Predictability of Swimming Prohibitions by Observational Parameters

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Using compiled bacterial analyses to predict water quality when certain conditions are observed, provides a way to establish a public health policy that is proactive. Conditions were reviewed using a geometric mean specifying different parameters which included the amount of rain in previous days, wind direction and speed, tides and high tide height, water temperature, drought or flood conditions for the season, different materials coming into the swimming areas and the location and amount of any sewage spills. Only three events showed statistical significance (Chi-Squared $P < 0.0001$): rain events of 1.00 inch or more in a 24 hour period under normal weather conditions, rain events in a 24 hour period under drought conditions over 0.5 inches, and when "floatable" material from distant sewage spills (i.e. grease balls) are present at a beach. This evaluation enables a public health policy to be developed that restricts swimming when certain conditions are present without waiting for bacteriological examinations to prove that a problem exists.

The method used by the City of Stamford to determine what conditions initiates a preemptive closure may be applicable to any recreational water body. The results that were found may be applicable to any recreational water with characteristics similar to those of Stamford. By using a rain gauge, marine police and lifeguards, it can be determined if conditions warrant bathing areas be closed, before any bacterial analysis can be performed. Because all elevations in bacteria levels are not accounted for, this policy does not eliminate the need for testing. As of 2000, the United States Environmental Protection agency listed only three areas in the country having established models for preemptive closure of bathing waters. It is hoped that this will help others establish their own methods and parameters. [i]

Prior to1990, the beach closure policy was based on bacteria tests taken from designated points on the beaches. If one or more samples from a beach were found to contain more than the recommended level of bacteria per 100 mL, the beach was closed and more samples were taken. Sampling continued until acceptable samples were obtained and then the beach was reopened. This should sound familiar to most persons involved with monitoring recreational waters because it is the way most beach closings operate. Sampling would be on a weekly basis usually on a Monday, so if test results were elevated, retesting could occur prior to the weekend. Rarely were samples collected if it was raining and rainfall levels were generally not recorded. Before 1988, a few individual samples had been found with high bacteria, but no correlation was made as the cause. One particular beach area was kept closed to swimming for over twenty years without ever reviewing the cause of the elevated bacteria levels found in its water.

Several factors occurred to revise the methods previously used. First, certain areas off of the coast became conditionally[ii] open for recreational shellfishing. Also, 1988 had much rain over a short time period in July and 1989 was an extremely wet summer.[iii]

Until 1988, recreational waters were sampled for approximately 15 weeks each summer, 11 points on four beaches having an average per season of 14 of the samples being elevated. By reviewing this data, there seemed to be a correlation between elevated samples and rain, but there was insufficient data to make a significant correlation.

In 1988 many elevated samples were found, particularly after a rainy period at the end of July. More samples of the swimming area were taken and many samples surveying water entering the beach areas were analyzed. Over 500 samples of beach water were collected and examined. Also observed was the presence of discolored white Styrofoam like objects washing ashore. Bacteriological tests were performed indicating that some form of sewage was present, with total and fecal coliform bacteria present in the millions per gram. Sampling was done several times a week from the area around elevated sites, a river and a stream, leading into separate saltwater ponds that emptied near bathing areas. Extensive testing was done at marinas. Offshore sampling was done to see if there were any problems with boats or marinas. Known shoreline septic systems were rechecked. The sewage treatment plant was not considered, since it had an excellent record of the cleanest discharge with the fewest overflows of any plant in the area. Also the plant was geographically separated from our bathing areas by a large peninsula. FDA dye testing of the facility in 2000 showed that a discharge from this plant would not affect shellfish beds near the recreational beaches. In Stamford, storm water is not combined with sanitary sewers and thus is not treated. The storm drains were found to be free from improper sanitary sewer connections or seepage.[iv] Storm drains do not discharge directly to the recreational swimming areas and are tested by both the State Aquaculture Division and the Stamford Health Department[v].

The accumulated data made it was clear that there was not a point source of the problem. Prior to and including 1988 total coliform and fecal coliform bacteria were used as the indicator organisms of water quality. Levels above 1,000 total coliform or 400 fecal coliform per 100 mL were considered elevated. Previous years showed an average of 14 elevated samples per season, but in 1988, there were 68. Past information was reviewed, including extensive testing done five years earlier (for the purpose of opening recreational shellfish beds), but still no specific "smoking gun" was found.

It was not until the next year, with over 30 inches of rain and 11 rain events greater than one inch, that the data pointed to rain as a potential influence. In 1989 the State of Connecticut announced it would adopt enterococcus bacteria as the indicator organism for recreational water in 1990. This method was evaluated in 1989 and samples were gathered under as many diverse conditions as possible. All recreational water samples were analyzed for total coliform, fecal coliform and enterococcus bacteria. It became more apparent by using enterococcus bacteria, that rainfall caused a problem. The use of total coliform and fecal coliform bacteria did not make the issue of storm water apparent because some coliform organisms are saprophytes and can bloom without being linked to a pollution source.[vi] [Graph set 1]

The initial statistical methods used to analyze the data involved determining the geometric mean of the sample data under different conditions. [Table 1] This was later verified independently using multiple regression and chi-squared analysis to determine that tide, wind and water temperature were non-significant ($P > 0.05$). Enterococcus values alone were used by the independent source, not total and fecal coliforms. The data was stratified by rain (less than 1 inch and 1 inch or more), bacteria level (less than 60 colonies/ 100 mL and greater than or equal to 61 colonies/ 100 mL), and days after the rain event (less than 2 and greater than or equal to 2), which revealed a significant relationship ($P < 0.01$). The more rain, the higher the level of enterococcus bacteria in the bathing water [vii]. Using these evaluations, a policy was established to close the beaches for 24 hours after a rain event of more than 1 inch. There was no significant elevation in the bacteria levels after 48 hours. [Table 2]

It was concluded that bacterial elevations were due to rain, washing a densely populated area having many roads, buildings and parking lots. All of this goes into storm drains, streams and rivers without the benefit of natural treatment through salt marshes and wetlands, not a point source, as others would later agree.[viii]

Monitoring the beach areas was continued on a weekly basis, with special emphasis on sampling immediately after a rain, at low tide or during any other adverse condition, which might affect the water quality.

Evaluation of this data in 1992 employed the geometric mean to determine effects of the various conditions. Significant rain events were the only condition that would elevate the geometric mean above 35/100 mL for enterococcus bacteria.[ix]

In 1995, five years of data was compiled and made public information. [Table 3]
Several new factors were analyzed in the 1995 study. First was the amount of rain causing high enterococcus levels. 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 or August. Bacterial counts were greatly 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 effect caused by lower amounts of rain is not as widespread and predictable as for that observed after a rainfall greater than an inch, but it can prove to be significant in times of decreased rain during the summer months.

Figure #2 is a map of Stamford beaches and illustrates the consequence of significant rainfall in samples taken several hours after 0.7" of rain during drought conditions at low tide. The results of tests taken two days after the initial profile shows no significant bacteria counts at any area.
Rarely occurring events were also reviewed, small to moderate sewage spills (no large spills occurred during the monitoring period), the presence of floatable material[x], characterized as grease from sewage treatment plant bypasses or overflows, and excessively high tides, either due to storms or the natural lunar cycle. Sewage grease was an issue in 1988 when it was observed washing into bathing areas and initially believed it to be the main cause of beach closures during that summer.

The presence of sewage grease was found to be significant only at the beach where it was found and not at neighboring beaches. The geometric mean of samples taken from beaches where the sewage grease was present was greater than 35/100 mL. The appearance of floatables usually occurred between one to 10 days after a sewage discharge from treatment plants with combined storm water and sewer connections. Some of these discharges were reported and some were assumed, since the plants' capacity were exceeded by rains greater than 2.0 inches[xi] [xii] [xiii]. The floatable components of these discharges are "grease balls" and a thin, highly visible film or slick and are wind driven. Analysis of these grayish-white Styrofoam-like substances gave bacteria results as great as 1,000,000 colony forming units per gram for both fecal coliform and enterococcus bacteria. The primary chemical constituent was determined to be moderately high hydrocarbons not of petroleum origin by gas chromatography-mass spectrometry[xiv] and referenced to oleic acid by infrared spectrometry. [Figure 3, Figure 4]

Further proof of the impact of these floatables occurred in 1997 and again more notably in1998, when floatables washed onto one beach. This was preceded by the appearance of reddish water and after a problem at a neighboring sewage treatment plant (probably due to almost 4 inches of rain that occurred on June 12th and 13th). The town where the problem originated closed their beaches for several weeks. A neighboring town's beach located between where the problem originated and Stamford, had one beach closest to this area closed for one week with enterococcus colonies per 100 mL averaging 151 and fecal coliform colonies per 100 mL averaging 868. Stamford’s beaches were analyzed and found to contain a significant number of rotifers[xv] and jellyfish and a low level of enterococcus and fecal coliform bacteria. Analysis of these rotifers and using the saprobic index, the water was found to be moderately to heavily polluted at the time. This is shown in Table 4. When the sewage grease did wash onto shore, the enterococcus levels were elevated until the floatables were no longer was present.

When floatables were found in open water, there was no significant elevation in bacterial counts of the surrounding water. This unexplained characteristic caused some confusion in identifying them, but as they washed up on shore and were subject to wave action, they broke apart releasing bacterial contamination.

Lifeguards and marine police were trained to recognize sewage grease and other suspicious events in the waters and to report to the Health Department. Beach closures can occur when these items are observed and remain in effect until they stop washing ashore and these materials are removed from the beach. Usually the marine police have observed a slick approaching and give one days notice before these floatables wash ashore. Lifeguards will report and send samples of any unusual substance found in the water to the Health Department.

Normal tidal fluctuations do not appear to affect the water quality at the beaches. Unusually high tides, particularly the perigee tide occurring in summer, might have an influence by washing out storm drains in the same way a rain does. Storm drains were considered a point source in the early 80's because of the large numbers of raccoons living within the system. This changed in 1991 with the rabies epidemic[xvi] when the raccoon population was reduced by up to 95%. Raccoon habitation of the storm drains was well documented during "Operation Shellfish" and was considered a primary cause of the high bacteria levels in Stamford's storm drains. There was no significant occurrence of elevated bacteria levels after these tides in the recreational waters and the geometric mean of the enterococcus bacteria remained low.

In 1996 the information was again reviewed with each beaches’ characteristics scrutinized. The same conclusion was reached, rainfall was the predominant influencing factor.

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 conditions of normal or above normal rainfall for a season, one inch of rain is generally needed to elevate bacteria levels in swimming areas with a single source of storm water influx. Under near drought or drought conditions, a half an inch of rain is all that is necessary 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 impact on water quality.[xvii] [Table 5]

Again the geometric mean was used to evaluate all beaches collectively and each individually to determine the effect rainfall had on bacterial levels. An evaluation of all beaches after a rain of less than half an inch gave a geometric mean of 6.02; after a rain of 0.5 to 0.99 inches the geometric mean was 23.2, and after a rain event of more than 1 inch, the geometric mean was greater than 52. The presence of floatable material at a beach gave a geometric mean of enterococcus bacteria of 44 and a rain event greater than 0.5 inch under drought conditions gave a geometric mean of 85.

The topography of each beach was evaluated and believed to have a significant impact on how rain affects water quality.

One beach, Cove Island, has four sampling points, three on the main beach which is bordered on the east side by the outlet of a small river and one in a sheltered cove 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 and a fishing pier. West beach is to the west of the same drainage and marina as Cummings Beach. Southfield beach is in a protected harbor to the west of the sewage treatment plant outfall and at the mouth of another small river.

The east and mid sample points at Cummings beach and Horseshoe beach at Cove Island are protected from 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 nearby. Reviewing the data provides evidence that man-made and natural barriers may protect a beach from the effect of runoff after a rain. Cummings beach is considered sheltered, Cove Island, West and Southfield beaches are not. [Table 6] Cummings beach is most influenced by a strong incoming current from Long Island Sound and is the beach where floatable materials wash ashore most often.

Southfield Park's beach has been the most troublesome with high numbers of bacteria occurring not only after direct rainfall, but also for several days after a significant rain event. Rain of 0.25 inches caused elevated levels of bacteria in almost 40% of the samples taken. This beach has been closed to swimming for over thirty years. There are several factors believed to be affecting the water quality of this beach; it is within a highly industrialized area with a significant amount of storm water drainage to the harbor, the beach is at the mouth of a river, and the point in the harbor where it is located is very restricted with very poor tidal flushing. Performing a survey on this beach showed swimming might allowed three days after a rain event of a quarter inch or more during a dry season, but could not be opened during a normal or wet year. As of 1999 the beach area at the park is no longer considered a swimming area and the beachfront has been eliminated.

A comprehensive survey of all storm water sources, storm drains, rivers and streams emptying into both Westcott Cove and Cove Harbor, where all the bathing areas are located, was undertaken during 1998. Highest levels of bacteria were found after significant rain, again confirming the beach closure policy.

Perhaps the most difficult issue in using predictive closures is dealing with the public. Their perception is that the water is getting “dirtier” when public swimming areas are closed, but in reality it means that the issues and problems of water quality are becoming more apparent. If beach water is rarely tested, swimming will almost never be prohibited. The news media can be extremely helpful, assisting in explaining the situation and in a supportive role for public health[xviii] [xix].

Establishing a predictive model for beach closures is resource-intensive and many samples under many different conditions should be evaluated. Unusual occurrences of elevated bacteria levels should not be discounted until all possible explanations have been exhausted. Once a predictive model is established, then public health is promoted by prohibiting swimming and preventing the potential exposure to disease when the risk is highest, but before conclusive results can be obtained. This also gives those who go to the recreational bathing areas maximum opportunity to enjoy these areas, since they are not needlessly closed while awaiting a bacterial retest.

Table 1. Evaluation Using the Geometric Mean under various conditions: rain, tide and water temperature

Condition tested	bacteria	Number of samples	Geometric mean	Arithmatic mean	Number elevated samples
All samples	total coliform	291	27.5	583	24
	fecal coliform	328	11.9	160	21
	enterococcus	569	6.5	96.9	48
Rain < 1.00 inch	total coliform	71	186	1,134	11
	fecal coliform	71	50	242	10
	enterococcus	71	43	146	32
low tide	total coliform	51	13.8	373	2
	fecal coliform	58	4.8	112	2
	enterococcus	58	3.3	30	5
flood tide	total coliform	127	26.8	480	14
	fecal coliform	146	11	147	11
	enterococcus	146	6.1	123	15
high tide	total coliform	84	47.9	778	6
	fecal coliform	88	24.1	143	5
	enterococcus	88	13.7	97	20
ebb tide	total coliform	28	19.3	543	2
	fecal coliform	35	11.7	334	3
	enterococcus	35	5.1	63	7
Water temp. < 51C	total coliform	11	3.7	101	0
	fecal coliform	11	1.9	75	0
	enterococcus	14	2.0	51	1
Water temp 51-60C	total coliform	84	39.4	815	13
	fecal coliform	84	11.8	296	10
	enterococcus	84	7.6	212	13
Water temp > 61C	total coliform	186	31.1	512	11
	fecal coliform	220	14.3	124	11
	enterococcus	377	6.2	62	34

Table 2. 1989 Evaluation of Rainfall on Individual Beaches

Beach	location	# of tests over limit		Geometric mean	
Days after 1 " rain		1 day	> 1 day	1 day	> 1 day
Cove Horseshoe	Mid	3	0	5.4	1.6
Cove Island	east	4	0	39.6	2.5
	mid	5	0	37.7	1.0
	west	4	0	59.5	4.0
Cummings Park	east	2	0	19.0	1.6
	mid	5	0	48.3	1.8
	west	2	0	17.5	1.0
West	south	4	0	41.8	1.6
	north	4	0	24.3	1.6

Table 3. 1995 Evaluation of Influence of various amounts of rainfall on beaches

Beach	Previous days rain amount	total samples	total elevated values	percent elevated
Cove Island	no rain	179	4	2.22
	trace to 0.249"	143	4	2.72
	0.25" to 0.499"	29	2	6.90
	0.5" to 0.99"	35	6	17.14
	over 1.00"	16	10	62.50
Cummings	no rain	30	0	0.00
	trace to 0.249"	108	5	4.50
	0.25" to 0.499"	27	0	0.00
	0.5" to 0.99"	23	4	17.39
	over 1.00"	12	2	16.67
West	no rain	89	0	0.00
	trace to 0.249"	70	3	4.17
	0.25" to 0.499"	14	1	7.14
	0.5" to 0.99"	16	4	25.00
	over 1.00"	8	3	37.50

Table 4. Rotifer determinations before an incident of sewage grease washing onto the shore

Rotifer determination performed by Save the Sound's Research Assistant, Iliana Ayala. Enterococcus testing performed by Stamford's Health Department Laboratory.

1. A two day rain event of 3.940" occurs, Sewage treatment plants with Combined Storm and Sewer systems are overwhelmed.
2. Rotifers were found in red discolored water off the beaches on June 24, 1988, sewage grease did not wash on to the shore until June 25 and June 26. The water was devoid of algae.

6/24 water determinations before the red color occurred:

enterococcus / 100 mL	2
fecal coliform / 100 mL	10

6/24 water determinations after red color:

Rotifer Species	S_i (Saprobic Index)	number of each species
Brachionus rubens	3.2	85
Encentrum lupus	2.4	170
Asplancha bright welli	2.3	204

Bacteria	1 plate	duplicate	average
enterococcus / 100 mL	35	35	35
fecal coliforms /100 mL	200	160	180
E. coli / 100 mL	180	160	170

6/25 bacteria determinations: water

enterococcus / 100 mL	70	85	77.5
fecal coliform / 100 mL	350	320	335
E. coli / 100 mL	280	260	270
sewage grease			
enterococcus / gram	1,000,000		

6/29 bacteria determinations: water

enterococcus / 100 mL	5	5	15
fecal coliform / 100 mL	<10	10	< 10

1. Hydrobiologia 100, 1983 pp 169 - 201.

2. Paolo Madoni, A Sludge Biotic Index (SBI) for the Evaluation of the Biological Performance of Activated Sludge Plants Based on the Microfauna Analysis, Water Resources, Volume 23, No. 1, pp 65-75, 1994.

3. Wilhelm Foissner, Evaluating Water Quality using Protozoa and Saprobity Indexes, Society of Protozoologist, 1992.

4. Vladimir Sladecek, Rotifers as Indicators of Water Quality, Department of Water Technology, 1993.

Table 5. Evaluation of Drought Conditions and the Amount of Rain Causing Closure Conditions

The effects of abnormal events have been removed from this table.

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

Table 6. Natural and Manmade Barriers may Protect Swimming Areas from Storm Runoff Affects

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

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[i] United States Environmental Protection Agency Beach Watch Program, May 1999, *Review of Potential Modeling Tools and Approaches to Support the BEACH Program.*

[ii] State of Connecticut Marine Aquaculture Division, 1988, *Memorandum of Understanding Between the State of Connecticut Marine Aquaculture Division and the City of Stamford,* The agreement called for closure of the shellfish beds for 6 days with as little as 0.5" of rain or 10 days with any rainfall greater than 1.00".

[iii] Information collected by the rain gauge operated by the Environmental Health Division of the Stamford Health Department and confirmed by the NOAA Station #5N-06-7970-3 at the Stamford Museum and Nature Center.

[iv] Operation Shellfish, in the mid 1980's a joint project between the Health Department's Environmental Health and Laboratory sections and the Department of Public Works' Liquid Waste Division searched each house in the Westcott Cove drainage area, looking for direct sewage connections to storm drains, migrations and breaks between the sanitary sewer to the storm drain.

[v] Bell & Romick, State of Connecticut, Department of Agriculture, Bureau of Aquaculture and Laboratory*, 2000 & 2003 Triennial Evaluation.*

[vi] Clesceri, Greenberg & Trussell, Standard Methods For the Examination of Water and Wastewater, 1992, *Significance of Coliform Types,* 18th Edition, 9225 D, pp. 9-67.

[vii] Glassman, MJ., D.M.D., O'Brien, G., BS, et all, 1990, "Rainfall As A Predictor of Unacceptable Bathing Water Bacteria Levels", 1990 Annual American Public Health Association Meeting Abstract Listing, Presentation in the Stamford Health Department.

[viii] United States Environmental Protection Agency, Office of Enforcement and Compliance, 1995, *A September 1995 Pro-Act fact sheet on storm water pollution prevention*.

[ix] Connecticut Department of Health Services, May 1989,*Guidelines for Monitoring Bathing Waters and Closure Protocol.*

[x] Clesceri, Greenberg & Trussel, Standard Methods for the Examination of Water and Watsewater,1992, *Floatables*, 18th Edition, 1992, sec. 2530 A, B & C, pp. 2-49 to 2-52.

[xi] Personal correspondence with Thomas J. Murray, Assistant Director of Waste Water Treatment for Westchester County, New York from 1967 to 1988.

[xii] Massachusetts Water Resources Authority, Fall 1996, *Combined Sewer Overflows.*

[xiii] Untied States Environmental Protection Agency, 1997, *Floatable Debris, Long Island Sound Study.*

[xiv] Connecticut Agricultural Station analysis on floatable material submitted July 1994.

[xv] Iliana Ayala, MS, Research Assistant for Save the Sound, INC. whose master thesis concerned rotifer identification, performed this determination.

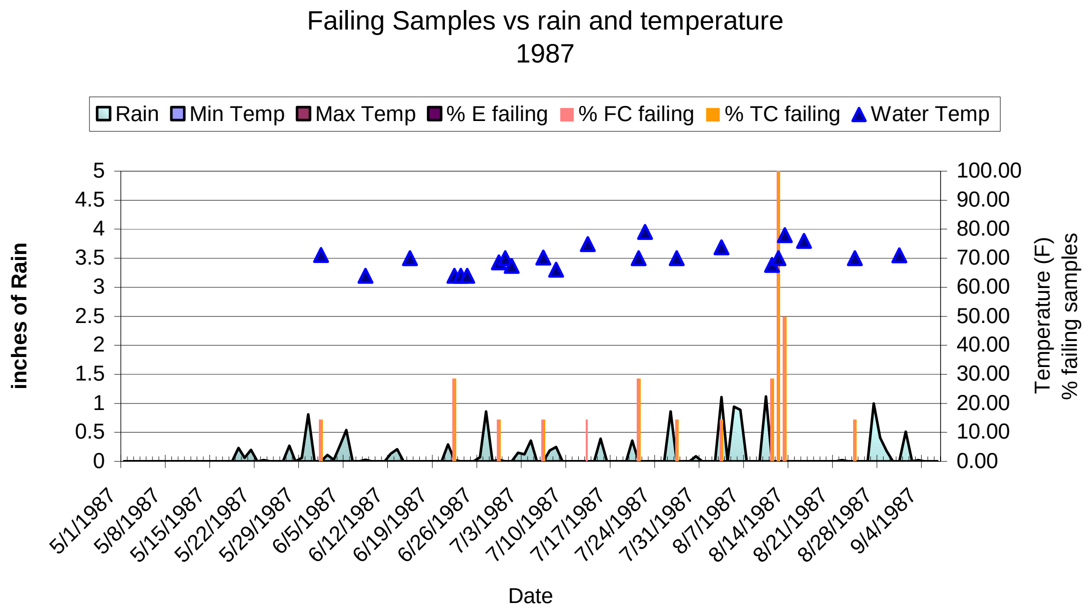
[xvi] State of Connecticut Department of Health Services, April 1991, *CONNECTICUT EPIDEMIOLOGIST, Epidemiology section,* Volume 11, No. 3.

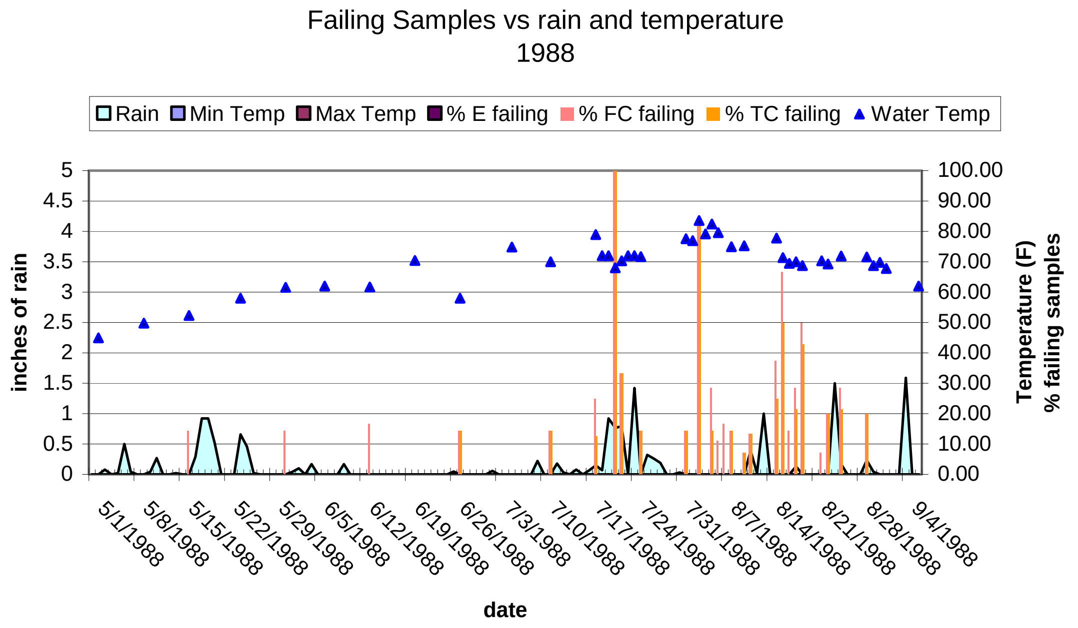
[xvii] State of Connecticut Department of Environmental Protection, February 1998, *Connecticut Water Bodies Not Meeting Water Quality Standards, State of Connecticut Department of Environmental Protection report to the United States Environmental Protection Agency*.

[xviii] The good and bad about beach closing, The Stamford Advocate, July 20, 1998.

[xix] Testing the Sound's water, Stamford Health Department monitors shoreline for bacteria, The Stamford Advocate, June 9, 1999.

Graph Set 1

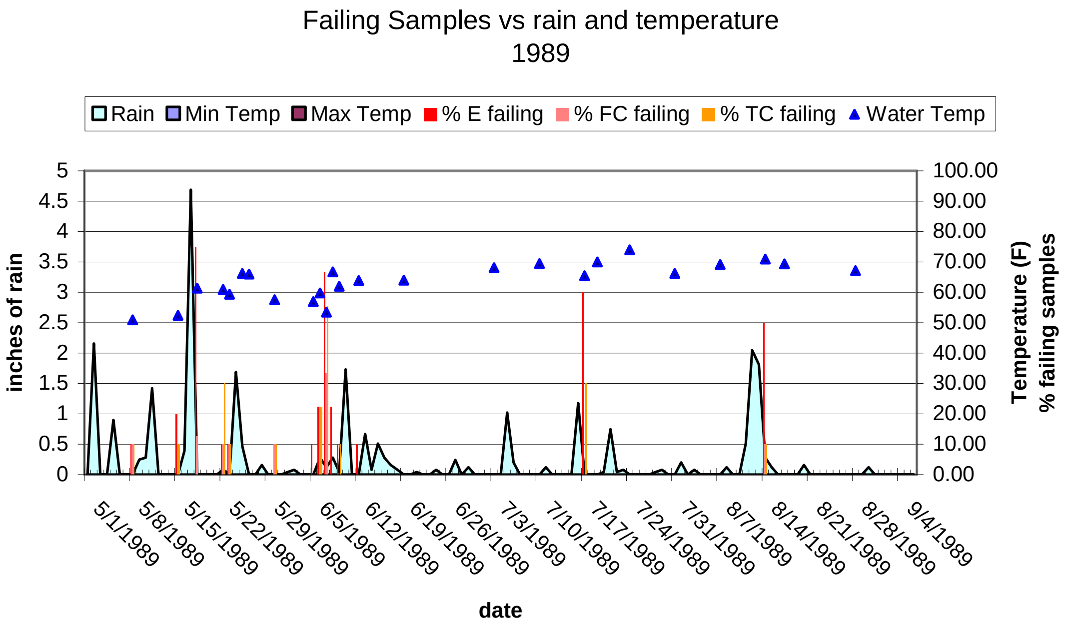


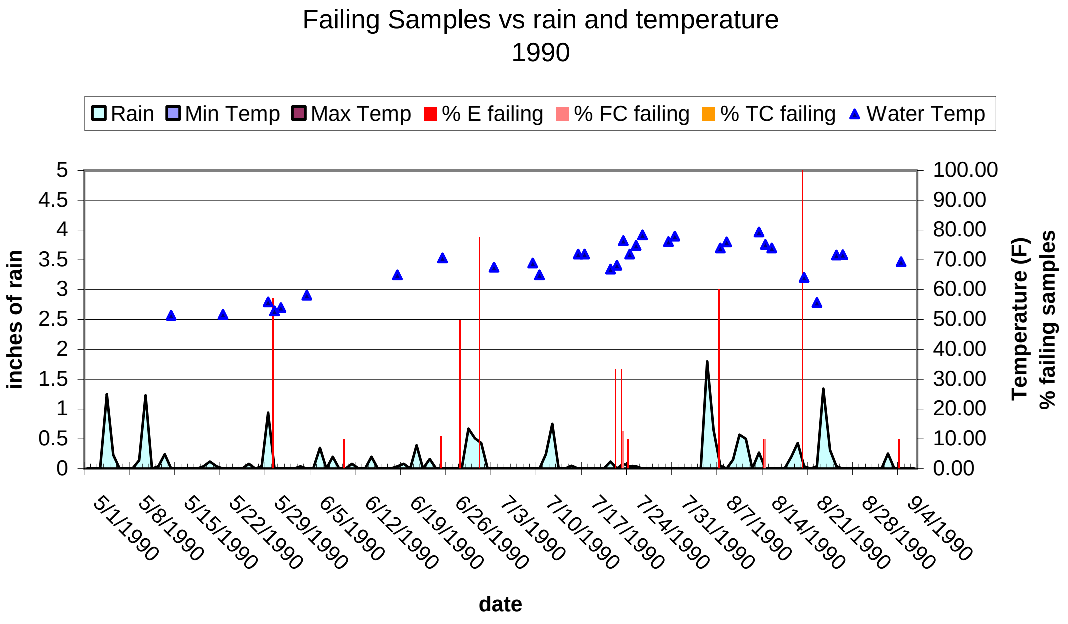


▨ - Tests for Fecal Coliform Bacteria with values > 400 colonies/ 100 mL

▨ - Tests for Total Coliform Bacteria with values > 1,000 colonies/ 100 mL

- No tests for enterococcus bacteria


Failing Samples vs rain and temperature
1989


Failing Samples vs rain and temperature
1990

▨ - Tests for Fecal Coliform Bacteria with values > 400 colonies/ 100 mL

▨ - Tests for Total Coliform Bacteria with values > 1,000 colonies/ 100 mL

🟥 - Tests for Enterococcus Bacteria with values > 61 colonies/ 100 mL

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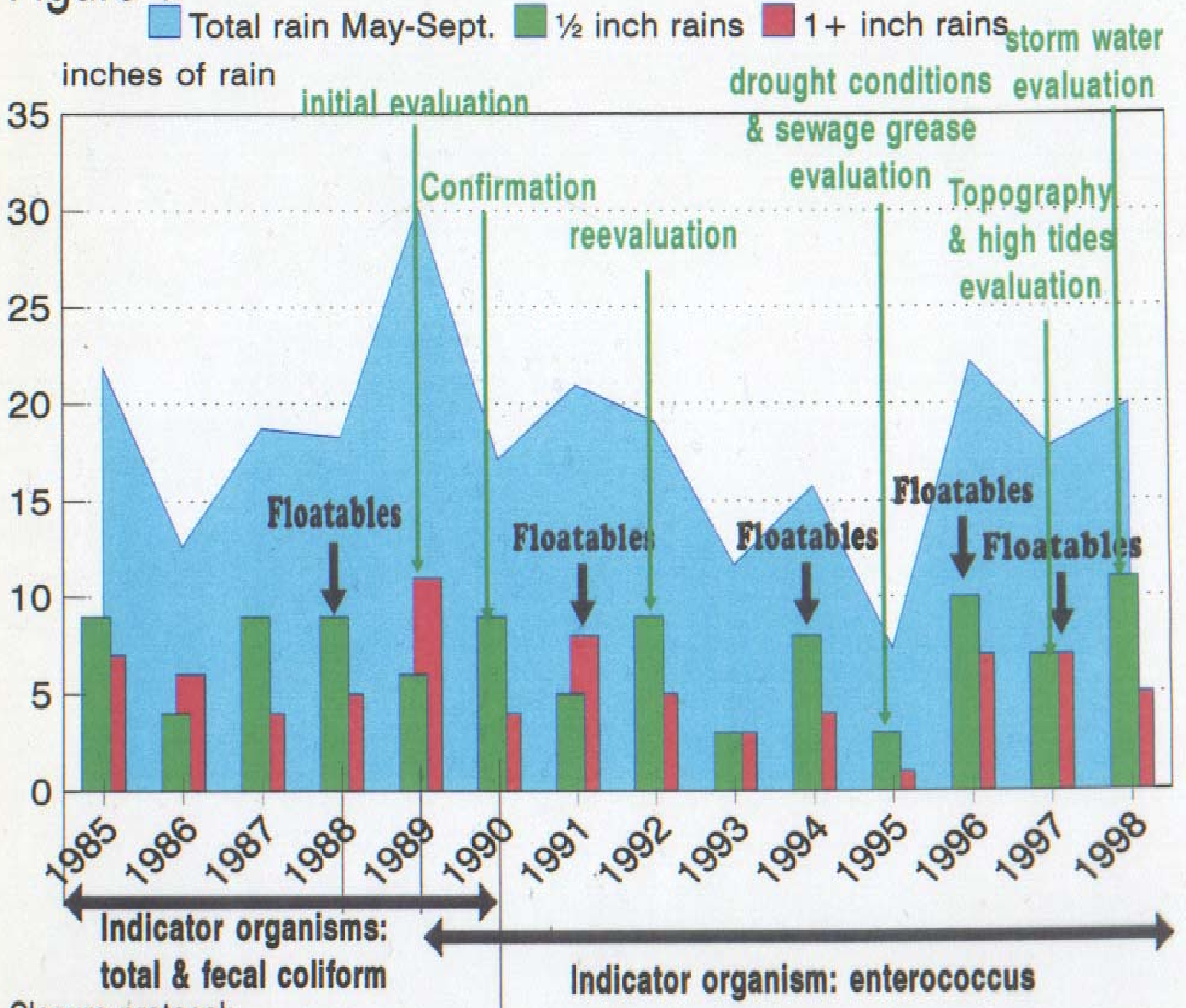
Graphics

Figure 1



Closure protocol:

Failing sample: 1,000 total coliform
400 fecal coliform

Reopening: passing retest

Failing sample: 61 enterococcus colonies/100 mL
1" rain or 3/4" rain in drought, sewage grease
Reopening: passing retest or 24 hr time period
or no sewage grease

Figure 2

Figure 3

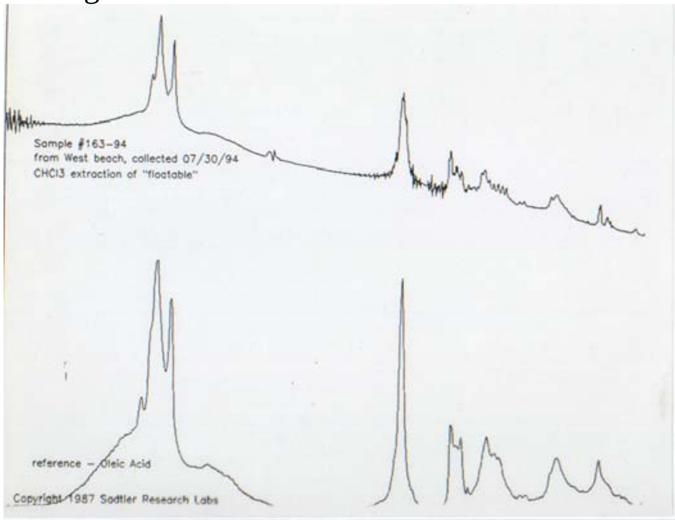
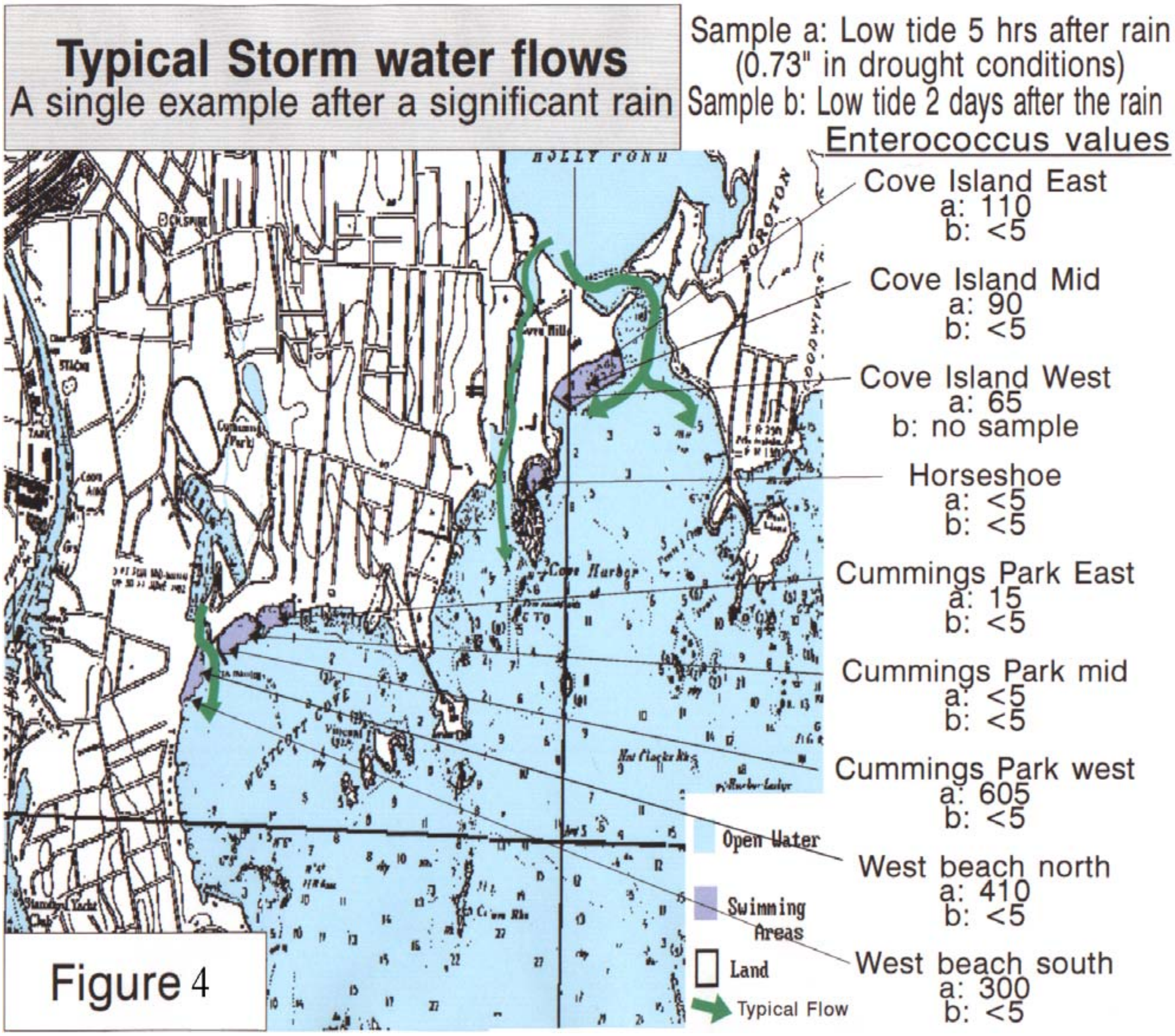
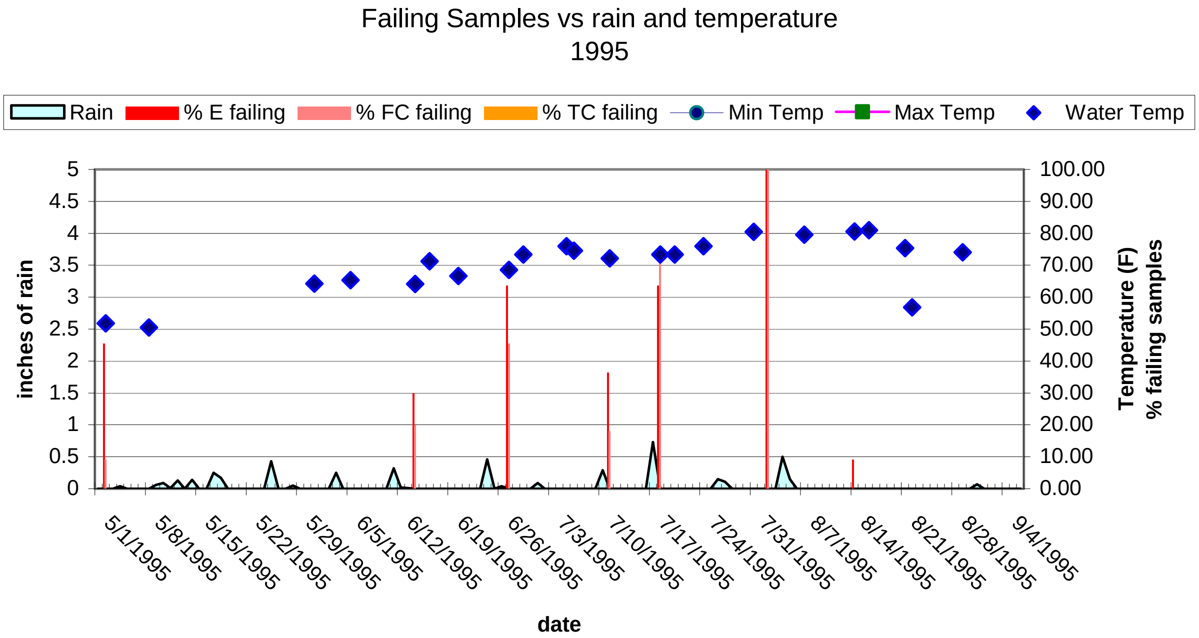


Figure 4


Typical Storm water flows
A single example after a significant rain
Sample a: Low tide 5 hrs after rain
(0.73" in drought conditions)
Sample b: Low tide 2 days after the rain
Enterococcus values
Cove Island East
a: 110
b: <5
Cove Island Mid
a: 90
b: <5
Cove Island West
a: 65
b: no sample
Horseshoe
a: <5
b: <5
Cummings Park East
a: 15
b: <5
Cummings Park mid
a: <5
b: <5
Cummings Park west
a: 605
b: <5
West beach north
a: 410
b: <5
West beach south
a: 300
b: <5
HOLLY POND
NOROTON
Cove Harbor
WESTCOTT COVE
Cummings Park
Open Water
Swimming Areas
Land
Typical Flow
Figure 4

Dry weather conditions



▤ - Tests for Fecal Coliform Bacteria with values > 400 colonies/ 100 mL

🟧 - Tests for Total Coliform Bacteria with values > 1,000 colonies/ 100 mL

🟥

- Tests for Enterococcus Bacteria with values > 61 colonies/ 100 mL