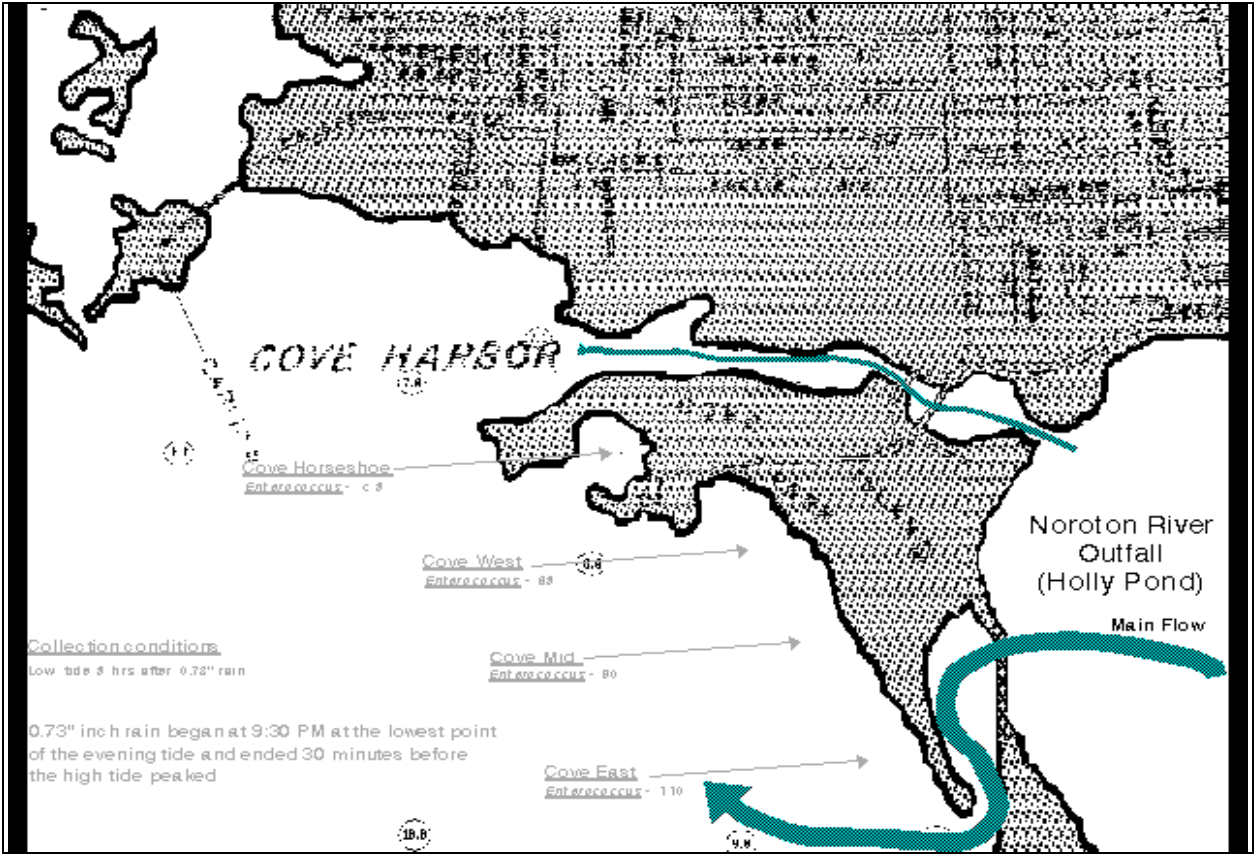
Summer rain patterns

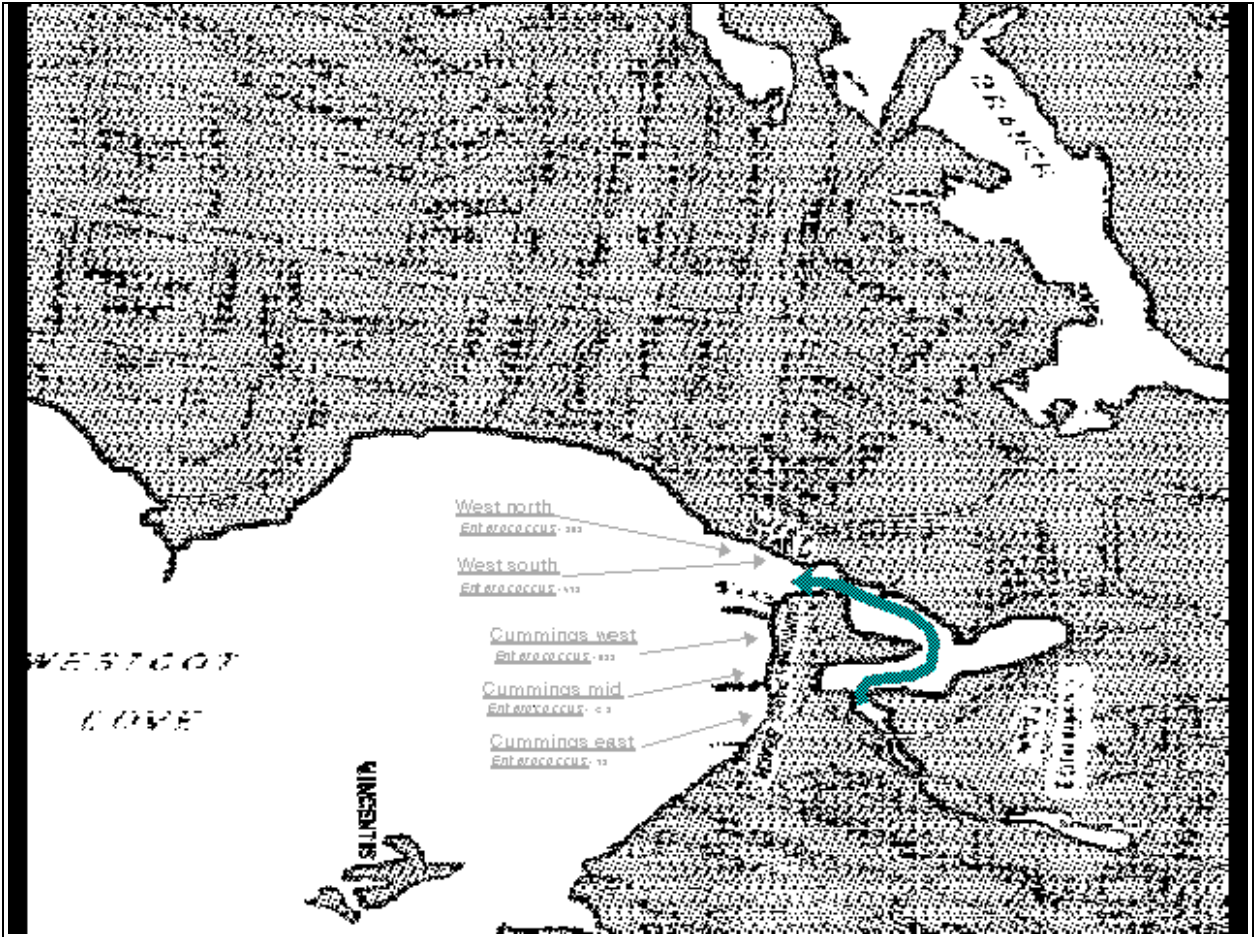
Rain and temperature totals

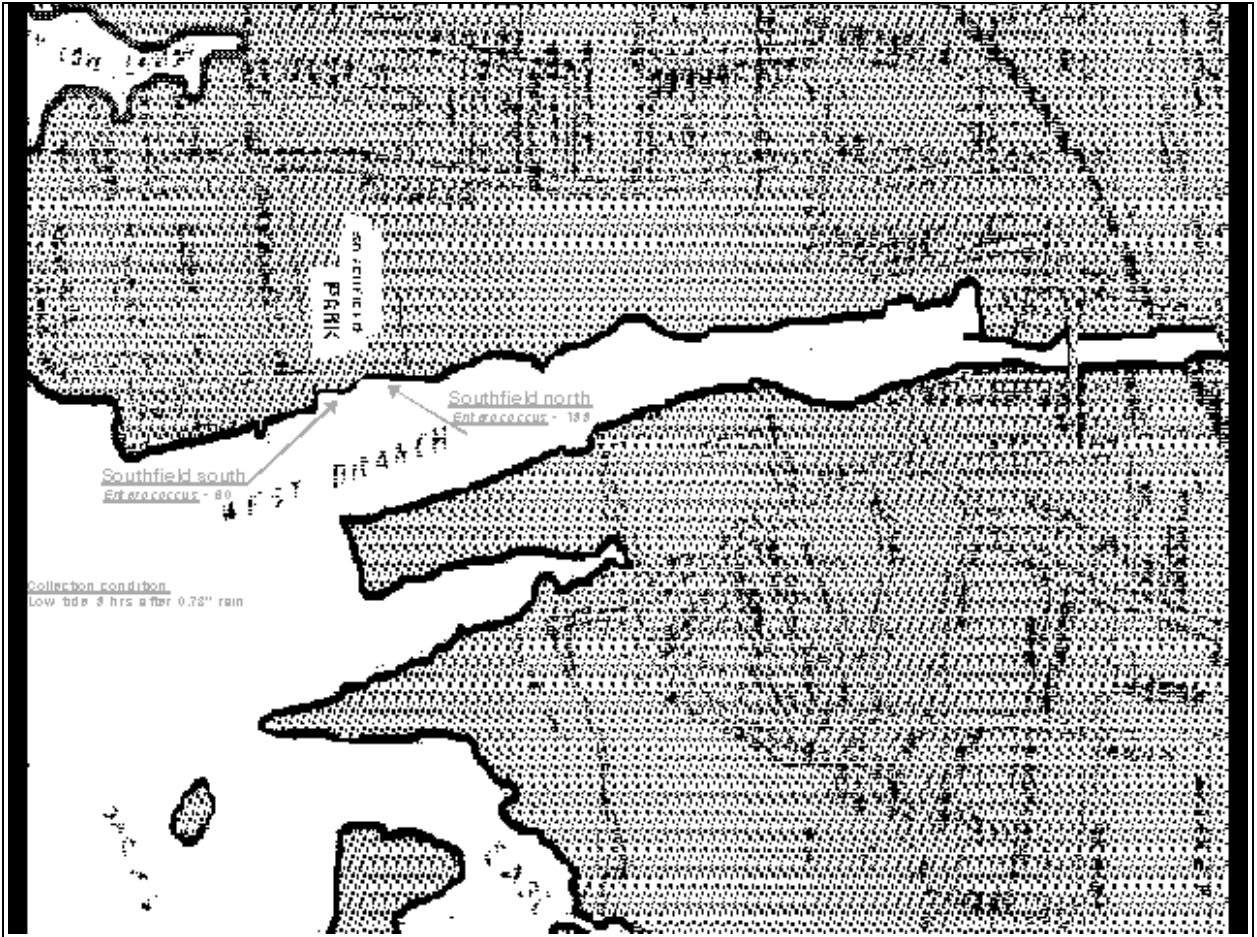


Mean water temp	83.28	87.83	70.32	83.48	88.27	88.84	88.34	87.38
# of > 1.00 rains	10	3	7	4	1	4	0	8
# 0.5 to 0.99 rains	7	2	3	10	3	7	2	10
# 0.25 to 0.49 rains	3	8	2	10	11	3	8	7
Amount of rain	20.138	17.182	18.882	12.732	8.802	14.84	8.334	24.01
	38	48	32	81	47	87	48	88

- Days of rain
- Mean water temp
- | Low water temp
- | High water Temp
- ▨ # Of > 1.00 rains
- ▨ # 0.5 to 0.99 rains
- ▨ # 0.25 to 0.49 rains
- Amount of rain







ⁱClesceri, L., A. Greenberg and R. Trussell(1992), *Standard Methods of Analysis for Water and Wastewater*, 18th Edition, American Public Health Association, Washington, DC

ⁱⁱStamford Public Works Department (1985), *Operation Shellfish, project report for the sanitary sewer evaluation and repair in the Westcott Cove drainage area*, Stamford, CT.

ⁱⁱⁱConnecticut Department of Health Services (1989), *Guidelines for Monitoring Bathing Waters and Closure Protocol*, Hartford, Connecticut. Clesceri, L., A. Greenberg and R. Trussell(1992), *Standard Methods of Analysis for Water and Wastewater*, 18th Edition, American Public Health Association, Washington, DC

ⁱⁱⁱⁱStamford Public Works Department (1985), *Operation Shellfish, project report for the sanitary sewer evaluation and repair in the Westcott Cove drainage area*, Stamford, CT.

^vConnecticut Department of Health Services (1989), *Guidelines for Monitoring Bathing Waters and Closure Protocol*, Hartford, Connecticut.