FINAL REPORT

BACTERIAL WATER QUALITY SURVEY OF THE EAST BRANCH OF THE WESTPORT RIVER ESTUARY

1984 - 1985

Prepared for the Town of Westport
Board of Selectmen

by:

GHR Engineering Associates, Inc.
75 Tarkiln Hill Road
New Bedford, MA 02745

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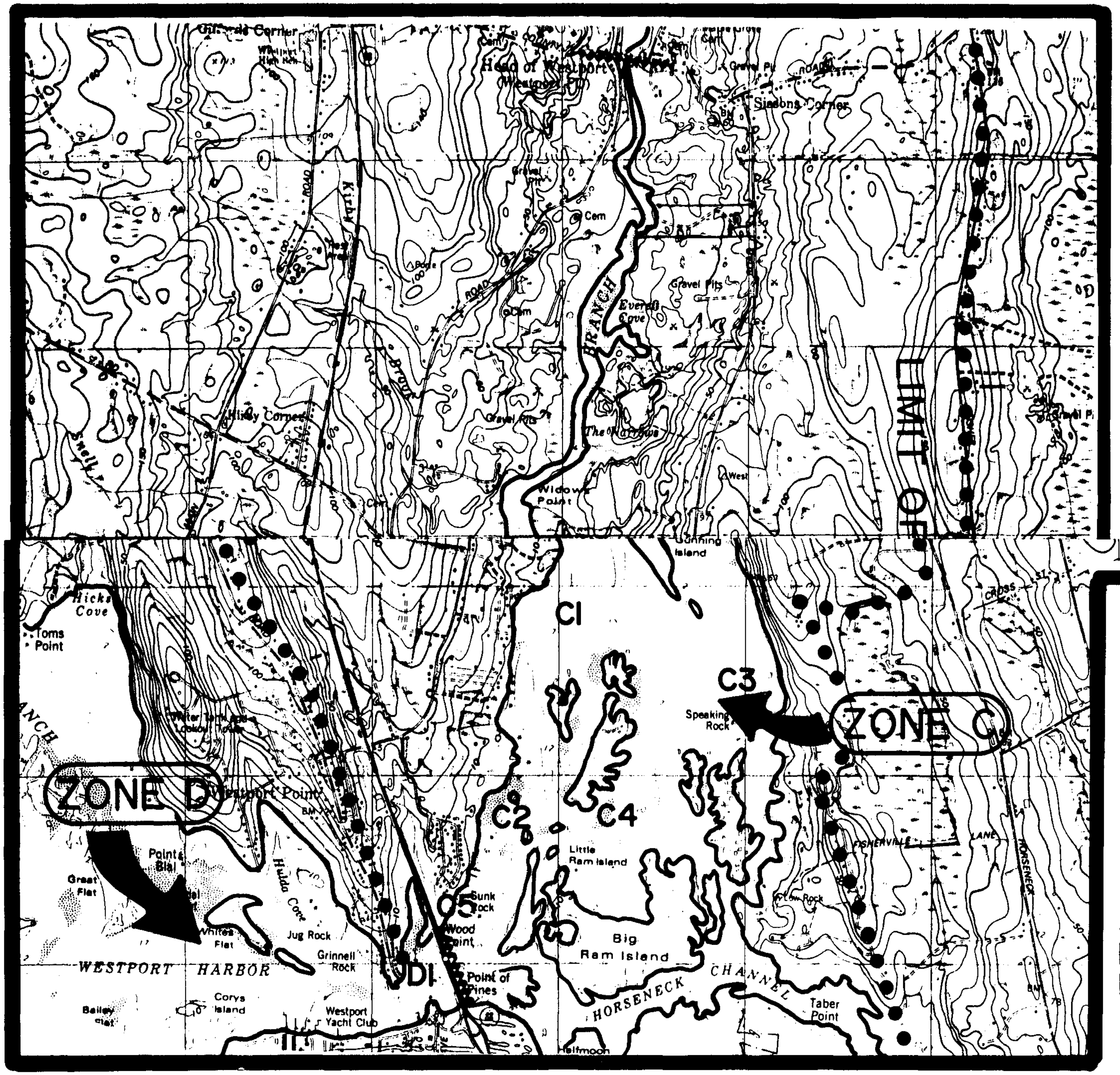
1.00 INTRODUCTION

During the period of August 1984 through November 1985, GHR Engineering Associates, Inc., under contract to the Town of Westport Board of Selectmen, conducted a water quality survey of the East Branch of the Westport River. The study area (Figure 1) is actually an estuary where freshwater discharge from the Westport River mixes with salt water from Rhode Island Sound. For clarity, the study area will be referred to as the Estuary. The primary objective of this study was to establish the relationship between rainfall events and bacteria levels in the Estuary. The purpose of the study was to determine whether a relationship between rainfall events and bacteria levels could be used as the basis for periodically opening areas of the Estuary which are currently closed to shellfishing.

A large portion of the "fishable" area of the Estuary is currently closed. The remaining "fishable" area is, as a result, subject to more intensive harvesting and is yielding lower catches to those who still fish in the Estuary. If closed areas of the Estuary can be opened on a periodic or conditional basis, we believe that a more productive fishery could be maintained. This study focused on the water quality issues governing shellfish harvesting in the Estuary. There are other issues ✓ which must be addressed prior to conditionally opening areas to shellfishing. Primary among these is the relationship between bacteria levels in overlying water and in the edible tissues of the shellfish. Establishing this relationship was not within the scope of this study, but is the subject of research efforts in other coastal areas.



ENGINEERING ASSOCIATES, INC.

FIGURE I

EAST BRANCH, WESTPORT RIVER

ESTUARY STUDY AREA

SAMPLING LOCATION PLAN

SCALE: 1":2600'

This study is one part of the Town of Westport's efforts to improve water quality in the Estuary. The upper reaches of the estuary have been subject to a series of closures by the Massachusetts Department of Environmental Quality Engineering (DEQE), which now prohibits the taking of shellfish from all portions of the Estuary north of a line which runs in an approximate east-west direction across the northern tip of Gunning Island. The closure affects approximately 750 acres or 59 percent of the total 1,270 acres of the shellfish producing portion of the Estuary. Specifically, the closure affects all 230 acres of oyster (Crassotrea virginica) beds, approximately 80 percent of the soft shell clam (Mya arenaria) habitat area, and 50 percent of the hardshell clam (Mercenaria mercenaria) habitat area. This loss severely affects both commercial and recreational shellfishermen.

1.10 Previous Studies

Previous studies of water quality in the East Branch of the Westport River have been conducted by a number of regulatory agencies and private consultants (DEQE 1979, U.S. Soil Conservation Service 1984, and Boston University 1986). These investigations focused on identifying the source or sources contributing bacterial contamination to the River. The investigators are in general agreement that both human and animal sources contribute to contamination of the River and that the primary sources are located upstream of Cornell Point. Localized contamination sources within the Estuary below Hix Bridge were not found to contribute substantially to the widespread contamination observed in the Estuary.

The previous studies also found that bacterial contamination levels appeared to be related to rainfall events and, therefore, that surface runoff following storm events is the primary transport conduit for bacteria entering the River. This observation was based on the fact that bacteria levels increase following a storm and then rapidly decrease to pre-storm levels. A very different pattern would have been encountered if the bacteria were coming primarily from the continuous direct discharge of contaminated water to the River (e.g., the direct discharge of sewage). This type of discharge would more than likely result in high bacteria levels during low flow or non-storm periods with levels decreasing during and immediately after rainfall events as a result of dilution effects of the "clean" rainwater flow.

Many recommendations for reducing bacterial contamination in the River have been made in the past. The recommendations focus on improving agricultural practices to eliminate discharge of runoff from animal feed lots and freshly manured fields, and on upgrading management of private wastewater disposal systems (i.e., septic systems). Currently, there is no regulatory framework within which some of these changes can be mandated and implemented. Therefore, implementation must rely on public education, enforcement of existing regulations and a continued effort to identify specific sources of bacterial contamination. These efforts will not result in cleanup of the Estuary for a number of years under even the most optimistic conditions.

1.20 Current Study

The GHR study was developed to assess the possibility of conditionally reopening closed shellfishing areas based on the relationship between rainfall events and bacteria levels in the Estuary. The original plan was to conduct weekly sampling surveys of the Estuary to provide baseline quality data for a 12-month period. This was to be supplemented by a series of six episodic sampling surveys following storm events to monitor the time required for the dissipation of bacteria levels. The Massachusetts DEQE provided the Town with guidance in developing the study, reviewed the initial study plan and recommended that sampling surveys focus more on storm event sampling than on monitoring seasonal trends. They also recommended testing of shellfish meats following storm events to determine the time required for shellfish to "cleanse" themselves of bacteria to the point where they are acceptable for human consumption.

The work plan was modified to focus more on storm event sampling to the extent that the logistics of collection and analysis could accomodate the changes. In all, thirty-eight sampling surveys were conducted, twenty-seven of which were routine surveys and eleven of which were episodic surveys. During routine sampling surveys, samples were collected from thirteen locations in the Estuary. Three upstream locations were added during the final eight surveys to provide data on water quality of the major freshwater inputs to the Estuary. During episodic surveys, nine additional stations were sampled to provide more specific data on sources located within the Estuary which are contributing to bacterial contamination.

A total of 20 shellfish samples from the Estuary were analyzed for total and fecal coliform. The analyses were intended to provide some initial insight into the relationship between water quality and shellfish contamination levels. Additional research would be required to firmly establish the relationship in the Estuary.

2.00 THE STUDY AREA

The study area was defined as a section of the East Branch of the Westport River extending southward from the Head of Westport Bridge to the Route 88 Bridge (see Figure 1). The Estuary as described above is approximately 7.5 miles long and relatively narrow. The total drainage area which discharges into the Estuary is approximately 29.5 square miles (mi^2). Over one half of the drainage area (17.7 mi^2) is located north of the Head of Westport and drains to the Estuary through two major streams, the East Branch of the Westport River and Bread and Cheese Brook. The major drainage areas within the Estuary are listed below:

DRAINAGE BASIN	DRAINAGE AREA mi^2 (acres)	PERCENT OF TOTAL DRAINAGE
East Branch to Bread and Cheese Brook	11.5 (7360)	38.8
Bread and Cheese Brook to East Branch	5.5 (3521)	18.6
East Branch from Bread and Cheese Brook to Head of Westport	0.77 (490)	2.6
Estuary from Head of Westport to Hix Bridge	6.57 (4205)	22.2
Estuary from Hix Bridge to Rte 88 Bridge	5.28 (3381)	17.8
TOTAL DRAINAGE AREA	29.62 (19000)	

(Adapted from Boston University, 1986)

Land use and hydrology of the entire East Branch have been studied by other investigators (Boston University, 1986). They found that the mixture of developed (commercial, industrial, residential) and agricultural land in the watershed varies but that, in general, 20 percent or more of the land area below Lake Noquochoke is currently used for either agricultural purposes or has been developed. While the total percentage is not great, these land uses have tended to concentrate near streams and open water for obvious logistical (i.e., access to water) and aesthetic reasons. This location bias has tended to amplify the impact of agricultural and development related runoff on the Estuary by placing contamination sources close to the receiving waters. This results in rapid transport of the contaminant load to the Estuary after a rainfall, and tends to minimize the subsequent slow release of contaminants from ~~less~~ developed upland areas.

For the purpose of this investigation, the study area was divided into four zones. The division was based on a combination of factors including the physical shape (morphology) of the estuary, bacterial contamination levels, shellfish habitat and the current status of the area relative to DEQE shellfishing closure orders. The four zones are described below.

Zone A. This zone includes the area between the Head of Westport bridge and the southern tip of Cadmans Neck, including Cadmans Cove. This area was the first section of the Estuary closed to shellfishing. It is primarily an oyster and softshell clam fishery and includes approximately 230 acres of oyster beds and 17 acres of softshell clam beds. This zone is approximately 4.3 miles long and ranges from 50 to 3400 feet in width. The average depth north of Jesses Neck is less than 5 feet at mid-tide and ranges from 5 to 25 feet in depth from Jesses Neck to the southern tip of Cadmans Neck. Cadmans Cove is a generally shallow area which receives runoff via a small intermittent stream along the northern shoreline.

Zone B. This zone includes the area southward from the southern tip of Cadmans Neck to the northern tip of Gunning Island. The southern border was selected to coincide with the closure line established by DEQE in their August 15, 1984 letter to the Town of Westport. This area is primarily hardshell clam (quahog) and softshell clam habitat and includes approximately 520 acres of quahog beds and 26 acres of softshell clam beds. This zone is approximately 1.5 miles long and ranges from 3100 to 3400 feet in width. A chain of small islands is oriented in a north/south direction approximately 800 feet off the eastern shore of the Estuary. To the east of these islands the Estuary ranges from 5 to 15 feet in depth, while to the west of the islands the Estuary is generally very shallow with depths ranging from 2 to 15 feet. The area west of the islands is ideal quahog habitat and represents nearly 50 percent of the available quahog habitat in the Estuary.

Zone C. This zone includes the area between the southern border of Zone B and the Route 88 Bridge. This area is dotted with tidal flats, grassy islands, granite outcroppings and serpentine channels. The area is primarily quahog habitat. It is the only remaining area of the Estuary open to shellfishing and includes approximately 520 acres of quahog beds.

Zone D. This zone encompasses the area southwest (downstream) of the Route 88 Bridge. This area includes Westport Harbor and the inlet channel connecting the harbor to Rhode Island Sound. The sampling in this zone served as a control area for monitoring water quality outside the study area.

In August 1985, the study area was expanded upstream into the East Branch of the Westport River and Bread and Cheese Brook. Review of data gathered up to that time indicated that the primary bacterial input(s) to the Estuary are located north (upstream) of all sampling stations. New sampling locations were identified in the upstream area to help refine the assessment of contaminant dissipation in the Estuary.

Episodic surveys were conducted during October and November 1984 and during March and May 1985. These surveys provided valuable data on the dissipation of bacteria levels following a storm event. The major problem in conducting the episodic surveys was the occurrance of another storm event within several days of the first storm. Only the March 1985 episodic survey could be continued for 15 days following a storm. This series of surveys provided a rare opportunity to observe the dissipation of bacteria levels over an extended period of time. Other episodic surveys ran for 3 to 8 days following a storm event and provided data during the critical dissipation period when tidal flushing action, natural die-off and other natural processes purge bacterial contamination from the Estuary.

3.13 Shellfish Sampling

Shellfish samples were collected from Zones A and B during August and October 1985. Each shellfish sample is actually an analysis of the meat from ten to twenty individual shellfish collected from a small sample area. The oyster samples were collected from areas corresponding to water quality sampling stations A-1, A-2 and A-3. Quahog samples were collected from Zone B near station B-3 and from Zone C near Station C-1. Soft shell clam samples were collected from Zone A near station A-3 and from Zone B near station B-3. A water sample was collected from each station for fecal coliform analysis prior to collecting shellfish samples. The water data was intended to provide a means to correlate shellfish contamination with overlying water quality. Results are summarized in Section 4.00 and tabulated in Appendix A.

3.20 Sample Analysis

All water samples collected during the survey were analyzed for fecal coliform using the membrane filtration procedure (commonly referred to as the MF procedure), salinity, turbidity and temperature. In addition, water samples from Stations A2, B1, C1 and C3 were analyzed for total and fecal coliform using the 5-tube Most Probable Number Method (commonly referred to as the MPN method). Initially Stations A1, A3, A4, B2, B3, B4, C2, C4, and D1 were analyzed for fecal coliform using the 3-tube MPN procedure. Water samples were also selectively tested for fecal streptococcus using both the MF and MPN procedures. Shellfish samples were analyzed for total and fecal coliform using the 5-tube MPN procedure.

The initial objective of using the three different methods for analyzing water samples for fecal coliform was to identify the best testing procedure for tracking fecal coliform densities through the Estuary. The MF procedure was selected for use throughout the study and was backed by the 5-tube MPN at selected stations. The 3-tube MPN was dropped from the study when correlations to the 5-tube MPN were found to be no better than the MF procedure. Samples analyzed using the 3-tube MPN were also found to be more variable in results than the samples analyzed using the MF procedure. The 5-tube MPN was used as the focal point of the survey for its stable and reproducible results.

Fecal streptococci were analyzed using both the 5-tube MPN and MF procedures to gain a better understanding of the correlation between the two test methods. The MPN method showed more stable and reproducible results than the MF method and no direct correlation between the two methods was established.

Temperature data was obtained in the field at the time of collection and was measured in degrees Celsius. Salinity and turbidity testing was done in the laboratory using samples collected along with the bacteriological samples. The methods used were Method 120.1 (Electrometric) for salinity and Method 180.1 (Nepholometric) for turbidity, from "The Examination of Water and Wastes", EPA 600/4-79-020.

Shellfish samples were received in the Laboratory in the condition that they were in at the time of collection. They were washed and scrubbed using sterile procedures and underwent an initial preparation before being analyzed. The preparation consisted of hemogenizing the meats and liquors of a representative amount of shellfish from a given location in a sterilized blender. The blendings are then analyzed using the 5-Tube MPN procedure.

a

All bacteriological testing on water was done in accordance with guidelines established in the APHA publication "Standard Methods for the Analysis of Water and Wastewater 15th Edition" and was backed by continuous Quality Control (QC). The QC consisted of field replicates, field blanks, laboratory replicates, and laboratory blanks as well as multiple technician analysis to ensure the best possible data was being obtained. In addition, DEQE accompanied the sampling team during one survey and collected duplicate samples from selected locations. Analyses performed in their Lakeville laboratory were in good agreement with our test results.

Bacteriological testing on shellfish was done in accordance with the APHA publication "Laboratory Procedures for the Examination of Seawater and Shellfish" (APHA, 1985). The strictest of quality control programs was established to ensure the representativeness of results obtained using these procedures. Equipment blanks were run before and after each sample was analyzed, and method blanks were run on a regular basis. These steps were used to ensure carry-over from sample to sample was not occuring.

4.00 DISCUSSION OF TEST RESULTS

A large amount of water quality data was generated during the course of this study. These results provide a comprehensive picture of bacterial water quality in the Estuary over a 16 month period. In general, the data confirmed the findings of previous investigators that the primary bacteria inputs to the Estuary are located north of the study area (i.e., above Cornell Point) and that there is a definite and strong relationship between storm events and the presence of elevated bacteria levels in the Estuary. The relationship was found to be consistent and predictable throughout the study period and would lend itself to use in predicting water quality in shellfishing areas.

The actual data are summarized in Appendix A. Bacteria data are grouped by zone and by test method. Where appropriate, two methods of analyses were used to test the same sample, and the results were also tabulated for comparison of the two methods (e.g., fecal coliform by MF vs MPN). Typically the two methods (MF and MPN) were run on 25 to 30 percent of samples to establish a relationship between the more rigorous method (MPN) and the simpler and less costly procedure (MF).

For simplicity, results are described in general terms in the text with specific reference to the data tables in Appendix A. Summary tables and graphs have been included to illustrate the general trends and patterns which were observed. The results are presented in relationship to the primary objectives of the study, which was to identify the relationship between rainfall and fecal coliform levels in the Estuary.

4.10 Water Quality Results

Water quality results are summarized in Appendix A. During the first four sampling surveys, both the MF and 3-tube MPN procedures were used to enumerate fecal coliform levels. Based on the result of the initial sampling surveys, the membrane filter technique (MF) was selected over the 3-tube MPN technique for enumerating fecal coliform for all sampling stations. The MF technique provided a simpler procedure and produced results more comparable to the 5 tube MPN procedure which was used at stations (A-2, B-1, C-1 and C-3) to provide a water quality data base which meets the monitoring requirements of the DEQE for shellfishing areas.

The use of the MF methods produced a data base descriptive of the relative distribution of bacterial contamination throughout the Estuary. The 5-tube MPN method produced a data base which is representative of bacterial water quality in the Estuary over a 16 month period. These 5-tube MPN results are the only results which are useable in calculating average bacteria levels in accordance with Section 74, Chapter 130 of the Massachusetts General Laws.

A-2

In addition to coliform testing, samples from the Head of Westport and station A-1 were analyzed for fecal streptococcus. The analyses provided an indication of probable sources between animal-derived and human-derived wastes. Based on the test results, it was determined that data from station A-2 cannot be used for the normal fecal coliform to fecal strep comparisons because it is too far removed from the contaminant sources. Data from the Head of Westport station were found to be useable and indicated that the primary source of bacterial contamination is non-human in nature.

4.11 Coliform Bacteria Results

The results of extensive coliform analyses in the Estuary show a consistent pattern of diminishing coliform levels with distance downstream from the Head of Westport. The highest coliform levels during each survey were measured in Zone A with levels increasing in the upstream direction. Data from upstream stations, sampled from May 1985 on, showed bacteria levels 2 to 10 times higher at and above the Head of Westport than at station A-1 (the furthest upstream routine sampling station in the Estuary). The geometric mean MPN fecal coliform level at station A-2 (Hix Bridge) was 124 cfu*/100ml for all samples and values ranged from a low of 2 to a high of greater than 24,000 cfu/100 ml. The geometric mean (average) is commonly used to assess bacteriological data because it compensates for the geometric growth and die-off patterns encountered with bacterial populations.

* cfu - Colony forming units.

As part of the data assessment, the MPN data from station A-2 were sorted into five groups based on the number of rain free days (RFD) prior to sample collection. Data were compiled for 0-1, 2-3, 4-5, 6-10 and 11-21 days following a rainfall event and summarized in Tables 4-1 through 4-5. The geometric means for each period were calculated and plotted on Figure 4-1. This plot shows the general pattern of bacteria levels following a storm event. The line drawn across the graph at 14 cfu provides an indication of the number of RFDs required before the average fecal coliform level falls below the maximum value allowed in shellfishing areas. At station A-2, this level is not achieved until at least 10 consecutive RFDs have occurred. It shows that bacteria levels decrease rapidly from a high level (832 cfu) immediately following a storm event to relatively low level (30 cfu) within 4 to 5 days. While not suitable for shellfishing, the fact that bacteria levels in Zone A, which feed into the lower Estuary (i.e., Zones B and C), do not remain elevated for long periods of time has important effects on downstream water quality.

Sampling of local drainage areas and shoreline development areas in Zone A (stations A-4, A-6, A-7 and A-8) did not identify any of these areas as consistent contributors to bacterial contamination of the Estuary. That is, bacterial levels were normally lower at these stations than at nearby mid-channel sampling stations. The opposite result would be expected if the streams feeding these sampling points were contributing significant levels of bacterial pollution to the Estuary.

Station A-6 did on several occasions show bacteria levels as high as or higher than levels measured in the Estuary. This station monitors the discharge from Snell Creek and indicates that there are sources of bacterial contamination draining into the stream. These sources are intermittant in nature and may produce localized effects, but they do not produce substantial, long lasting effects on bacteria levels in the Estuary as a whole.

Station A-4 measured water quality in Cadman Cove, which was placed in Zone A based on DEQE closure orders. The water quality data from this station correlate more closely with data from Zone B than with data from others stations in Zone A. This is most likely due to the fact that Cadman Cove is in direct hydraulic communication with Zone B. That is,

TABLE 4-1

WESTPORT RIVER SURVEY

Results of Fecal Coliform Analysis
<2 Precipitation Free Days Prior to Sampling
Fecal Coliform (CFU/100 ml MPN)

Date	Maximum Precipitation (in inches)	Station A-2	B-1	C-1	C-3
09/04/84	0.7	170	31	13	8
10/03/84	2.51	2,400 (1)	920	220	2,400
10/30/84	0.98	24,000 (2)	70	110	49
11/06/84	0.69	3,500	49	49	46
03/13/85	2.05	9,200	540	110	280
05/07/85	0.41	130	49	22	5
05/13/85 (3)	1.03	46	5	<2	4
05/29/85	0.85	540	49	140	130
07/23/85	1.00	6	8	22	12
08/01/85	0.52	1,600	350	17	170
09/10/85	0.73	5,400	130	130	130
11/07/85	2.45	7,600 (4)	7,600 (4)	7,600 (4)	1,600
11/12/85	0.70	230	45	<10	<20
Geometric Mean		832	87 98	55	63

(1) >~~<~~2,400 Assumed @ 2,400

(2) >~~<~~24,000 Assumed @ 24,000

(3) Rainfall Event occurred within 1 tide cycle of sampling, therefore full effect not seen

(4) Assume 7,600 Based on MF data

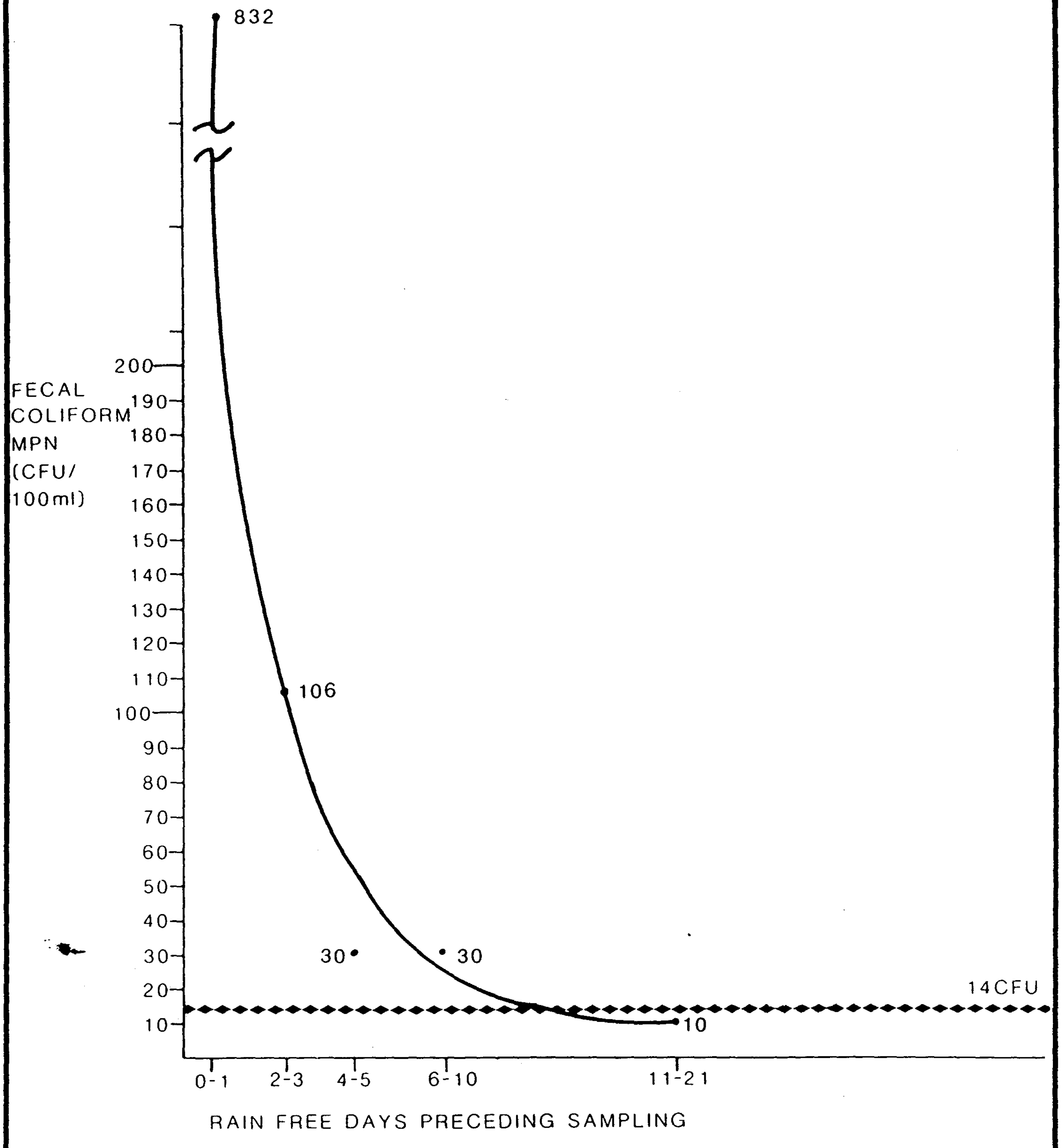


FIGURE 4-1 PLOT OF MEAN FECAL COLIFORM LEVELS AT STATION A1 0-1,2-3,4-5,6-10 AND 11-21 DAYS AFTER A RAINFALL EVENT

TABLE 4-2

WESTPORT RIVER SURVEY

Results of Fecal Coliform Analysis
2-3 Precipitation Free Days Prior to Sampling
Fecal Coliform (CFU/100 ml MPN)

Date	Maximum Precipitation (in inches)	Station A-2	B-1	C-1	C-3
08/06/84	0.52	110	43	8	8
09/18/84	1.08	280	49	2	<2
11/15/84	0.51	350	350	110	130
03/15/85	2.05	23	94	49	22
05/09/85	0.41	240	23	6	5
05/15/85	1.03	49	13	13	5
05/20/85	0.94	4	2	<2	<2
07/30/85	1.13	2,400 (1)	1,600	45	24
10/08/85	0.74	130	2	2	2
10/22/85	0.34	49	8	8	13
Geometric Mean		106	32	10	8

(1) $\overset{>}{<}$2,400 Assumed @ 2,400

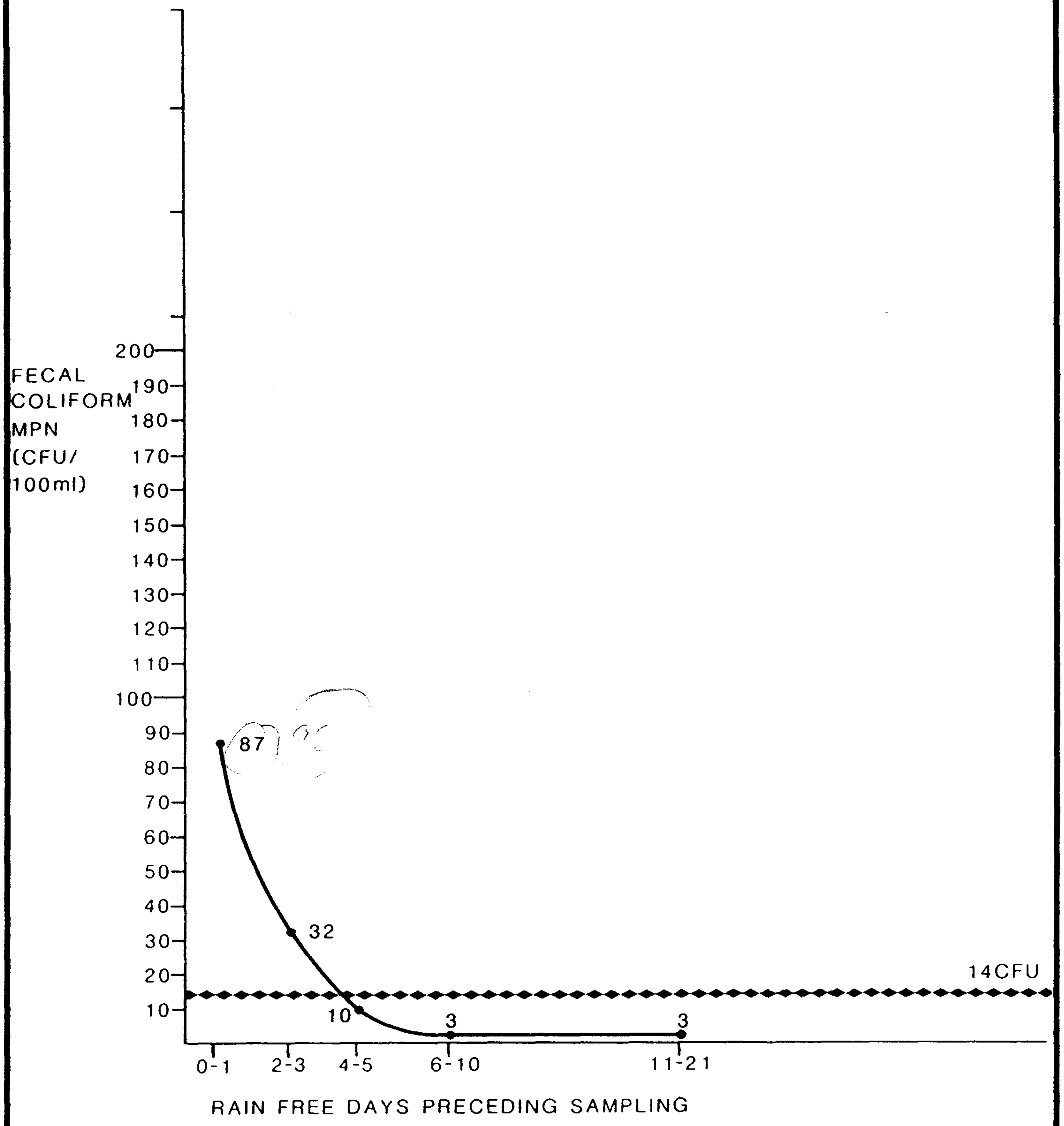


FIGURE 4-2 PLOT OF MEAN FECAL COLIFORM LEVELS AT STATION B1 0-1,2-3,4-5,6-10 AND 11-21 DAYS AFTER A RAINFALL EVENT

TABLE 4-3

WESTPORT RIVER SURVEY

Results of Fecal Coliform Analysis
4-5 Precipitation Free Days Prior to Sampling
Fecal Coliform (CFU/100 ml MPN)

Date	Maximum Precipitation (in inches)	Station A-2	B-1	C-1	C-3
11/09/84	0.69	79	13	2	7
12/03/84	0.58	13	13	13	7
07/26/85	1.00	21	17	6	39
08/06/85	0.47	79	11	<2	8
10/29/85	0.21	14	4	7	2
Geometric Mean		30	10	5	8

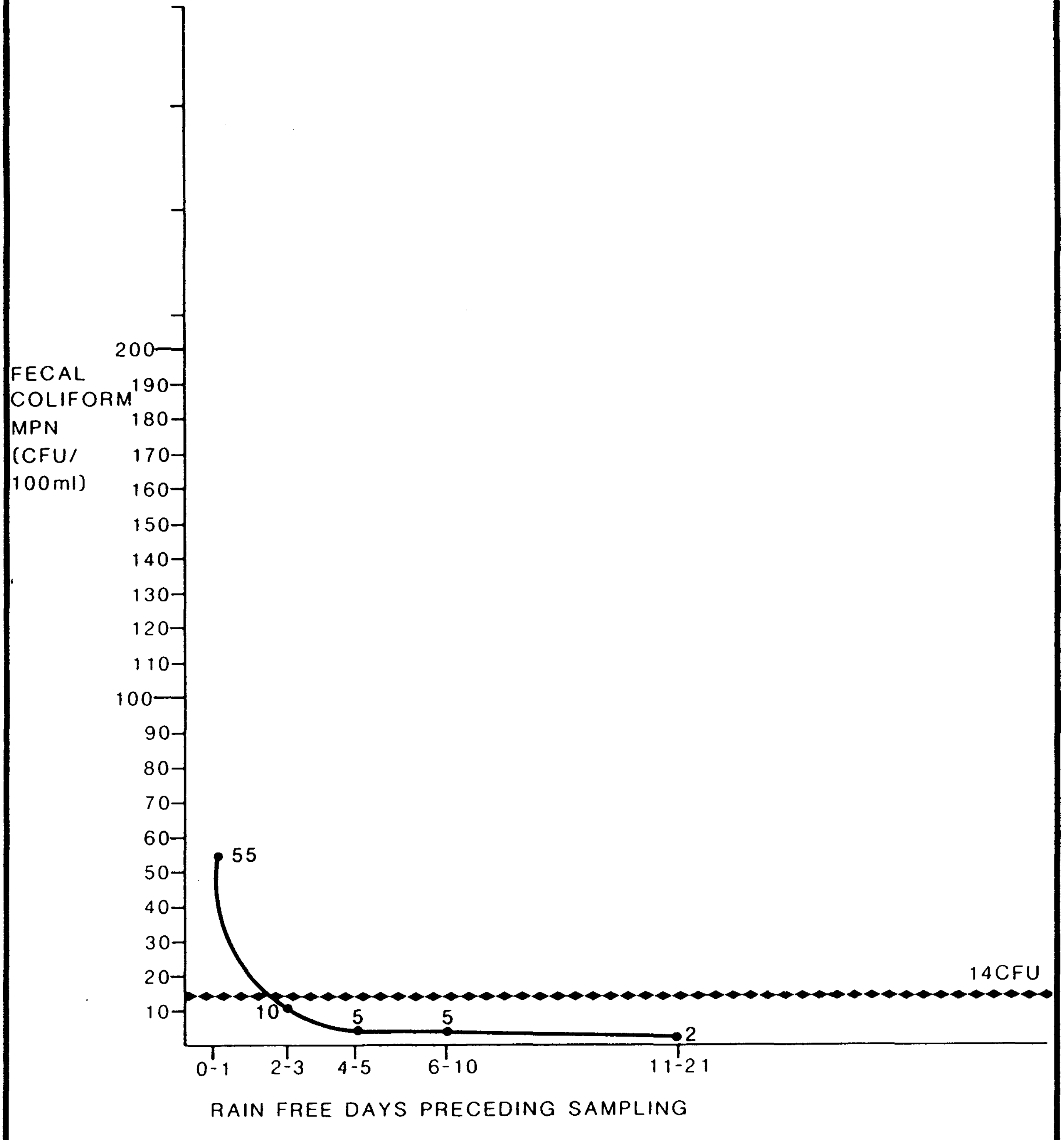


FIGURE 4-3 PLOT OF MEAN FECAL COLIFORM LEVELS AT STATION C1 0-1,2-3,4-5,6-10 AND 11-21 DAYS AFTER A RAINFALL EVENT

TABLE 4-4

WESTPORT RIVER SURVEY

Results of Fecal Coliform Analysis
6-10 Precipitation Free Days Prior to Sampling
Fecal Coliform (CFU/100 ml MPN)

Date	Maximum Precipitation (in inches)	Station A-2	B-1	C-1	C-3
08/20/84	0.31	280	<2	8	~~14~~ 3
10/09/84	2.51	33	4	<2	<2
12/19/84	0.63	11	<2	2	2
03/18/85	0.31	40	11	14	14
03/20/85	2.05	8	2	11	5
04/17/85	0.27	22	<2	2	<2
Geometric Mean		30	3	5	4

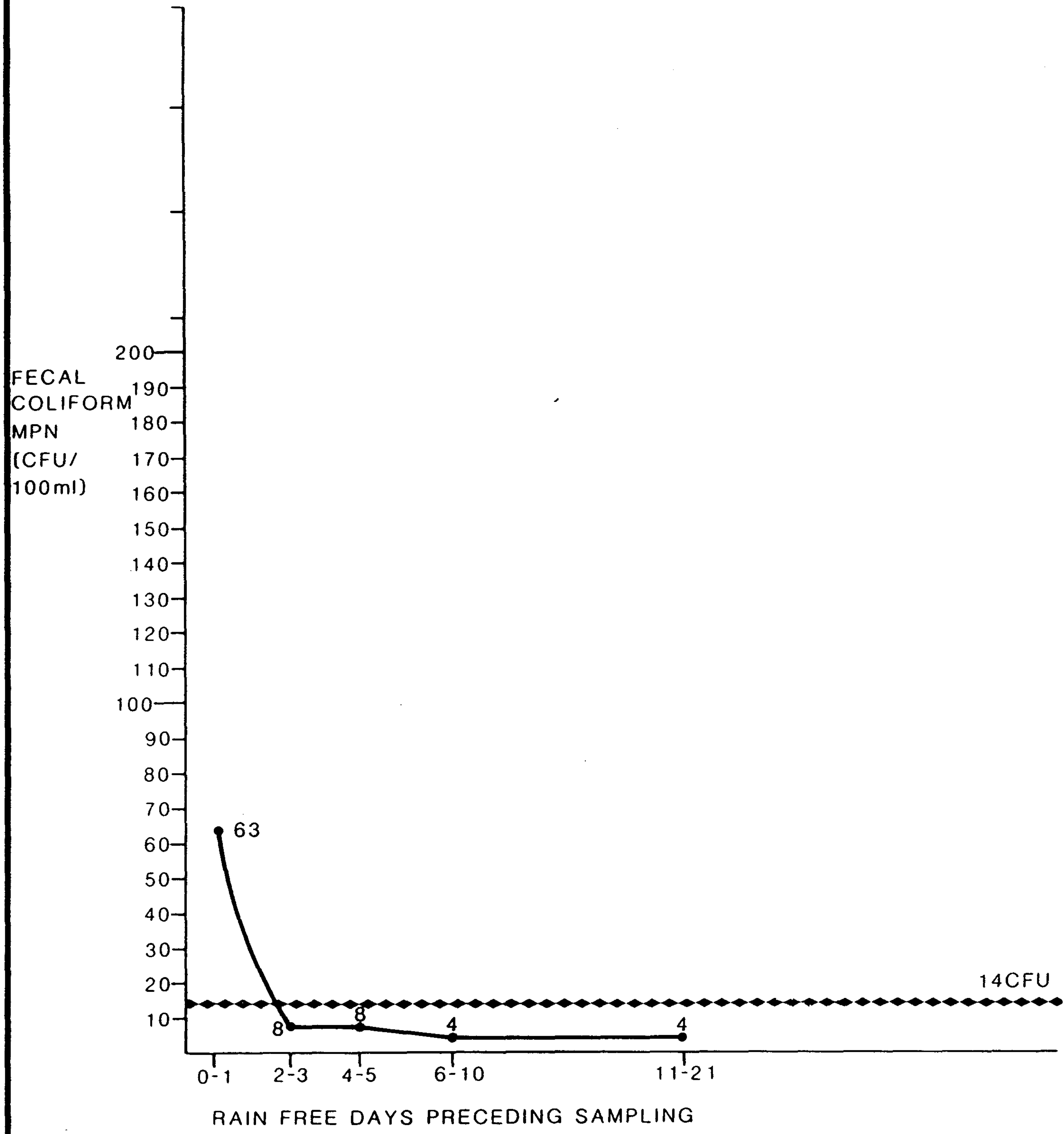


FIGURE 4-4 PLOT OF MEAN FECAL COLIFORM LEVELS AT STATION C3 0-1,2-3,4-5,6-10 AND 11-21 DAYS AFTER A RAINFALL EVENT

TABLE 4-5

WESTPORT RIVER SURVEY

Results of Fecal Coliform Analysis
11-16 Precipitation Free Days Prior to Sampling
Fecal Coliform (CFU/100 ml MPN)

Date	Maximum Precipitation (in inches)	Station A-2	B-1	C-1	C-3
10/18/84	2.56	33	<2	<2	<2
02/28/85	1.46	14	8	2	11
03/27/85	2.05	2	2	2	<2
Geometric Mean		10	3	2	4

tidal inflow to the cove is from Zone B, rather than from Zone A. As a result, water quality in Cadman Cove resembles that observed in Zone B. Subsequent to DEQE closure of Cadman Cove, two septic systems on Cadman Neck have been repaired and a dairy farm, located nearby the stream feeding the Cove, has relocated out-of-State. Future investigations and management plans should consider this area to be part of Zone B.

Overall, Zone A can be described as the primary receiving and dilution area for bacterial contamination discharged to the Estuary from upstream sources (i.e., Bread and Cheese Brook, East Branch of the Westport River and Kirby Brook). Bacterial levels consistently decrease in the downstream direction. When bacteria levels entering Zone A at the Head of Westport are high (i.e., above 1000 cfu/100 ml) the bacteria levels at station A-3, located at the downstream end of Zone A, generally decrease by one order of magnitude or more.

Bacteria levels in Zone B were consistently 3 to 10 times lower than levels measured in Zone A during the same sampling event. Unlike Zone A, bacteria levels were relatively consistent throughout Zone B, indicating that this area is well mixed and that tidal circulation effectively distributes the inflow from Zone A throughout this area. The mean MPN fecal coliform level for station B-1 for the study period was 23 cfu/100 ml. This exceeds the maximum average fecal coliform level of 14 cfu/100 ml, which has been established for shellfishing areas. The MPN fecal coliform data for station B-1 is compiled in Tables 4-1 through 4-5 for 0-1, 2-3, 4-5, 6-10 and 11-21 RFDs and the geometric mean for each period is presented. The mean fecal coliform value for each period is plotted on Figure 4-2. This figure indicates that the mean fecal coliform level falls below 14 cfu/100 ml four to five days after a rainfall event. This is approximately one-half the time required to reach similar levels in Zone A. In addition, fecal coliform levels 2 to 3 days after a rainfall were below 100 cfu/100 ml in 80 percent of the samples collected during this interval (see Table 4-2). The general pattern of bacterial contamination in Zone B can be described as rising to elevated levels for 1 to 3 days following a storm event, then decreasing rapidly to less than 20 cfu/100 ml by the fourth day after a rainfall event.

Sampling of local drainage areas in Zone B (stations B-5 through B-8) did not identify any of these areas as consistent contributors to bacterial contamination. On one occasion (May 13, 1985) a high fecal coliform count was measured at station B-6 (3,600 cfu/100 ml). This sample was collected within several hours of a 1.03 inch rainfall. Being the only high sample result from this station, it is likely that this stream receives a slug of surface runoff from its sloped drainage basin. The stream drains a large pasture area which extends all the way down to the mouth of the stream near the sampling point. This pasture is the likely source of the bacteria. However, given the fact that the contamination is of short-term duration, it is doubtful that this source is a substantial contributor to the Estuary wide problem.

Overall, Zone B can be described as a transition area where normally low fecal coliform levels rise for 2 to 3 days after a rainfall and then diminish to pre-storm levels. This differs greatly from the pattern observed in Zone A where fecal coliform levels remain high for 6 to 10 days after a rainfall.

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Bacteria levels in Zone C were consistently lower than levels observed upstream in Zones A and B. The mean MPN fecal coliform levels during the study period were 10 and 14 cfu/100 ml for stations C-1 and C-3, respectively. These values meet the established average water quality conditions for shellfishing areas and reaffirm that this area continues to be suitable for shellfishing at all times. The MPN fecal coliform data for stations C-1 and C-3 are compiled in Tables 4-1 through 4-5 for 0-1, 2-3, 4-5, 6-10, 11-21 RFDs and the geometric mean for each period is presented. The mean fecal coliform values for each period are plotted on Figures 4-3 and 4-4 for stations C-1 and C-3, respectively. These figures show that the mean fecal coliform levels only rise for one day following a rainfall event and then immediately diminish to acceptable levels. It should be noted that short-term rises in fecal coliform levels are allowed under the shellfish management regulations and do not indicate a need for temporary closures following rainfall events.

Fecal coliform levels were generally consistent throughout Zone C. This indicates that, like Zone B, the area is well mixed and that tidal circulation effectively distributes the inflow from upstream throughout this area. The samples collected at station C-5, which monitors local drainage from a section of Westport Point east of Route 88, were always low and did not indicate any local contaminant sources discharging into this area during the study period.

Overall, water quality in Zone C remained suitable for shellfishing throughout the study period. The bacteria levels entering the Estuary from the northern drainage areas are effectively dissipated in Zones A and B so that water quality remains at acceptable levels in Zone C. Fecal coliform levels in Zone C rarely exceeded 250 cfu/100 ml and these temporary excursions occurred only after a rainfall of 2 inches or more.

Bacteria levels at station D-1 were intended to monitor background water quality downstream from the study area. Therefore, only MF fecal coliform analysis was performed. The data is summarized in Tables A-3.4, A-3.8 and A-3.13. With the exception of one day, MF fecal coliform levels were less than 50 cfu/100 ml. On November 7, 1985, a fecal coliform value of 1,300 cfu/100 ml was recorded on this location. This sample followed an extremely heavy rainfall (2.45 inches) during which a major contamination release appears to have occurred in the area above the Head of Westport.

Bacteria levels upstream from the study area are summarized in Tables A-3.9 and A-3.14 in Appendix A. The fecal coliform levels were measured by the MF procedure at these stations because the streams are essentially freshwater in this area and the MF procedure produces acceptable results in freshwater. The Head of Westport station can be used to represent upstream bacteria inputs. The fecal coliform levels measured at this station consistently exceed levels observed at station A-1, the closest downstream station in the Estuary. Table 4-6 presents a comparison of MF

TABLE 4-6

COMPARISON OF FECAL COLIFORM LEVELS AT THE HEAD OF WESTPORT AND STATION A-2 AND STATION B-1 WITHIN 2 DAYS OF A RAINFALL EVENT

DATA	MAXIMUM PRECIPITATION (inches)	HEAD OF WESTPORT MF	STATION A-2 MPN	STATION B-1 MPN
5/07/85	0.41	192	130	49
5/13/85	1.03	1,600	46	5
5/29/85	0.85	2,000 [4]	540	49
7/26/85	1.00	553	21	17
8/01/85	0.52	6,800	1,600	350
9/10/85	0.73	11,000	5,400	130
11/07/87	2.45	39,000 (3)	7,600 (2)	7,600 (2)
11/12/85	0.70	170	230	45
Geometric Mean		1,898	423	87

1. Results in cfu/100 ml
2. Assume 7600 based on mf data
3. Sample collected 11/05/85
4. [illegible] > [illegible]

fecal coliform levels at the Head of Westport and MPN fecal coliform levels at stations A-2 and B-1 on 8 sampling days which occurred within 2 days of a rainfall event. Fecal coliform levels at the Head of Westport are consistently higher than at station A-2, and the geometric mean is nearly 3 times higher at the Head of Westport than at station A-2. This is a significant difference, and indicates that upstream sources account for a very large portion of the bacteria contamination in the Estuary. Data from the Head of Westport does not include the contamination contributions from the Kirby Brook drainage system which discharges to the Estuary below the Head of Westport and was not monitored during this study.

A comparison of fecal coliform levels at the three upstream sampling stations reveals an interesting pattern. Both the East Branch of the Westport River (Forge Pond Outlet) and Bread and Cheese Brook, above Route 177 contribute fecal coliform to the Estuary. However, during 11 of 16 sampling surveys the fecal coliform levels at the Head of Westport were higher than levels at either of the two upstream stations. This was unusual considering that the additional drainage area contributing to the river flow between the two upstream stations and the Head of Westport is only 490 acres or 4.3 percent of total 11,370 acres in the upstream drainage area. This indicates that some significant source(s) is located within this limited area.

The existance of contributing source(s) in the Head of Westport area was further evidenced during the November 7, 1985 sampling survey when fecal coliform levels at the Bread and Cheese Brook, Forge Pond Outlet and Head of Westport sampling stations were 900, 705 and 39,000 cfu/100 ml, respectively. The high value at the Head of Westport affected bacteria levels throughout the Estuary and likely accounts for the 1,300 cfu/100 ml fecal coliform count measured at station D-1. This sampling event followed a 2.45 inch rainfall event which probably caused excessive surface runoff to scour the source area. The high coliform level observed at Station D-1 probably represents the "first-flush" of the Estuary following a rainfall.

4.12 Shellfish Test Results

The relationship between fecal coliform levels in edible shellfish meats and overlying water show a marked difference from species to species. The three shellfish species analyzed in the study (oysters, quahogs and soft shell clams) each exhibit a different capacity to accumulate and depurate bacteria. The results of tissue analyses are summarized in Appendix B Table B-2. Each species will be discussed separately. The shellfish meat results are compared to overlying water quality only to provide an indication of the general relationship between the two measurements. Many physical and biological factors affect bacteria accumulation in shellfish tissue (e.g., temperature, salinity, time of day and season. Therefore, the few results obtained during this study serve primarily as a basis for future measurements.

B-1.1

The oysters examined in the study were all collected from Zone A at stations A-1, A-2 and A-3 and the results can be found in Appendix B Tables B-1.3 and B-2.1. The August 15th, 1985 sampling of oysters showed a direct relationship between the overlying water quality and fecal coliform levels in oyster meats. At all three stations the ratio of fecal coliform in water to fecal coliform levels in meats was not more than 2 to 1 and at stations A-1 and A-2 the bacteria levels were identical in the water and the shellfish meats. The relationship did not hold true in the October 30th, 1985 sampling of station A-3 where very low levels of fecal coliform were found in the overlying water and a higher level was found in the meat. Of the four oyster samples which were collected and analyzed, none exceeded the established limit of 230 cfu/100 g for edible shellfish meats.

B-1,2 &

Four sets of quahog and overlying water samples were collected and analyzed in the study. Sample sets were collected in Zone B and Zone C for each sampling day (Appendix B, Table B-2.2). In three of the four sets of samples the fecal coliform levels in the meats of quahogs from Zone B were lower than those collected in Zone C. Water quality in the three sets were similar except in one case where the fecal coliform level in Zone C was four times greater than Zone B. In one set, the levels of coliform in meat from Zone B was greater than those of Zone C, while overlying water quality was similar. Like oysters, quahogs were at no time during study found to have fecal coliform levels exceeding the established limit.

Four sets of soft shell clams were also collected during the study, in this case a set consisted of samples from Zone A and Zone B on the same day. The results of the analysis can be found in Appendix B Tables B-1.3 and B-3.3. Unlike oysters and quahogs, 50% of the samples collected from both Zone A and Zone B during the study exceeded established limits for edible shellfish (230 CFU/100g). While fecal coliform levels in overlying water were found to be generally good, the levels of fecal coliform in meats showed no apparent correlation to them.

In six of the eight samples collected during the study, the overlying water was found to have fecal coliform levels lower than established shellfishing levels (14 cfu/100 ml) while only five of eight samples of soft shell clams fell within established shellfish meat limits. There was no apparent relationship between water and shellfish meat levels as indicated by water being acceptable and shellfish not acceptable in three samples and water being unacceptable with shellfish levels being acceptable in two samples. Only three of eight samples had both acceptable water fecal coliform levels and shellfish meat fecal coliform levels. There also appears to be no relationship between the two zones studied. One half of the sample sets showed higher fecal coliform levels in Zone B than Zone A, while the other half showed the opposite result. This may indicate soft shell clams needing a longer depuration period than oysters or quahogs.

4.13 Resulting Fecal Coliform and Fecal Streptococcus Analysis

Fecal streptococcus was analyzed at two stations in the Estuary, station A-2 and at the Head of Westport. The data is summarized in Appendix A Tables A-8.1 and A-9.1. Upon reviewing data compiled from station A-2 it was determined this station is too far downstream from potential sources to apply ratios between fecal coliform and fecal streptococcus. In order to apply ratios between the two bacteria, sample collection must occur as close to the source as possible. Fecal streptococci have a high rate of mortality in an aquatic environment whereas fecal coliform are much hardier and can survive where fecal streptococcus will not. The station at the Head of Westport proved valuable and produced workable data (Appendix A, Table A-9.1). The ratios obtained at this station were consistently at or below 1 to 1. These ratios may be higher than one would expect because of die off of fecal streptococcus as it migrates downstream away from the source.

The relationship of fecal coliform to fecal streptococcus can be used in certain circumstances to identify the source of bacterial contamination. Generally, when comparing fecal coliform levels to fecal streptococcus levels, ratios of 4 to 1 or greater indicate human contamination from domestic wastes, and ratios of 1 to 1 or less indicate animal contamination from agricultural sources. Ratios between these two levels indicate a possible mixture of human and animal sources.

Results of sampling in September, October and November of 1985 indicate that the primary source of bacteriological contamination above the Head of Westport, during this period, was from animal sources, either domestic or agricultural. Other fecal coliform data gathered from this area indicate that at least one of the sources of contamination is located between Route 177 and the Head of Westport. The identification of the exact source(s) was beyond the scope of this study.

4.14 Salinity and Turbidity Test

Salinity and turbidity results are summarized in Tables A-10 and A-11 of Appendix A. Salinity values provide an indication of the amount of freshwater inflow into the Estuary and of the degree to which freshwater and its associated bacterial contamination are "diluted" by the tidal inflow of saltwater. For example, assume that the average salinity in Westport Harbor is 30 parts per thousand (ppt) and that freshwater has a salinity of essentially zero. Then, if a water sample at station A-2 has a salinity of 20 ppt it is composed of 1/3 freshwater and 2/3 saltwater and the freshwater is diluted by a factor of 1/3. Furthermore, if one assumes that bacteria levels are conservative (i.e., they do not die off or multiply) and freshwater is the source of all bacterial contamination in the Estuary, then when that freshwater is diluted with "clean" saltwater the bacteria level will decrease in direct proportion to the amount of saltwater dilution. This concept is useful in assessing bacterial dissipation in the upper portions of the Estuary and may also prove to be a useful management tool in the Estuary.

Turbidity results did not correlate with other data gathered during the study period but is included for future reference by other researchers.

4.15 Rainfall Data

Daily rainfall data for Newport, RI, New Bedford, MA and Westport, MA are presented in Appendix C and monthly rainfall data is summarized in Table 4-7. For the study period, the average monthly rainfall at Newport, New Bedford and Westport were 3.26, 3.67 and 3.28 inches, respectively. August 1984 was the driest month of the study period with less than one inch of rain recorded, while August 1985 was the wettest month of the study period, with more than 12 inches of rain recorded at all three monitoring stations.

The frequency of storm events during the study period was determined for later use in assessing water quality data. The cumulative frequency of days preceeded by at least 2, 4, 6 and 11 RFDs (rain free days) was determined for the entire study period and for each quarter during the study period. (The first period included only August and September 1984). The information is presented in histogram form in Figure 4-5. This histogram shows that for the entire study period 46.4 percent of all days were preceeded by at least 4 RFDs. At first glance, the percentages appear to be high, but in many instances there are 2 or 3 days of rain followed by a relatively long dry period.

The pattern varies somewhat from season to season, but in general the frequency pattern was consistent and provides some basis for assessing the probability of encountering prolonged rain free periods. This information will be central to the discussion which follows in Section 5.00.

TABLE 4-7

MONTHLY PRECIPITATION FOR STUDY PERIOD
(In Inches)

MONTH	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
Aug '84	0.67	0.92	---
Sept '84	2.22	2.26	---
Oct '84	4.71	3.92	2.98
Nov '84	1.35	2.28	1.30
Dec '84	3.70	4.51	3.36
Jan '85	1.19	1.40	0.83
Feb '85	1.60	2.65	1.11
March '85	3.55	3.55	2.97
April '85	1.19	1.75	1.26
May '85	5.74	5.73	4.84
June '85	4.14	4.68	5.61
July '85	2.48	3.76	3.42
Aug '85	12.91	14.72	12.07
Sept '85	1.77	1.50	1.00
Oct '85	1.65	1.40	1.58
Nov '85	---	---	6.03
Dec '85	---	---	0.85
TOTAL	48.87	55.03	49.21
Mean Monthly	3.26	3.67	3.28

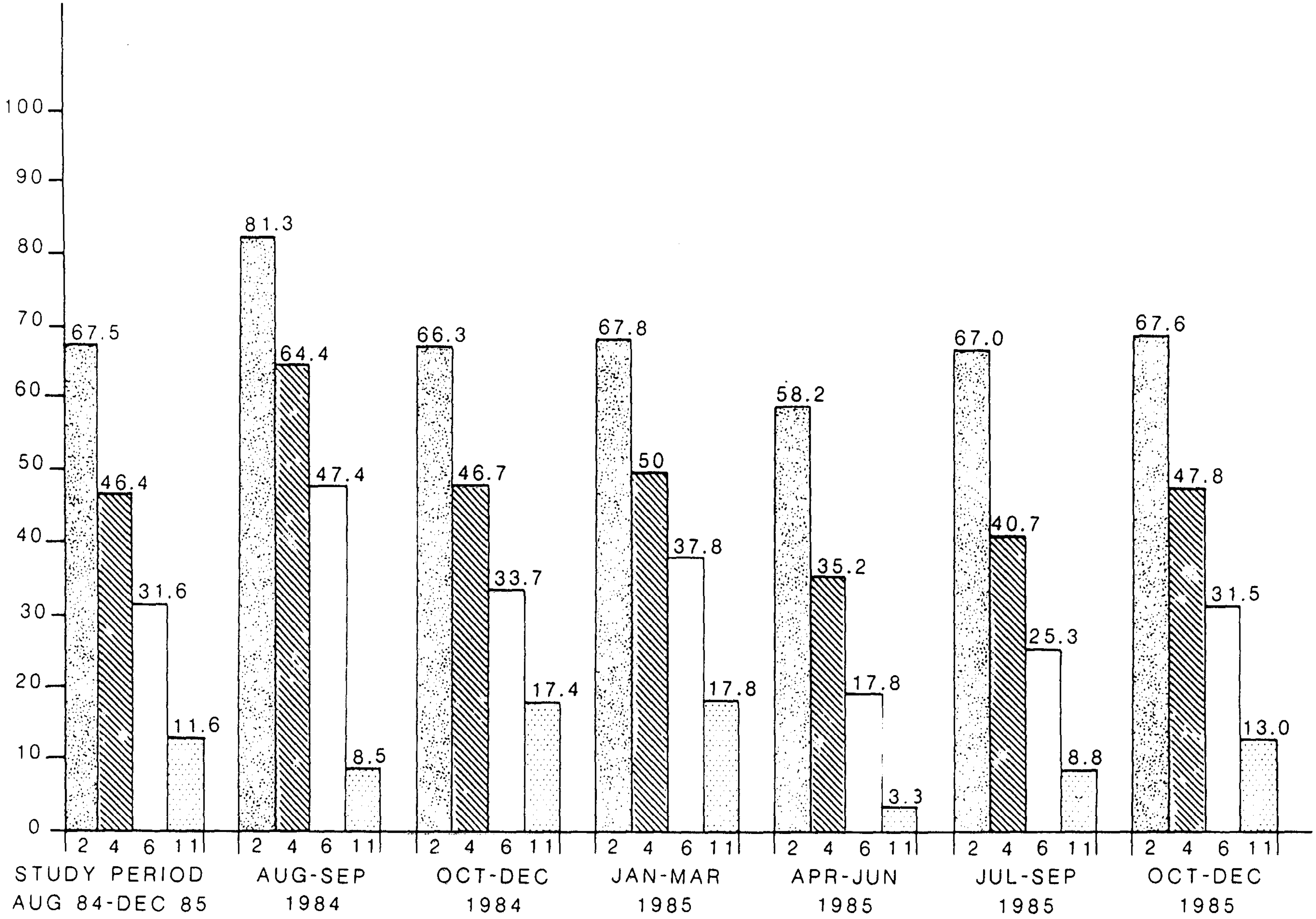

FIGURE 4-5
HISTOGRAM OF THE PERCENT OF TIME PRECEEDED BY 2, 4, 6 and 11 RAIN-FREE DAYS

5.00 DISCUSSION OF WATER QUALITY IN SHELLFISHING AREAS OF THE ESTUARY

The results of the GHR study show a regular pattern of fecal coliform contamination in the Estuary following rainfall events. In order to use the data for management of shellfishing in the Estuary it is necessary to establish a clear and simple relationship between rainfall and fecal coliform levels. Establishment of such a relationship provides a rational means of predicting water quality and does not require continuous bacteria monitoring and frequent communication and negotiation between the Town and the regulatory authorities (i.e., DEQE and the Mass. Division of Marine Fisheries). It was possible to identify this relationship for the Estuary and a portion of this information was presented in Section 4.00. This section presents a more detailed description of the relationship and the potential uses of this information in managing shellfishing in currently closed areas (Zones A and B).

5.10 Representativeness of Survey Data

The representativeness of survey data must be established before it can be used to properly assess water quality relationships in the Estuary. Representativeness means that the sampling data was gathered over a range of meteorological conditions which closely resemble the conditions actually encountered in the Estuary. If the frequency of sampling surveys does not represent actual field conditions, a bias in the interpretation of results will occur. For example, if all sampling occurs within two days following a rainfall, the average bacteria levels which are measured will be significantly higher than the actual average bacteria levels. This is because, on the average, over 60 percent of days are preceeded by at least 2 rain free days.

68% exactly

To assess the representativeness of survey data the actual number of days during the study period which occurred 0-1, 2-3, 4-5, 6-10 and 11-21 days following a rainfall event were tabulated. The percentage of the total 515 days of the study period which fell into each of the five time categories was calculated and is shown in Figure 5-1 along with the percent of sampling surveys which were conducted in each of these time categories. A review of the frequency data shows that the sampling frequency closely mirrors the actual conditions observed during the study period. There was a moderate bias of sampling towards time periods within 3 days of rainfall events. This sampling bias applies a conservative bias to any statistical interpretation of the data and tends to overestimate average bacteria levels observed in the Estuary by a small amount. Given the objective of allowing conditional opening of currently closed shellfishing areas while protecting public health, this conservative bias provides an additional margin of safety to the data interpretation.

In addition to the representativeness of sampling frequency, there is a significant bias induced by collecting all samples around low tide. In the Estuary the primary sources of bacterial contamination are in upstream areas, and the contamination extends furthest downstream at low tide. With a tidal prism amounting to 73 percent of the Estuary volume, it is likely that high tide bacteria levels in Zones A, B and C are approximately one-third to one-fourth the levels measured at low tide. This in turn implies that the true average bacteria levels are again lower than those calculated from the survey data.

5.20 Fecal Coliform Dissipation Following Rainfall Events

The results of this study show a rapid decrease in fecal coliform levels following a rainfall event. Figures 4-1 through 4-4 show how the average fecal coliform levels at stations A-2, B-1, C-1 and C-3 decrease following a rainfall. The data was divided into the five time categories based on the frequency of sampling following rainfall events and the general trends which were discerned from an initial review of the data. The use of time intervals of two days tends to average out a number of physical variables which affect bacteria levels in the Estuary. Among the variables are the duration of the rainfall, the number of tide cycles

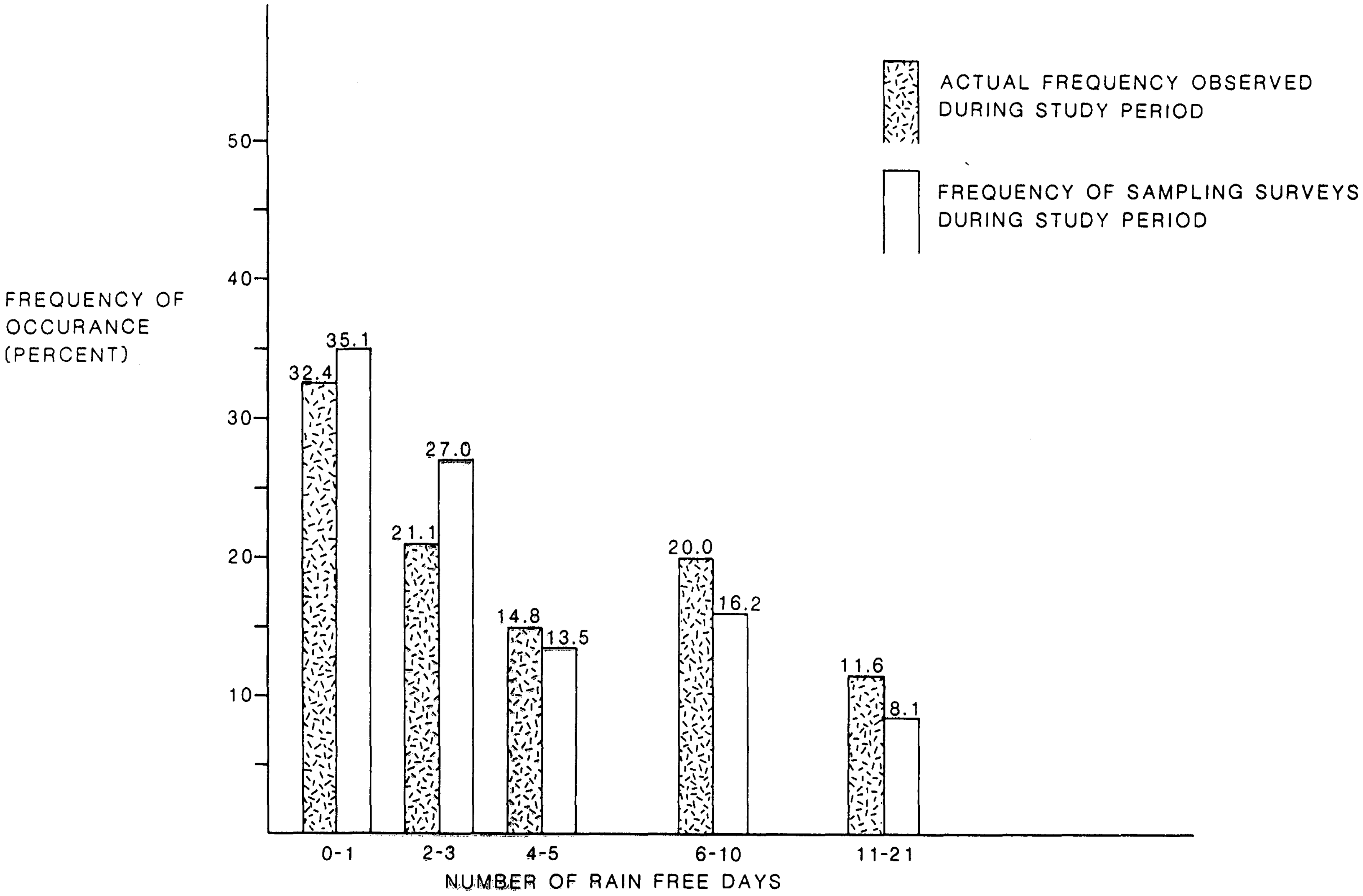

FIGURE 5-1

COMPARISON OF SAMPLING FREQUENCY TO ACTUAL FREQUENCY OF DAYS OCCURRING 0-1, 2-3, 4-5, 6-10 AND 11-21 DAYS FOLLOWING A RAINFALL EVENT between the end of the rainfall event and the sampling event, and the time lag between the beginning of a rainfall event and the distribution of bacterial contamination throughout the Estuary. The data was grouped into intervals following the day on which the rainfall event ended. Thus, the group designated 0 to 1 days following a rainfall includes data collected the first two days following a rainfall.

A rainfall event was defined as a period of continuous days during which the total rainfall exceeded 0.2 inches. The maximum precipitation values reported on Tables 4-1 through 4-5 are the highest total rainfall for the rainfall event which was recorded by the Newport, New Bedford or Westport gauging stations. When total precipitation is considered, the majority of rainfall events (29 of 37) recorded over 0.5 inches of rain.

To illustrate the degree to which bacterial levels in the Estuary dissipate following a rainfall event, a plot (Figure 5-2) was made of fecal coliform levels at 1, 3, 6, 8 and 15 days following a 2.05 inch rainfall event which ended on March 13, 1985. The figure shows that fecal coliform levels drop to moderate levels by the third day following the end of the rainfall and that fecal coliform levels in all zones fall below 14 cfu/100 ml by the sixth day. Whle bacteria levels in Zone A do not always decrease to such low levels, the general trend is consistent and predictable.

While

To further assess the effect of rainfall on average fecal coliform levels in Zones A, B and C, the mean MPN fecal coliform levels were calculated for stations A-2, B-1, C-1 and C-3 for all survey data and then for only data collected 2, 4, 6 and 11 or more days after a rainfall event. These average values are presented in Table 5-1 and plotted on Figure 5-3. A review of this data indicates that the mean fecal coliform value at station B-1 falls below the 14 cfu/100 ml maximum for all samples collected 2 or more days following a rainfall event. The mean fecal coliform values for stations C-1 and C-3 were always below the 14 cfu/100 ml maximum. However, the mean fecal coliform level at station A-2 did not fall below the 14 cfu/100 ml until 11 or more days after a rainfall event.

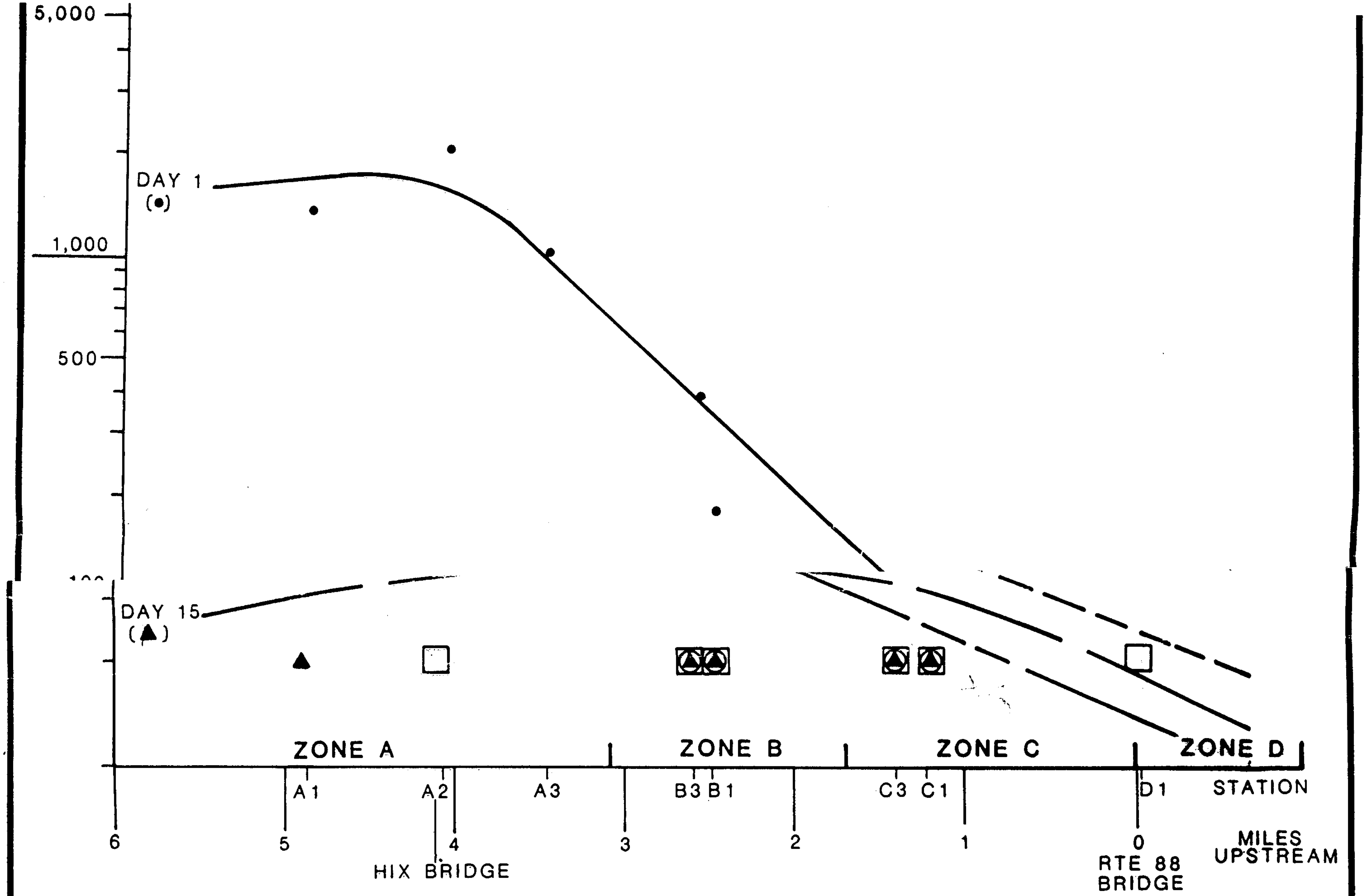

FIGURE 5-2

LONGITUDINAL PLOT OF FECAL COLIFORM LEVELS IN THE ESTUARY AT
1, 3, 6, 8 AND 11 DAYS FOLLOWING 2.05 INCH RAINFALL ON MARCH 15, 1985

TABLE 5-1

MEAN MPN FECAL COLIFORM VALUES FOR STATIONS A-2, B-1, C-1 AND C-3

Data Set	Geometric Mean MPN Fecal Coliform (cfu/100 ml) Station A-2	Station B-1	Station C-1	Station C-3
All Sampling Surveys	124	23	13 ~~10~~	14
Surveys Preceeded by 2 or more RFDs	44	10	6	6
Surveys Preceeded by 4 or more RFDs	24	5	4	5
Surveys Preceeded by 6 or more RFDs	21	3	4	4
Surveys Preceeded by 11 or more RFDs	10	3	2	4

RFD = rain-free days

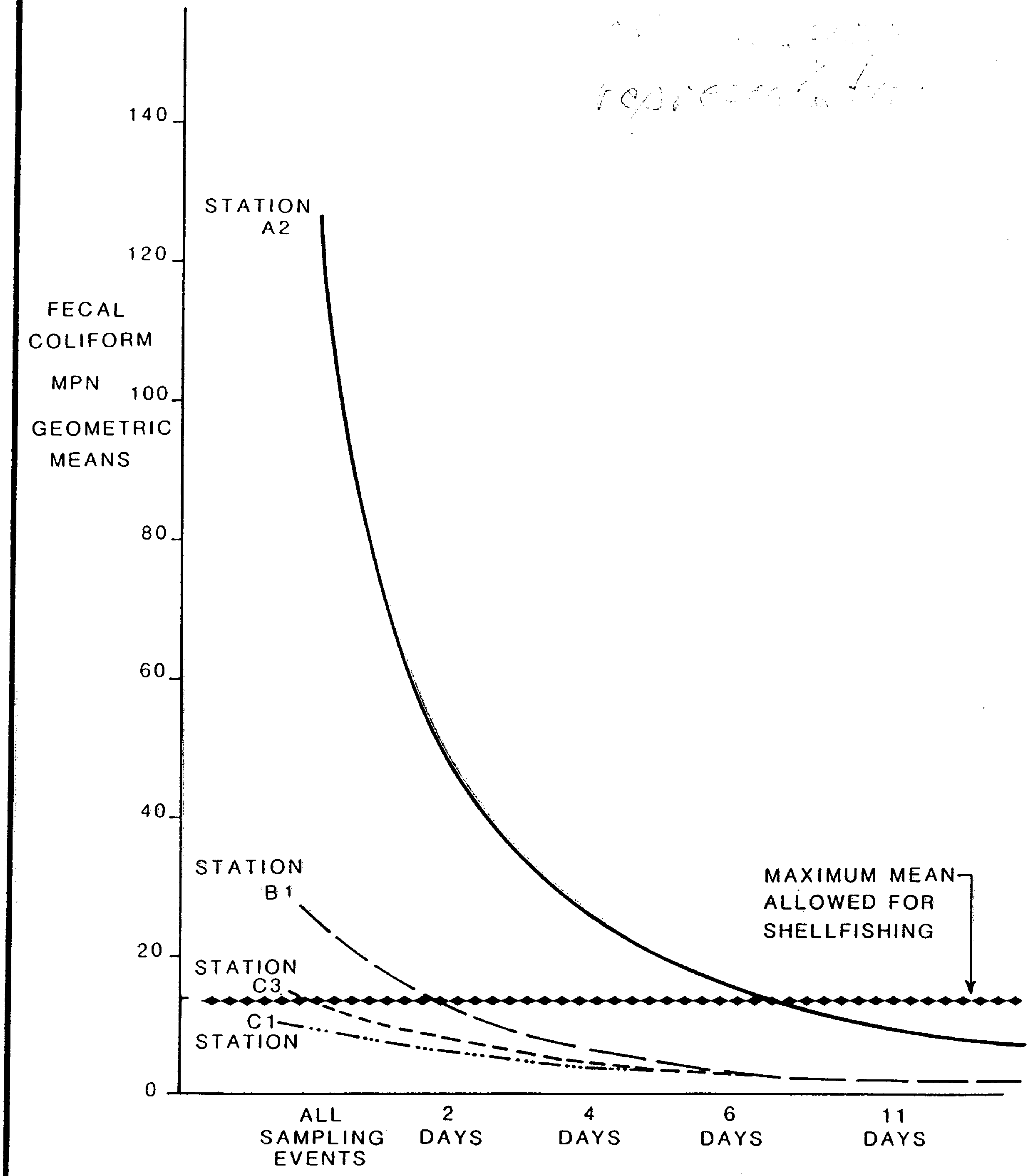

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FIGURE 5-3 **PLOT OF MEAN FECAL COLIFORM LEVELS AT STATIONS A-2, B-1, C-1, AND C-3 FOR ALL SURVEYS AND FOR SURVEYS CONDUCTED MORE THAN 2, 4, 6 AND 11 DAYS AFTER RAINFALL EVENT**

The fact that the mean fecal coliform levels decrease to acceptable levels in Zones A and B does not imply that these areas can be open to shellfishing on the eleventh and second day after a rainfall event, respectively. Rather it indicates that bacteria levels in these zones do decrease in a consistent and predictable manner and that the elapsed time after a rainfall event can be used to predict water quality in the Estuary. The decision to open areas of Zones A and B to shellfishing must be based on an assessment of the relationship between shellfish contamination and overlying water quality.

5.30 Assessment of the Conditional Opening of Areas Currently Closed To Shellfishing

As discussed in the previous section, fecal coliform levels in Zone B decrease to acceptable levels for shellfishing within 2 to 3 days after a rainfall event, while Zone A does not achieve these levels for over 10 days after a rainfall event. The primary focus of the assessment of reopening closed areas will focus on Zone B because the patterns are more clear and the reocvery time lowest for this zone. This does not mean that conditional opening of Zone A (particularly for oyster harvesting) should not be considered. Rather, the additional level of effort required to investigate and justify opening Zone A is much greater than it is for Zone B.

Two major questions arise when considering a conditional opening of Zone B. The first question is how long does it take for the shellfish to depurate or cleanse themselves of bacterial contamination once overlying water quality has reached acceptable levels. The second question is how many days could the area be opened if the depuration time were established.

Zone B contains habitat areas for both quahogs and softshell clams. The respiration and depuration rates for these two species differ considerably. In general, the softshell clam both accumulates and depurates bacteria more quickly than does the quahog. To evaluate the potential for conditional opening of Zone B we have assumed a conservative depuration time of 4 days for both quahogs and softshell clams. The actual number of days may be different but will probably be in the range of 2 to 4 days.

To assess the amount of time during which Zone B could be conditionally opened, an analysis was made of the number of days occurring at 2, 4, 6 and 11 or more days after a rainfall event. These frequencies indicate the amount of time during a period which occurs a given number of days or more after a rainfall event. For example, during the 515 day study period, 239 of the days occurred four or more days after a rainfall event. This means that 46.4 percent of the days of the study period were preceeded by at least four rain-free days. Figure 4-5 is a histogram depicting the percent of days preceeded by at least 2, 4, 6 and 11 or more rain free days during the entire study period.

The histogram also includes a breakdown of the data from the study period into three month intervals so that seasonal differences in the time distribution could be identified and their effects on conditional openings assessed. A review of Figure 4-5 shows that the frequency distribution is consistent for the entire study period. The only exception was the period of August and September 1984. The month of August received less than one inch of rainfall and was driest month of the study period. This, combined with the fact that this period comprised only a two month period, probably accounts for the anomolous results for the period. Since the general pattern of time distribution following rainfall events is relatively consistent we will discuss the potential for conditional openings of Zone B for shellfishing using the percentages developed for the entire study period. Projecting these percentages over a one year (365 day) period we would project that in that period:

a) 246 days would be preceeded by two or more rain-free days
b) 169 days would be preceeded by four or more rain-free days
c) 115 days would be preceeded by six or more rain-free days
d) 42 days would be preceeded by eleven or more rain-free days

In assessing the conditional opening of Zone B, we have now developed the following set of criteria:

1. The mean fecal coliform level in Zone B decreases to below 14 cfu/100 ml within two days after a rainfall event
2. A depuration period of four days should be allowed between the time that the mean fecal coliform level reaches the acceptable level (i.e., 2 days for Zone B) and the opening of Zone B for shellfishing
3. Based on items 1 and 2 above, a conditional opening of Zone B could be allowed beginning on the sixth day after a rainfall event.

At first glance, there would not appear to be many days available for shellfishing under these criteria. However, the analysis of rainfall data showed that there would be 115 days open for shellfishing in Zone B. These days would be evenly distributed over the year so that there would be approximately 29 shellfishing days each season. Realistically, the opening would occur at random intervals throughout the year and the duration of an opening may be as brief as one day or as long as sixteen days. It also appears that an opening can safely extend into the first day of the rainfall event which terminates the conditional opening. This is possible because there is a lag time between the onset of rain and the appearance of fecal coliform in the Estuary.

The impact of a conditional opening in Zone B is potentially very large. The harvestable areas of Zones B and C are both approximately 520 acres for quahogs. Therefore, the 115 days of potential shellfishing in Zone B represents a 30 percent increase in the shellfishing in the Estuary. The percent increase in shellfishing which is actually realized from conditional opening will depend on a number of factors including the time lapse established between the end of a rainfall event and the opening of Zone B, and the time of year that conditional openings occur. The periodic opening of Zone B would have several additional benefits. First, the pressure on quahog beds in Zone C would be reduced because fishermen would be attracted to more productive beds in Zone B, and second, overfishing in Zone B would be limited by the temporary nature of the conditional openings.

6.00 CONCLUSIONS AND RECOMMENDATIONS

The data gathered during this study show a clear and predictable relationship between rainfall events and episodes of bacterial contamination in shellfishing areas of the Estuary. The highest bacteria levels were typically encountered within 24 hours of a rainfall event, and the levels in shellfishing areas decreased to background levels within 2 to 3 days following the end of the rainfall event.

Bacteria levels were consistently highest in the upper portions of the Estuary (i.e. Zone A and stations above the Head of Westport) and decreased steadily in the downstream direction. This pattern of distribution indicates tht the primary source(s) of bacterial contamination are located upstream of the primary study area (i.e. above Station A5 located at Cornell Point). Further delineation of input sources above Cornell Point is limited because all suspected input streams and Kirby Brook in particular were not sampled during this study. However, based on the available data, it appears that a majority of the bacterial input is emanating from locations at and above the Head of Westport.

The rapid rise in bacteria levels following a rainfall event, followed by an equally rapid decrease, indicates that surface runoff provides the majority of bacterial contamination to the Estuary. This causes fecal coliform levels in shellfishing areas to exceed existing state standards. This means that the stormwater runoff contributes substantially higher bacteria loads over shorter time intervals than do continuous low level, low volume discharges, such as the effluent from the Lincoln Park wastewater treatment plant or any single septic system.

The relationship between rainfall and bacteria levels in the Estuary can be used as an effective predictive shellfish management tool. Using a conservative approach of adding a four-day depuration period to the time required for the mean fecal coliform level to fall below the maximum 14 cfu/100 ml, Zone B could be opened to shellfishing on the sixth day following the end of a rainfall event. We believe that this criteria is protective of the public health even after heavy rainfall (more than 2 inches), and that earlier openings could be justified after less intense storms.

From a management perspective, we advocate initially, using a single time criteria for conditional opening of Zone B. This would produce a consistent, predictable opening policy which could be understood by the public and enforced by the shellfish constable.

During the first year of conditional opening, Zone B could be opened to shellfishing on the sixth day after a rainfall event. Water samples could be collected on the third, fourth and fifth days after rainfall of less than 1 inch, in order to establish a more extensive data base than is currently available to assess the possibility for earlier openings of the area.

Conditional opening of the lower portion of Zone A below Hix Bridge may be possible in the future. To justify opening this area, additional sampling and analyses would be required. The sampling would focus on water quality in the area 3 to 10 days following rainfall events. This area is primarily oyster habitat. It may be possible to establish a relationship between bacteria levels in water and shellfish which could serve as basis for allowing openings at bacteria levels which exceed the established water quality standards.

The results of this study indicate that surface runoff is the primary source for episodes of bacterial contamination in the Estuary. This runoff results in short term rises in bacterial levels which are rapidly purged from the Estuary by tidal flushing, natural die-off and other natural processes. The efforts to reduce pollution in the Estuary therefore need to focus on source reduction and source elimination. For example, reducing runoff by installing retention ponds or surface berms could result in extending the release of stormwater for several days after the end of a rainfall. This extended storm release with its bacterial load could extend the flushing time by an equal amount of time and thus, compound the existing contamination problem in the Estuary.

The clean-up of bacterial pollution in the Estuary will be a long process consisting of careful monitoring of existing sources and control over new potential sources. The use of rainfall based conditional shellfish openings represents an important and realistic management tool which can be used during the interim period.

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See disc. pp 3-5, 3-6

TABLE A-1.1
WESTPORT RIVER SURVEY
5 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
1984		A-2		B-1		C-1		C-3	
		TC	FC	TC	FC	TC	FC	TC	FC
August	6	920	110	79	43	17	8	8	8
	20	1,600	280	<2	<2	220	8	6	3
September	4	170	170	31	31	23	13	23	8
	18	280	280	49	49	13	2	2	<2
October	3	>2,400	>2,400	920	920	280	220	>2,400	>2,400
	9	33	33	4	4	2	<2	<2	<2
	18	49	33	13	<2	7	2	2	<2
	30	>24,000	>24,000	94	70	110	110	49	49
November	6	9,200	3,500	79	49	49	49	46	46
	9	79	79	31	13	2	2	11	7
	15	920	350	540	350	170	110	130	130
December	3	49	13	23	13	33	13	17	7
	19	11	11	<2	<2	2	2	2	2

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

[redacted]

TABLE A-1.2
WESTPORT RIVER SURVEY
5 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
1985		A-2		B-1		C-1		C-3	
		TC	FC	TC	FC	TC	FC	TC	FC
February	28	14	14	13	8	5	2	17	11
March	13	5200	9200*	>2400	540	220	110	1600	280
	15	180	23	140	94	79	49	70	22
	18	260	40	31	11	9	14*	14	14
	20	8	8	2	2	4	11*	5	5
	27	17	2	13	2	2	2	2	<1
April	17	130	22	2	<1	8	2	5	<1
May	7	130	130	79	49	49	22	8	5
	9	240	240	31	23	26	6	13	5
	13	70	46	79	5	4	<1	4	4
	15	240	49	23	13	46	13	23	5
	20	49	4	4	2	<1	<1	<1	<1
	29	920	540	49	49	140	140	130	130
July	23	21	6	27	8	49	22	70	12
	26	21	21	17	17	12	6	39	39
	30	>2400	>2400	1600	1600	45	45	24	24
August	1	1600	1600	350	350	22	17	170	170

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

TABLE A-1.3
WESTPORT RIVER SURVEY
5 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
		A-2		B-1		C-1		C-3	
1985		TC	FC	TC	FC	TC	FC	TC	FC
Ausust	6	130	79	17	11	8	<2	8	8
September	10	16,000	5400	1600	130	540	130	350	130
October	8	350	130	49	2	14	2	13	2
	22	79	49	23	8	8	8	17	13
	29	49	14	4	4	11	7	4	2
November	5	350	4	2400	350	8	4	13	2
	7	>2400	>2400	>2400	>2400	>2400	>2400	>2400	1600
	12	490	230	78	45	45	<10	110	20

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

TABLE A-2.1
WESTPORT RIVER SURVEY
3 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
1984		A-1		A-2		A-3		A-4	
		TC	FC	TC	FC	TC	FC	TC	FC
August	6	>2,400	460	920	110	1,100	460	93	43
	20	>2,400	>2,400	1,600	280	1,100	1,100	15	15
September	4	>2,400	>2,400	170	170	240	43	75	39
	18	1,100	1,100	280	280	240	93	4	3
October	3			>2,400	>2,400				
	9			33	33				
	18			49	33				
	30			>24,000	>24,000				
November	6			9,200	3,500				
	9			79	79				
	15			920	350				
December	3			49	13				
	19			11	11				

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

TABLE A-2.2
WESTPORT RIVER SURVEY
3 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
1984		B-1		B-2		B-3		B-4	
		TC	FC	TC	FC	TC	FC	TC	FC
August	6	79	43	43	23	93	43	43	23
	20	<2	<2	11	6	6	3	6	3
September	4	31	31	43	43	43	15	43	15
	18	49	49	9	4	93	4	43	23
October	3	920	920						
	9	4	4						
	18	13	<2						
	30	94	70						
November	6	79	49						
	9	31	13						
	15	540	350						
December	3	23	13						
	19	<2	<2						

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

TABLE A-2.3
WESTPORT RIVER SURVEY
3 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
1984		C-1		C-2		C-3		C-4	
		TC	FC	TC	FC	TC	FC	TC	FC
August	6	17	8	39	39	8	8	25	25
	20	220	8	14	14	6	3	6	3
September	4	23	13	39	14	23	8	23	9
	18	13	2	9	4	2	<2	<3	<2
October	3	280	220			>2,400	>2,400		
	9	2	<2			<2	<2		
	18	7	2			2	<2		
	30	110	110			49	49		
November	6	49	49			46	46		
	9	2	2			11	7		
	15	170	110			130	130		
December	3	33	13			17	7		
	19	2	2			2	2		

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

TABLE A-2.4
WESTPORT RIVER SURVEY
3 TUBE MPN TOTAL AND FECAL COLIFORM RESULTS

DATE		STATION NUMBERS	
1984		D-1	
		TC	FC
August	6	43	23
	20	9	9
September	4	7	4
	18	9	<3

Total and Fecal Coliform in cfu (colony forming units)/100 ml MPN.

TABLE A-3.1
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS							
1984		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
August	6	318	134	80	20				
	20	346	158	96	<2				
September	4	224	114	36	4				
	10	372	294	192	<2				
October	3	1060	738	300	202				
	9	38	18	<2	2	58	80	58	2
	19	44	34	18	2				
	30	16,500	12,200	7900	58	25,600	7400	815	46
November	6	3110	1970	1180	33	4600	760	68	182
	9	26	20	6	16	70	128	93	30
	15	386	440	444	53				
December	3	18	<2	2	2				
	19	<2	<2	<2	10				

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.2
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS							
1984		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
August	6	10	7	10	8				
	20	<2	6	<2	<2				
September	4	6	20	8	2				
	18	12	6	16	10				
October	3	334	100	232	177				
	9	<2	2	<2	2	18	68	2	54
	18	6	2	6	2				
	30	54	56	364	74	240	130	249	71
November	6	20	34	168	38	52	780	58	18
	9	15	10	2	10	34	61	<2	2
	15	153	153	217	150				
December	3	6	4	12	2				
	19	<2	11	<2	<2				

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.3
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE	STATION NUMBERS				
1984	C-1	C-2	C-3	C-4	C-5
August 6	<2	2	4	6	
20	<2	4	<2	<2	
September 4	<2	2	10	2	
18	16	2	<2	<2	
October 3	126	111	300	85	
9	<2	<2	<2	2	<2
18	<2	2	<2	<2	
30	52	15	14	4	6
November 6	18	15	14	16	8
9	6	2	<2	<2	<2
15	89	38	22	28	
December 3	<2	2	2	2	
19	<2	<2	3	<2	

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.4
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION
1984		D-1
August	6	6
	20	6
September	4	8
	18	2
October	3	46
	9	2
	18	2
	30	8
November	6	8
	9	<2
	15	20
December	3	20
	19	<2

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.5
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS							
1985		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
February	28	4	<2	<2	<2				
March	13	1400	2120	1120	280				
	15	26	26	36	12	21	75	4	14
	18	13	8	8	<2	20	39	<2	<2
	20	4	<2	12	4	<2	22	<2	10
	27	2	4	4	<2				
April	17	23	24	6	<2				
May	7	107	75	161	45				
	9	76	34	59	<2	-	-	28	4
	13	106	41	70	20	220	2910	226	106
	15	140	92	61	14	164	100	80	16
	20	<20	6	2	<2	79	43	12	<20
	29	81	130	110	24				
July	23	8	14	6	2				
	26	14	20	<2	2				
	30	225	23	17	16				
August	1	740	310	430	220				

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.6
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS							
1985		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
February	28	24	<2	12	20				
March	13	194	278	460	175				
	15	8	30	23	14	20	93	8	13
	18	<2	6	2	6	13	21	2	4
	20	2	2	<2	2	35	2	<2	<2
	27	<2	<2	<2	2				
April	17	2	<2	2	<2				
May	7	66	35	24	42				
	9	8	6	6	8	<2	17	10	4
	13	6	218	2	2	135	3600	2	22
	15	12	6	10	14	36	71	16	12
	20	20	2	2	2	102	30	2	<2
	29	64	128	20	26				
July	23	2	2	4	<2				
	26	2	<2	2	<2				
	30	19	13	25	2				
August	1	84	135	92	79				

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.7
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS				
1985		C-1	C-2	C-3	C-4	C-5
February	28	<2	2	<2	<2	
March	13	96	66	105	99	
	15	13	10	10	11	4
	18	<2	<2	<2	2	2
	20	<2	2	<2	<2	<2
	27	6	<2	<2	<2	
April	17	<2	<2	<2	<2	
May	7	22	2	6	23	
	9	<2	<2	2	<2	<2
	13	<2	<2	<2	<2	12
	15	2	2	4	2	2
	20	2	<2	<2	20	<2
	29	32	29	53	36	
July	23	4	4	<2	<2	
	26	<2	20	2	2	
	30	6	11	8	10	
August	1	17	17	40	8	

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.8
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION
1985		D-1
February	28	<2
March	13	40
	15	14
	18	6
	20	<2
	27	<2
April	17	<2
May	7	2
	9	11
	13	2
	15	2
	20	<2
	29	10
July	23	2
	26	2
	30	2
August	1	27

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.9
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS		
1985		The Head of Westport	Forge Pond Outlet	Bread & Cheese Brook
March	13			
	15			
	18			
	20			
	27			
April	17			
May	7	192	153	40
	9	117	162	18
	13	1600	170	400
	15	202	304	59
	20	201	93	107
	29	>2000	530	600
July	23			
	26	553	121	62
	30	447	329	150
August	1	6800	2300	4400

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.10
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS							
1985		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
August	6	86	56	36	2				
September	10	9700	2600	1100	100				
October	8	126	128	64	2				
	22	59	34	15	2				
	29	24	2	<2	4				
November	5	26	4	2	4				
	7	6400	7600	8000	3100				
	12	130	120	100	150				

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.11
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS							
1985		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
August	6	<2	<2	4	20				
September	10	96	158	140	60				
October	8	4	2	8	6				
	22	4	<2	2	<2				
	29	<2	2	13	<2				
November	5	40	2	<2	<2				
	7	>4000	>4000	>4000	>4000				
	12	80	60	<20	<20				

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.12
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBERS				
1985		C-1	C-2	C-3	C-4	C-5
August	6	<2	<2	4	4	
September	10	62	120	20	90	
October	8	<2	<2	<2	2	
	22	4	<2	2	4	
	29	2	<2	2	<2	
November	5	<2	2	<2	2	
	7	>4000	>4000	>4000	2340	
	12	<20	<20	40	<20	

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.13
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBER
1985		D-1
August	6	<2
September	10	16
October	8	4
	22	2
	29	<2
November	5	<2
	7	1,300
	12	<20

Fecal Coliform in cfu (colony forming units)/100 ml MF.

TABLE A-3.14
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
MEMBRANE FILTRATION

DATE		STATION NUMBER		
1985		The Head of Westport	Forge Pond Outlet	Bread & Cheese Brook
August	6	313	256	103
September	10	11,000	9,000	1,550
October	8	170	210	20
	22	260	85	6
	29	91	12	175
November	5	39,000	705	900
	7	-	-	-
	12	170	240	170

Fecal Coliform in cfu (colony forming units)/100 ml.

TABLE A-4.1
WESTPORT RIVER SURVEY
COMPARISON OF MF AND MPN
FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
		A-2		B-1		C-1		C-3	
1984		MF	MPN	MF	MPN	MF	MPN	MF	MPN
August	6	318	110	10	43	<2	8	4	8
	20	346	280	<2	<2	<2	8	<2	14
September	4	224	170	6	31	<2	13	10	8
	18	372	280	12	49	16	2	<2	<2
October	3	1060	>2400	334	920	126	220	300	>2400
	9	38	33	<2	4	<2	<2	<2	<2
	18	44	33	6	<2	<2	2	<2	<2
	30	16,500	>24,000	54	70	52	110	14	49
November	6	1970	3500	20	49	18	49	14	46
	9	20	79	15	13	6	2	<2	7
	15	440	350	153	350	89	110	22	130
December	3	<2	13	6	13	<2	13	2	7
	19	<2	11	<2	<2	<2	2	3	2

Fecal Coliform in cfu (colony forming units)/100 ml.

TABLE A-4.2
WESTPORT RIVER SURVEY
COMPARISON OF MF AND MPN
FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
		A-2		B-1		C-1		C-3	
1985		MF	MPN	MF	MPN	MF	MPN	MF	MPN
February	28	<2	14	24	8	<2	2	<2	11
March	13	2120	9200	194	540	96	110	105	280
	15	26	23	8	94	13	49	10	22
	18	8	40	<2	11	<1	14	<2	14
	20	<2	8	2	2	<2	11	<2	<1
	27	4	2	<2	2	6	2	<2	<1
April	17	24	22	2	<1	<2	2	<2	<1
May	7	75	130	66	49	22	22	6	5
	9	34	240	8	23	<2	6	2	5
	13	41	46	6	5	<2	<1	<2	4
	15	92	49	12	13	2	13	4	5
	20	6	4	20	2	2	<1	<2	<1
	29	130	540	64	49	32	140	53	130
July	23	14	6	2	8	4	2	<2	12
	26	20	21	2	17	<2	6	2	39
	30	23	>2400	19	1600	6	45	8	24
August	1	310	1600	84	350	17	17	40	170

Fecal Coliform in cfu (colony forming units)/100 ml.

TABLE A-4.3
WESTPORT RIVER SURVEY
COMPARISON OF MF AND MPN
FECAL COLIFORM RESULTS

DATE		STATION NUMBERS							
		A-2		B-1		C-1		C-3	
1985		MF	MPN	MF	MPN	MF	MPN	MF	MPN
August	6	56	79	<2	11	<2	<2	4	8
September	10	2600	5400	96	130	62	130	20	130
October	8	128	130	4	2	<2	2	<2	2
	22	34	49	4	8	4	8	2	13
	29	2	14	<2	4	2	7	2	2
November	5	4	4	40	350	<2	4	<2	2
	7	7600	>2400	>4000	>2400	>4000	>2400	>4000	1600
	12	120	230	80	45	<20	<10	40	20

Fecal Coliform in cfu (colony forming units)/100 ml.

TABLE A-5.1
WESTPORT RIVER SURVEY
5 TUBE MPN FECAL STREPTOCOCCUS RESULTS

DATE		STATION NUMBERS	
1985		Station A-2	The Head of Westport
August	6	-	-
September	10	-	-
October	8	25	350
	22	540	1600
	29	14	79
November	5	49	>24,000
	7	>2400	-
	12	78	1300

Fecal Steptococcus in cfu (colony forming units)/100 ml MPN.

TABLE A-6.1
WESTPORT RIVER SURVEY
FECAL STREPTOCOCCUS MF RESULTS

DATE	STATION NUMBERS	
1985	A-2	The Head of Westport
August 6	-	-
September 10	590	10,300
October 8	82	161
22	30	712
29	2	120
November 5	-	-
7	4400	-
12	90	1067

Fecal Streptococcus in cfu (colony forming units)/100 ml MF.

TABLE A-7.1
WESTPORT RIVER SURVEY
FECAL STREPTOCOCCUS RESULTS
MF VS MPN

DATE		STATION NUMBERS			
1985		Station A-2		The Head of Westport	
		MF	MPN	MF	MPN
August	6	-	-	-	-
September	10	590	-	10,300	-
October	8	82	25	161	350
	22	30	540	712	1600
	29	2	14	120	79
November	5	-	49	-	>24,000
	7	4400	>2400	-	-
	12	90	78	1067	1300

Fecal Streptococcus in cfu (colony forming units)/100 ml.

TABLE A-8.1
WESTPORT RIVER SURVEY
FECAL COLIFORM VS FECAL STREPTOCOCCUS
RESULTS MPN

DATE		STATION NUMBERS		
		A-2		
1985		FC	FS	FC/FS
August	6	79	-	—
September	10	5400	-	--
October	8	130	25	5.2
	22	49	540	.09
	29	14	14	1.00
November	5	4	49	.08
	7	>2400	>2400	—
	12	230	1300	0.18

Fecal Coliform and Fecal Streptococcus in cfu (colony forming units) /100 ml MPN.

TABLE A-9.1
WESTPORT RIVER SURVEY
FECAL COLIFORM VS FECAL STREPTOCOCCUS
RESULTS MF

DATE		STATION NUMBERS				
		A-2		The Head of Westport		
1985		FC	FS	FC	FS	
August	6	56	-	313	-	
September	10	2600	590	11,000	10,300	[illegible]
October	8	128	82	170	161	1.06
	22	34	30	260	712	.37
	29	2	2	91	120	[illegible]
November	5	4	-	3900	-	-
	8	7600	4400	-	-	-
	12	120	90	170	1067	0.16

Fecal Coliform and Fecal Streptococcus in cfu (colony forming units) /100 ml MF.

TABLE A-10.1
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS							
1984		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
August	6	13.0	15.6	18.1	21.5				
	20	18.6	19.9	21.4	26.6				
September	4	23.5	23.7	23.8	29.1				
	18	18.5	19.9	20.9	27.5				
October	3	19.4	20.5	21.4	27.0				
	9	20.0	21.0	23.1	26.2	27.2	25.8	3.4	25.1
	18	21.9	22.8	23.5	28.1				
	30	16.2	15.8	17.1	25.5	11.7	5.2	0.9	23.8
November	6	14.5	17.5	18.1	25.3	11.9	18.6	2.4	24.7
	9	22.6	22.8	22.6	23.4	18.1	13.5	14.4	22.6
	15	12.3	13.5	15.5	24.8				
December	3	18.8	21.4	22.8	23.5				
	19	16.8	21.2	23.0	28.2				

Salinity in PPT.

TABLE A-10.2
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS							
1984		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
August	6	23.5	23.8	22.7	26.4				
	20	24.9	26.4	27.9	27.2				
September	4	28.1	28.5	27.2	28.1				
	18	27.4	27.4	27.0	27.7				
October	3	27.7	28.1	27.4	27.7				
	9	27.5	28.1	25.6	28.7	29.3	4.4	25.5	30.6
	18	27.7	29.1	27.2	28.3				
	30	26.4	26.8	23.8	25.8	19.7	24.1	24.7	9.1
November	6	25.8	26.2	22.1	25.3	6.0	8.6	24.7	23.8
	9	27.2	28.5	28.3	29.1	24.0	26.8	28.7	24.3
	15	22.2	24.1	21.5	24.0				
December	3	26.2	27.7	26.7	27.0				
	19	27.7	28.9	26.4	28.5				

Salinity in PPT.

TABLE A-10.3
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS				
1984		C-1	C-2	C-3	C-4	C-5
August	6	27.6	27.0	28.1	28.3	
	20	27.4	28.3	29.1	27.7	
September	4	28.9	29.1	29.4	29.8	
	18	28.3	29.3	29.8	30.0	
October	3	28.5	29.4	29.4	29.4	
	9	27.7	29.3	29.1	29.6	30.4
	18	30.0	30.0	29.8	30.8	
	30	26.6	28.1	28.1	28.7	29.1
November	6	26.4	25.5	26.8	28.3	29.1
	9	30.0	29.6	28.9	29.8	29.4
	15	27.7	29.2	27.7	29.2	
December	3	28.5	29.3	27.4	29.7	
	19	29.7	31.2	30.6	31.2	

Salinity in PPT.

TABLE A-10.4
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION
1984		D-1
August	6	28.6
	20	28.7
September	4	29.6
	18	30.2
October	3	29.8
	9	29.8
	18	31.0
	30	29.1
November	6	28.3
	9	31.2
	15	29.5
December	3	30.6
	19	31.7

Salinity in PPT.

TABLE A-10.5
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS							
1985		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
February	28	19.9	18.7	18.5	18.8				
March	13	-	3.46	5.81	22.8				
	15	4.00	6.89	7.79	17.7	2.60	7.07	2.02	18.5
	18	9.24	14.9	17.0	24.2	5.08	13.0	15.9	22.4
	20	-	18.8	20.3	21.0	8.36	10.9	8.72	22.1
	27	19.9	18.0	22.3	34.7				
April	17	17.7	21.0	23.9	25.5				
May	7	10.5	14.9	18.8	24.4				
	9	7.43	8.69	10.32	23.2	-	-	7.97	22.8
	13	9.96	13.8	16.3	18.8	5.48	6.89	5.63	17.4
	15	10.3	14.1	17.0	25.5	6.2	9.6	1.5	24.2
	20	15.9	19.2	22.1	22.4	13.4	13.8	10.5	21.4
	29	14.1	14.9	16.3	21.7				
July	23	26.1	27.2	28.3	29.9				
	26	18.8	18.1	18.8	22.1				
	30	16.3	18.8	20.6	22.1				
August	1	16.7	21.4	22.8	28.3				

Salinity in PPT.

TABLE A-10.6
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS							
1985		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
February	28	21.7	22.1	21.9	22.1				
March	13	16.7	17.4	17.0	20.6				
	15	15.6	15.6	15.6	16.3	2.02	2.56	18.5	17.4
	18	23.9	24.2	22.4	24.6	22.4	15.6	21.7	21.0
	20	22.1	24.2	22.1	23.2	1.16	24.2	23.5	29.3
	27	32.0	35.8	29.9	34.7				
April	17	27.7	27.7	27.7	29.9				
May	7	20.7	25.5	24.4	25.5				
	9	18.5	22.4	18.8	21.0	21.0	22.4	19.2	20.6
	13	21.4	22.4	22.1	22.1	1.12	6.56	22.1	25.5
	15	23.5	23.9	21.0	21.0	17.0	19.9	21.0	19.6
	20	25.5	26.1	26.1	28.8	4.8	25.0	27.2	22.4
	29	22.8	26.1	19.9	23.9				
July	23	29.9	31.5	29.9	31.5				
	26	22.1	27.7	21.0	27.7				
	30	21.0	26.6	24.4	28.3				
August	1	29.9	31.0	27.2	31.0				

Salinity in PPT.

TABLE A-10.7
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE	STATION NUMBERS				
1985	C-1	C-2	C-3	C-4	C-5
February 28	24.2	25.2	24.0	24.0	
March 13	24.4	26.6	25.5	27.2	
15	18.8	22.1	20.3	22.4	27.7
18	25.3	32.6	29.9	31.0	34.7
20	29.9	32.6	28.8	29.9	32.6
27	35.5	31.2	34.8	39.8	
April 17	31.5	31.5	28.3	28.8	
May 7	28.3	31.0	29.3	37.7	
9	23.9	26.6	28.3	29.3	32.0
13	27.2	28.3	26.1	27.2	29.9
15	23.2	27.2	26.1	28.8	29.9
20	29.9	30.4	31.0	30.4	
29	25.0	25.0	26.1	25.5	
July 23	33.7	33.1	31.5	32.0	
26	28.8	29.9	28.3	25.5	
30	29.3	29.3	29.3	29.3	
August 1	28.8	29.9	31.0	29.9	

Salinity in PPT.

TABLE A-10.8
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION
1985		D-1
February	28	27.5
March	13	38.2
	15	28.3
	18	34.2
	20	32.6
	27	38.4
April	17	32.6
May	7	31.0
	9	32.0
	13	29.3
	15	31.0
	20	31.0
	29	24.4
July	23	32.0
	26	29.9
	30	33.1
August	1	37.7

Salinity in PPT.

TABLE A-10.9
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS		
1985		The Head of Westport	Forge Pond Outlet	Bread & Cheese Brook
March	13			
	15			
	18			
	20			
	27			
April	17			
May	7	<0.38	<0.38	<0.38
	9	6.2	0.40	0.58
	13	0.40	4.18	0.40
	15	0.80	<0.22	<0.22
	20	0.80	0.40	0.40
	29	0.22	<0.22	<0.22
July	23			
	26	<0.22	<0.22	<0.22
	30	0.80	0.44	0.40
August	1	1.16	13.8	0.44

Salinity in PPT.

TABLE A-10.10
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS							
1985		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
August	6	8.69	9.60	11.04	21.0				
	13	-	-	-	-				
	14	-	-	-	20.6				
	15	17.7	21.4	23.8	-				
September	10	4.54	6.53	9.42	17.4				
October	8	16.3	17.7	21.0	27.7				
	22	19.6	21.4	22.8	27.2				
	29	14.5	19.2	19.9	26.6				
November	5	9.96	17.4	20.6	22.4				
	7	2.38	3.82	8.69	14.9				
	12	19.6	22.1	23.5	22.1				

Salinity in PPT

TABLE A-10.11
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS							
1985		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
August	6	19.6	20.6	17.7	21.4				
	13	-	-	8.36	-				
	14	-	-	-	-				
	15	-	-	-	-				
September	10	15.2	16.7	14.5	17.7				
October	8	27.2	28.8	25.3	27.7				
	22	22.1	24.2	25.0	28.3				
	29	27.2	26.6	26.6	28.3				
November	5	23.2	27.7	27.7	29.3				
	7	16.7	14.5	14.1	16.7				
	12	28.3	27.2	28.8	32.0				

Salinity in PPT.

TABLE A-10.12
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS				
1985		C-1	C-2	C-3	C-4	C-5
August	6	22.8	25.5	25.5	27.7	
	13	-	-	22.8	-	
	14	-	-	-	-	
	15	-	-	-	-	
September	10	17.7	20.3	21.7	21.4	
October	8	28.3	27.7	27.7	29.3	
	22	21.7	28.3	35.3	31.5	
	29	27.7	29.3	28.8	29.9	
November	5	27.2	27.7	26.6	29.9	
	7	19.6	22.8	23.2	24.2	
	12	32.6	33.1	27.7	31.5	

Salinity in PPT.

TABLE A-10.13
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBER
1985		D-1
August	6	26.6
	13	-
	14	-
	15	-
September	10	22.1
October	8	28.8
	22	31.5
	29	29.3
November	5	30.4
	7	27.2
	12	32.6

Salinity in PPT.

TABLE A-10.14
WESTPORT RIVER SURVEY
SALINITY RESULTS

DATE		STATION NUMBERS		
1985		The Head of Westport	Forge Pond Outlet	Bread & Cheese Brook
August	6	<0.22	<0.22	<0.22
	13	-	-	-
	14	-	-	-
	15	-	-	-
September	10	<0.22	<0.22	<0.22
October	8	<0.22	<0.22	<0.22
	22	0.80	<0.22	<0.22
	29	<0.22	<0.22	<0.22
November	5	0.80	<0.22	<0.22
	7	-	-	-
	12	<0.22	<0.22	<0.22

Salinity in PPT.

TABLE A-11.1
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS							
1984		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
August	6	3.6	3.6	3.5	2.8				
	20	3.4	3.2	2.8	1.3				
September	4	3.4	2.7	2.8	1.1				
	18	2.6	2.1	2.0	0.64				
October	3	5.3	3.2	3.0	2.4				
	9	1.2	1.4	1.5	1.3	1.6	1.5	1.0	1.5
	18	1.3	2.0	1.3	1.6				
	30	2.0	1.9	1.6	1.5	2.4	1.7	0.74	2.6
November	5	1.8	1.6	1.4	1.5	1.8	1.4	0.7	1.6
	9	1.6	1.4	1.7	2.0	1.5	1.4	1.4	1.7
	15	2.4	2.6	2.8	2.8				
December	3	1.5	1.8	1.9	1.7				
	19	1.8	2.1	2.0	2.0				

Turbidity in NTU.

TABLE A-11.2
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS							
1984		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
August	6	2.9	2.9	2.8	2.7				
	20	2.2	2.1	1.9	2.4				
September	4	1.8	1.5	2.4	1.6				
	18	1.8	1.6	2.4	2.2				
October	3	2.9	3.2	2.4	3.0				
	9	1.4	1.4	1.6	1.6	2.1	1.4	1.2	1.2
	18	1.5	1.5	1.4	1.2				
	30	1.4	1.6	1.7	1.2	2.1	2.4	2.4	4.8
November	6	1.5	1.4	1.4	1.7	0.7	2.2	1.6	2.8
	9	1.4	1.4	1.4	1.2	1.7	1.1	1.5	1.1
	15	2.8	3.6	3.0	3.2				
December	3	1.8	2.2	1.6	2.2				
	19	1.6	2.1	1.5	1.6				

Turbidity in NTU.

TABLE A-11.3
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS				
1984		C-1	C-2	C-3	C-4	C-5
August	6	2.6	2.5	2.3	2.2	
	20	2.0	1.8	1.2	1.5	
September	4	1.3	1.4	1.3	0.94	
	18	1.7	1.6	1.7	1.6	
October	3	2.8	3.1	5.1	3.9	
	9	1.2	1.3	1.5	1.4	2.4
	18	1.7	1.6	1.8	1.7	
	30	1.4	1.2	2.2	1.5	1.8
November	6	1.5	1.4	1.4	1.5	1.9
	9	1.4	0.94	2.0	0.86	1.1
	15	3.0	3.4	3.7	4.0	
December	3	1.7	2.0	1.8	1.7	
	19	1.8	1.5	1.8	1.8	

Turbidity in NTU.

TABLE A-11.4
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION
1984		D-1
August	6	2.0
	20	1.2
September	4	1.0
	18	1.2
October	3	3.2
	9	1.6
	18	1.9
	30	1.5
November	6	1.6
	9	1.2
	15	3.0
December	3	2.0
	19	1.8

Turbidity in NTU.

TABLE A-11.5
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS							
1985		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
February	28	6.1	5.6	3.7	5.8				
March	13	-	7.0	5.1	3.0				
	15	4.0	3.4	3.3	3.0	3.0	1.0	1.1	3.2
	18	3.5	3.3	3.4	3.4	4.6	3.0	2.8	2.9
	20	-	2.2	2.2	2.0	3.2	2.0	1.3	3.8
	27	2.2	2.2	2.0	1.4				
April	17	4.0	3.2	2.6	2.2				
May	7	3.0	2.6	3.0	2.2				
	9	2.8	2.6	2.2	1.6	-	-	1.3	1.9
	13	3.2	2.6	2.2	1.8	3.4	3.5	1.6	2.5
	15	3.8	2.6	2.4	2.2	2.9	2.4	0.6	2.6
	20	2.7	2.5	2.6	2.8	2.5	1.4	3.4	
	29	2.4	2.4	2.1	2.2				
July	23	4.5	3.4	3.4	2.9				
	26	5.2	4.1	3.8	5.8				
	30	6.1	4.1	3.6	4.2				
August	1	95	80	20	20				

Turbidity in NTU.

TABLE A-11.6
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS							
1985		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
February	28	4.5	4.0	4.2	4.6				
March	13	3.6	3.2	3.7	3.0				
	15	2.6	3.2	2.6	2.5	2.0	3.8	2.6	3.1
	18	2.8	3.0	3.4	3.2	3.0	2.8	2.7	3.7
	20	2.2	2.0	1.9	1.9	1.2	2.6	1.9	1.7
	27	1.8	1.4	1.8	1.8				
April	17	3.0	3.0	2.6	3.0				
May	7	2.6	2.2	2.0	2.2				
	9	1.8	1.8	1.8	1.8	2.0	2.0	1.8	1.8
	13	1.9	1.8	2.0	2.0	1.4	3.7	2.3	1.7
	15	1.5	2.0	2.6	2.4	2.1	2.2	2.4	2.2
	20	2.5	2.5	2.2	2.0	2.2	2.3	2.3	1.6
	29	2.2	2.4	2.8	3.2				
July	23	3.0	3.4	2.1	2.8				
	26	2.9	2.5	3.2	2.1				
	30	3.4	2.7	2.8	2.2				
August	1	3.8	4.4	4.3	4.6				

Turbidity in NTU.

TABLE A-11.7
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS				
1985		C-1	C-2	C-3	C-4	C-5
February	28	2.9	4.2	3.1	7.3	
March	13	2.8	2.2	3.1	2.6	
	15	2.4	3.0	2.6	2.5	2.4
	18	3.0	2.1	3.0	2.6	2.4
	20	1.8	1.8	1.8	2.1	2.2
	27	1.4	1.6	1.3	1.4	
April	17	2.7	3.0	3.2	3.6	
May	7	2.4	2.0	2.4	2.4	
	9	2.0	1.6	1.8	1.8	1.6
	13	1.5	1.4	1.4	1.4	1.0
	15	2.4	1.8	1.9	1.8	1.4
	20	1.9	1.4	1.8	1.4	
	29	2.6	3.3	2.1	2.6	
July	23	1.8	1.6	1.6	1.3	
	26	2.0	1.4	1.9	1.4	
	30	1.4	1.8	1.9	1.6	
August	01	4.4	3.9	4.0	3.9	

Turbidity in NTU.

TABLE A-11.8
WESTPPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBER
1985		D-1
February	28	4.4
March	13	2.2
	15	2.9
	18	2.0
	20	2.2
	27	1.8
April	17	3.6
May	7	2.1
	9	1.6
	13	1.4
	15	1.4
	20	1.1
	29	2.2
July	23	2.2
	26	1.4
	30	1.4
August	1	2.7

Turbidity in NTU.

TABLE A-11.9
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS		
1985		The Head of Westport	Forge Pond Outlet	Bread & Cheese Brook
March	13			
	15			
	18			
	20			
	27			
April	17			
May	7	1.8	2.0	1.6
	9	1.4	1.6	0.9
	13	1.4	1.7	1.4
	15	1.2	1.2	1.0
	20	1.4	1.6	1.0
	29	1.8	1.7	1.3
July	23	1.6	1.3	2.2
	26	2.4	2.7	1.3
	30	2.0	2.2	1.1
August	1	2.7	2.8	3.2

Turbidity in NTU.

TABLE A-11.10
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS							
1985		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
August	6	3.8	3.8	3.2	2.6				
	13	-	-	-	-				
	14	-	-	-	3.0				
	15	3.8	3.2	2.9	-				
September	10	2.4	2.1	1.8	1.9				
October	8	1.8	1.6	1.6	2.6				
	22	1.8	1.7	1.6	1.5				
	29	1.9	2.2	2.0	2.2				
November	5	1.4	1.6	1.2	1.3				
	7	2.2	1.9	1.9	2.2				
	12	2.0	3.0	3.0	2.8				

Turbidity in NTU.

TABLE A-11.11
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS							
1985		B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8
August	6	3.0	2.5	3.0	2.7				
	13	-	-	3.9	-				
	14	-	-	-	-				
	15	-	-	-	-				
September	10	1.2	1.4	1.4	1.2				
October	8	1.8	1.7	1.7	1.6				
	22	1.6	1.5	1.6	1.6				
	29	2.3	2.2	2.1	5.5				
November	5	1.1	1.2	1.2	1.2				
	7	1.9	2.0	1.9	1.8				
	12	2.4	2.2	2.1	1.8				

Turbidity in NTU.

TABLE A-11.12
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS				
1985		C-1	C-2	C-3	C-4	C-5
August	6	2.5	2.6	2.0	1.8	
	13	-	-	2.0	-	
	14	-	-	-	-	
	15	-	-	-	-	
September	10	1.2	1.2	1.7	1.6	
October	8	2.0	2.0	1.4	1.8	
	22	1.7	1.6	1.5	1.6	
	29	1.8	1.8	1.9	2.0	
November	5	1.6	2.0	1.9	2.8	
	7	1.8	1.8	1.7	4.0	
	12	3.2	2.3	3.6	1.8	

Turbidity in NTU.

TABLE A-11.13
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS
1985		D-1
August	6	1.7
	13	-
	14	-
	15	-
September	10	1.2
October	8	1.4
	22	1.1
	29	2.4
November	5	1.4
	7	1.9
	12	1.7

Turbidity in NTU.

TABLE A-11.14
WESTPORT RIVER SURVEY
TURBIDITY RESULTS

DATE		STATION NUMBERS		
1985		The Head of Westport	Forge Pond Outlet	Bread & Cheese Brook
August	6	2.1	2.3	1.1
	13	-	-	-
	14	-	-	-
	15	-	-	-
September	10	1.1	1.7	1.5
October	8	1.6	2.0	0.89
	22	1.5	2.0	0.88
	29	1.8	2.5	1.1
November	5	5.0	2.4	2.0
	7	-	-	-
	12	1.8	1.6	1.0

Turbidity in NTU.

TABLE B-1.1
WESTPORT RIVER SURVEY
MPN TOTAL AND FECAL COLIFORM RESULTS

Oysters

DATE	STATION NUMBERS					
	Zone A1		Zone A2		Zone A3	
1985	TC	FC	TC	FC	TC	FC
August 15	330	230	220	37	45	<10
October 30					330	130

Shellfish Samples: Total and Fecal Coliform in cfu (colony forming units)/100 gm MPN.

TABLE B-1.3
WESTPORT RIVER SURVEY
MPN TOTAL AND FECAL COLIFORM RESULTS

Soft Shell Clams

DATE	STATION NUMBERS			
	Zone A		Zone B	
1984	TC	FC	TC	FC
August 14	9200	2800	9200	1300
October 8	700	78	2400	1300
22	490	230	230	130
30	330	20	1300	78

Shellfish Samples: Total and Fecal Coliform in cfu (colony forming units)/100 gm MPN.

TABLE B-1.2
WESTPORT RIVER SURVEY
MPN TOTAL AND FECAL COLIFORM RESULTS

Quahogs

DATE	STATION NUMBERS			
	Zone B		Zone C	
1984	TC	FC	TC	FC
August 13	1400	74	2400	140
October 8	110	<10	220	93
22	1400	78	1300	<10
30	330	45	170	130

Shellfish Samples: Total and Fecal Coliform in cfu (colony forming units)/100 gm MPN.

TABLE B-2.1
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
OYSTER MEAT VS OVERLYING WATER QUALITY

Oysters

DATE	STATION NUMBERS					
	Zone A1		Zone A2		Zone A3	
	Water	Shellfish	Water	Shellfish	Water	Shellfish
August 15	240	230	31	37	22	<10
October 30					<1	130

Water Samples: Fecal Coliform in cfu (colony forming units) /100 ml MPN.
Shellfish Samples: Fecal Coliform in cfu (colony forming units) /100 gm MPN.

TABLE B-2.2
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
QUAHOG MEAT VS OVERLYING WATER

Quahogs

DATE	STATION NUMBERS			
1985	Zone B		Zone C	
	Water	Shellfish	Water	Shellfish
August 13	<10	74	40	140
October 8	2	<10	2	93
22	8	78	13	<10
30	2	45	2	130

Water Samples: Fecal Coliform in cfu (colony forming units) /100 ml MPN.

Shellfish Samples: Fecal Coliform in cfu (colony forming units) /100 gm MPN.

TABLE B-3.3
WESTPORT RIVER SURVEY
FECAL COLIFORM RESULTS
SOFT SHELL CLAM MEAT VS OVERLYING WATER

Soft Shell Clams

DATE	STATION NUMBERS			
	Zone A		Zone B	
	Water	Shellfish	Water	Shellfish
August 14	2	2800	2	1300
October 8	130	78	2	1300
22	49	230	8	130
30	<1	20	2	78

Water Samples: Fecal Coliform in cfu (colony forming units)
/100 ml MPN.
Shellfish Samples: Fecal Coliform in cfu (colony forming units)
/100 gm MPN.

TABLE C-1.1
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
AUGUST 1984

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2			
3	.06	.52	
4			
5			
* 6			
7		.09	
8	.03		
9		TR	
10			
11			
12		TR	
13			
14	.18	.31	
15			
16			
17			
18		TR	
19			
* 20			
21			
22			
23			
24		TR	
25	.38		
26			
27			
28			
29			
30			
31			
Total	0.67	0.92	

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.2
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
SEPTEMBER 1984

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2		.01	
3	.10	.21	
* 4	.52	.49	
5	.07		
6			
7			
8			
9			
10			
11	.12	.12	
12	.17	.12	
13			
14	.02	.78	
15	1.08	.48	
16			
17			
*18			
19			
20			
21			
22			
23			
24			
25			
26	.01	.01	
27			
28	.13	.04	
29			
30			
31			
Total	2.22	2.26	

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.3
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
OCTOBER 1984

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1	.58	.70	.70
2	1.93	.60	.60
* 3			
4			
5			
6			
7			
8			
** 9			
10			
11			
12			
13			
14	.02		
15		.02	
16			
17			
* 18			
19			
20		TR	
21		TR	
22			
23	.79	.87	.90
24	.27	.30	.35
25			
26	.35	.44	.25
27		.01	
28		TR	
29	.76	.98	.18
**30	.01		
31			
Total	4.71	3.92	2.98

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.4
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
NOVEMBER 1984

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2	.07	.03	
3			
4			
5	.34	.69	.30
** 6			
7			
8			
** 9		TR	
10		.01	
11	.01	.62	.45
12	.51	.09	.05
13		TR	
14	.01	.05	
* 15		.04	
16	.14	.17	.20
17			
18			
19	.02		
20			
21			
22			
23			
24			
25			
26			
27			
28			
29	.25	.58	.30
30			
31			
Total	1.35	2.28	1.30

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.5
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
DECEMBER 1984

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2			
* 3	.40	.59	.36
4			
5			
6	1.17	1.14	.09
7			
8			
9			
10	.29	.63	.31
11			
12			
13			
14			
15	.04	.06	
16			
17			
18			
* 19	.41	.51	.55
20	.05		
21	.04	.48	.45
22	1.04	.72	.55
23			
24	.03	.12	.70
25	.21	.10	.10
26			
27		.02	
28	.02	.07	
29			
30		TR	
31		.07	.07
Total	3.70	4.51	3.36

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.6
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
JANUARY 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1	.12	.10	.05
2	.25	.18	.14
3			
4		.02	.05
5	.32	.22	.19
6			
7			
8		.52	.32
9			
10			
11			
12			
13			
14			
15		TR	
16			
17	.22	.11	.75
18			
19	.22	.20	
20	.05	.20	
21			
22			
23			
24			
25	.01	TR	
26			
27			
28			
29			
30			
31		.03	
Total	1.19	1.40	0.83

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.7
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
FEBRUARY 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1	.15	.11	
2	.09	.14	
3	.09	.08	
4			
5		.13	.10
6	.46	.63	.25
7	.09	.05	.02
8			
9			
10			
11			
12	.14	.68	.65
13	.54	.78	.09
14			
15			
16			
17			
18			
19			
20			
21			
22			
23		.04	
24			
25			
26			
27	.04	.01	
* 28			
29			
30			
31			
Total	1.60	2.65	1.11

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.8
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
MARCH 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2	.29	.34	.35
3			
4	.06	.23	.40
5	.73	.61	.20
6			
7			.02
8	.31	.21	.23
9			
10			
11			1.65
12	2.05	1.94	
* 13			
14			
**15		TR	
16			
17			
**18	.07	.11	.05
19			
**20			
21			
22			
23			
24			
25			
26			
* 27			
28			
29			
30	.03	.03	
31	.01	.08	.07
Total	3.55	3.55	2.97

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.9
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
APRIL 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1	.67	.73	.55
2	.06	TR	
3		.05	
4			
5		.03	
6			
7			.10
8	.27	.31	.15
9			
10			
11			
12			
13			
14		.09	
15		.12	
16			
* 17			
18			
19		TR	
20			
21			
22	.14	.22	.46
23			
24			
25			
26		.01	
27	.07	.10	
28	.02	.09	
29			
30			
31			
Total	1.19	1.75	1.26

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.10
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
MAY 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2	.37	.78	.75
3	1.88	1.37	1.28
4			
5			
6	.35	.41	.30
* 7	.01		
8		TR	
** 9			
10			
11			
12	.35	.04	.12
**13	.68	.67	.24
14			
**15			
16			
17	.23	.13	.38
18	.03	.81	.05
19	.04	.03	
**20			.02
21	.32	.32	.60
22	.63	.45	.32
23			
24			
25			
26			
27			
28	.33	.49	.60
* 29	.52	.23	.08
30			
31			
Total	5.74	5.73	4.84

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.11
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
JUNE 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1	.54	1.11	1.43
2			
3			
4			
5	.81	.79	1.26
6	.07	.02	
7	.03		
8		.01	
9			
10			
11			.02
12	.07	.06	.02
13	.03	TR	
14	.15		
15			
16	.66	.81	1.15
17	.32	.31	.12
18	.12	.14	.08
19			
20	TR		
21			
22			
23	.06	.11	.05
24	.07	.17	.44
25		.17	.04
26	.20	.06	.15
27	.25	.43	.33
28	.44	.07	.17
29	.32	.42	.35
30			
31			
Total	4.14	4.68	5.61

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.12
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
JULY 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2			
3			
4			
5		TR	
6		TR	
7	TR	TR	
8			
9			
10		.59	.45
11	.43	.07	.03
12			
13			.02
14			
15			
16	.29	1.03	.62
17			
18			
19			
20			
21			
22	.59	.90	1.00
* 23			
24			
25			
* 26	1.02	1.04	.75
27	.11	.08	.05
28			
29			
* 30			
31	.04	.05	.05
Total	2.48	3.76	3.42

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.13
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
AUGUST 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
* 1	.43	.14	.47
2			
3			
4			
5			
* 6			
7			
8	1.04	1.74	1.75
9			
10			
11		.01	
12			
13			
14			
15			
16			
17			
18			
19	TR	.07	
20	TR		
21		.01	
22	.03	TR	
23			
24			
25	1.71	1.87	1.50
26	4.43	4.50	5.30
27			
28			
29			
30	3.72	5.70	3.00
31	1.55	.08	.05
Total	12.91	14.72	12.07

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.14
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
SEPTEMBER 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2	TR	.03	
3			
4		TR	
5	.02		.23
6	.56	.25	.19
7	.14	.05	
8			
9	.52	.67	.07
* 10	.21	.06	.04
11	.04	.18	.05
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24	.18	.21	.24
25	TR		
26			
27	.10	.05	.18
28			
29			
30			
31			
Total	1.77	1.50	1.00

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.15
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
OCTOBER 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2			
3	.32	.24	.25
4	.08	.07	.10
5	.34	.07	.08
6			
7			
* 8			
9			
10			
11			
12			
13	.28	.28	.19
14			
15	.33	.25	.44
16		.08	
17	TR		
18			
19	.15	.19	.34
20			
21			
* 22			
23			.04
24		.01	.01
25	.15	.21	.13
26			
27			
28			
* 29			
30			
31			
Total	1.65	1.40	1.58

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.16
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
NOVEMBER 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2			
3			
4			
* 5			2.03
6			.42
* 7			
8			
9			
10			
11			.70
* 12			
13			.03
14			.20
15			
16			.45
17			.57
18			
19			
20			
21			
22			.66
23			
24			
25			
26			.37
27			.05
28			.55
29			
30			
31			
Total			6.03

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.

TABLE C-1.17
WESTPORT RIVER SURVEY
DAILY RAINFALL SUMMARY (IN INCHES)
DECEMBER 1985

DATE	NEWPORT, RI	NEW BEDFORD, MA	WESTPORT, MA
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			.17
12			.11
13			.38
14			.01
15			
16			
17			
18			.03
19			
20			
21			.03
22			
23			.02
24			
25			
26			
27			
28			
29			
30			
31			.10
Total			.85

* Regular Sampling Event.
** Episodic Sampling Event.
TR = Trace.