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SANITARY SURVEY REPORT FOR THE ATLANTIC COAST, GULF OF MAINE, NEW HAMPSHIRE

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TABLE OF CONTENTS

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List of Figures

List of Tables

I. Executive Summary

This report describes the results of a sanitary survey for the Atlantic Coast, Gulf of Maine, New Hampshire, conducted in accordance with National Shellfish Sanitation Program (NSSP) guidelines. Following the 1998 closure of all Atlantic Coast waters for shellfish harvesting due a lack of a sanitary survey, the NHDHHS and other state agencies initiated a sanitary survey of the area. Ambient water quality monitoring and a shoreline survey of pollution sources began in early 1999. Ambient monitoring, pollution source impact evaluations, and other activities were conducted in 2000 by the New Hampshire Department of Environmental Services after NHDES was granted the authority to classify shellfish growing waters by the New Hampshire Legislature in 1999. The results of the sanitary survey indicate that the sanitary quality of most of the Atlantic Coast is suitable for shellfish harvesting. The only exceptions to this would be closed Safety Zones around the Seabrook municipal wastewater treatment plant outfall off Seabrook Beach, the Wallis Sands wastewater treatment plant outfall (operated by the NH Department of Resources and Economic Development), and the Star Island wastewater treatment plant outfall (operated by the Star Island Corporation). Additionally, the discharges of Parsons Creek in Rye, Chapel Brook in North Hampton, an unnamed creek just north of Chapel Brook at Bass Beach in Rye, and Little River in North Hampton showed high fecal coliform loadings which require Prohibited Zones around each discharge. Finally, unacceptably high fecal coliform levels associated with a year-round seagull gathering area near the discharge of Eel Pond in Rye, New Hampshire, also require the establishment of a Prohibited Zone. Other factors which will require temporary closure of some or all of the Atlantic Coast include rainfall events of more than three inches, significant discharges of raw or partially treated sewage from the Seabrook, Hampton, Portsmouth, or Wallis Sands wastewater treatment facilities, and the presence of PSP toxin at unacceptably high levels.

II. Introduction

The NHDES, under the authority granted by RSA 143:21 and 143:21-a, is responsible for classifying shellfish growing waters in the State of New Hampshire. The purpose of conducting shellfish water classifications is to determine if growing waters are safe for human consumption of molluscan shellfish. The primary concern with the safety of shellfish growing waters is contamination from human sewage, which can contain a variety of disease-causing, or pathogenic, microorganisms. Shellfish pump large quantities of water through their bodies during the normal feeding process. During this process the shellfish also concentrate microorganisms which may include pathogenic microorganisms, and a positive relationship between sewage pollution of shellfish growing areas and disease has been demonstrated many times (NSSP, 1997).

Though testing shellfish growing waters and/or shellfish meats for the pathogenic microorganisms themselves would seem to be the most direct method of determining whether or not growing waters are safe, several factors preclude this approach. Perhaps the most important is that the number of pathogens that may be in sewage is large, and laboratory methods that are practical, reliable, and cost effective are not available for all of the pathogens that may be present. Therefore, shellfish water classifications are based on evidence of human sewage contamination, which may include direct evidence (identification of actual pollution sources) or indirect evidence (elevated or highly variable indicator bacteria levels in the growing waters). If such evidence is found, then pathogens may be present, and the area is closed to harvesting. Areas may also be closed if contamination from animal waste or poisonous/toxic substances is found.

Under the authority granted by RSA 143:21 and 143:21-a, NHDES uses a set of guidelines and standards known as the National Shellfish Sanitation Program (NSSP) for classifying shellfish growing waters. These guidelines were collaboratively developed by state agencies, the commercial shellfish industry, and the federal government in order to provide uniform regulatory standards for the commercial shellfish industry. The NSSP is used by NHDES to classify all growing waters, whether used for commercial or recreational harvesting, because these standards provide a reliable methodology to protect public health. Furthermore, RSA 485-A:8 (V) states that "Those tidal waters used for growing or taking of shellfish for human consumption shall, in addition to the foregoing requirements, be in accordance with the criteria recommended under the National Shellfish Program Manual of Operation, United States Department of Food and Drug Administration."

The key to the accurate classification of shellfish growing areas is the sanitary survey. The principal components of a sanitary survey include: (1) an evaluation of the pollution sources that may affect the areas, (2) an evaluation of the meteorological and hydrographic factors that may affect distribution of pollutants throughout the area, and (3) an assessment of water quality. The development of each of these components for the Atlantic Coast Sanitary Survey is described in this report.

III. Description of Growing Area

The Atlantic Coast growing waters extend from Frost Point in Rye, New Hampshire to the Seabrook, New Hampshire/Massachusetts border, and include 42,224 acres of water within the three-mile limit under state jurisdiction (Figure 1). The 20 miles of shoreline include land in the municipalities of Rye, North Hampton, Hampton, and Seabrook.

Land use in the municipalities in the study area is summarized in Table 1.

Table 1: Land Use Data for Study Area Municipalities
(after Rubin and Merriam, 1998)

Town	Total Acres	Developed (%)	Undevelopable (%)	Developable (%)
Rye	8,353	30	31	39
North Hampton	8,914	27	18	55
Hampton	8,901	37	32	31
Seabrook	5,923	38	33	29

The land area along the immediate shoreline (east of Route 1A) is largely developed (64 percent), predominantly with residential use. Approximately 31 percent of the shoreline is undeveloped, with a majority of this land permanently protected from development. Five percent of the shoreline is considered developable (after Rubin and Merriam, 1998). Commercial fishing operations are concentrated at the fishing cooperatives in Portsmouth and Seabrook, as well as in Rye Harbor. Charter fishing boats operate primarily from Hampton, Seabrook, and Rye. Tourism-related businesses are also concentrated in Hampton, Seabrook, Rye, and Portsmouth. The towns of Hampton and Seabrook (and a small portion of Rye) have municipal sewer systems, and most of the shoreline properties in these towns are served by municipal sewer. Onsite (septic) systems are the most common means of sewage disposal for shoreline properties in Rye and North Hampton. Population data for the municipalities in the study area are summarized in Table 2.

Table 2. Population Data for Study Area Municipalities
(developed from NH Office of State Planning population estimates)

Town	1999 Est. Population	1990-99 Percent Change	1999 Pop. Density (/acre)
Rye	4,786	3.8	0.57
North Hampton	4,086	12.3	0.46
Hampton	13,496	9.9	1.52
Seabrook	7,135	9.7	1.21

New Hampshire's Atlantic Coast hosts a variety of shellfish resources, including surf clams (*Spisula solidissima*), blue mussels (*Mytilus edulis*), and ocean quahogs (*Arctica islandica*). Sea scallops (*Placopenten magellanicus*) may also be found in the deeper waters off the coast. Shellfish habitat substrates found in Atlantic Coastal waters range from sand, cobble, hard, and mixed. Atlantic Coast shellfish resources and habitats have not been formally surveyed, so little detailed information on their occurrence, spatial extent, or density is available. However, NH Fish and Game/Marine Fisheries Division provided information to generally characterize the occurrence of these resources (Figure 2).

A sanitary survey for the Atlantic Coast, developed in accordance with National Shellfish Sanitation Program guidelines, has never been conducted to date. Limited water sampling and pollution source identification efforts in the area, primarily conducted in the 1980s by a number of state agencies, gave a sense that Atlantic Coast water quality was generally good. Although some recreational harvesting for human consumption had been allowed, the entire Atlantic Coast was closed to all harvesting for human consumption in 1998 by the NHDHHS, the state agency with authority to classify shellfish growing waters at that time (Figure 3). The closure was instituted in recognition of the fact that no formal sanitary surveys had ever been done, and that formal water sampling and shoreline survey programs would need to be conducted not only to ensure that shellfish harvesting was indeed safe, but also to comply with NSSP guidelines. Since 1998, the NH Fish and Game Department has enforced the closure in accordance with its statutory responsibilities, and the NHDES, upon receiving statutory authority to classify shellfish growing waters in 1999, has maintained it. Immediately following the closure in 1998, the NHDHHS began conducting a sanitary survey of the area. After the authority to classify shellfish waters was transferred to NHDES in 1999, NHDES assumed responsibility for completing the sanitary survey.

Figure 1: Atlantic Coast Growing Waters

Figure 2: Atlantic Coast Shellfish Resources

Figure 3: Previous Classification Map (1998-2000)

IV. Pollution Source Survey

A. Study Area and Methodology

Under the direction of the NHDHHS, the NH Coastal Program performed a shoreline survey for pollution sources in 1999. Trained volunteers from the Great Bay Coast Watch assisted with the survey work. The surveys, generally conducted on the east (ocean) side of Route 1A/Ocean Boulevard, were conducted in the late spring and summer of 1999. The survey began at the Seacoast Science Center in Rye, and moved south through North Hampton, Hampton and Seabrook, to the Massachusetts border. Rye Harbor was not included as part of this field investigation. After the initial inspections, additional field visits were conducted on sites west of Route 1A to follow up on leads from citizens and agency personnel.

Town tax maps were secured from each town for use as field maps to identify individual parcels. Water quality samples collected in the field were labeled using tax map and lot number convention for identification.

Potential bacterial pollution sources were identified and sampled, and the sampling locations were mapped using a Global Positioning System (GPS). The sampling locations included suspected failing septic systems, road drainage pipes, miscellaneous pipes, seeps, culverts, wetland and pond discharges, and steady streams. Volunteers completed field sampling forms and sketches of sample locations, and delivered the water samples to UNH Jackson Estuarine Laboratory (JEL) in Durham for fecal coliform and *E. coli* analyses. Samples were collected in Whirlpak bags, labeled, and kept on ice packs in coolers until delivery to the JEL lab.

B. Summary of Sources and Location

The initial field survey involved the on-site inspection of all properties immediately on the coast. Nearly 450 properties were included in the initial survey and additional field visits (west side of Route 1A). Appendix 1 lists the approximately 40 properties on which field staff identified possible sources of pollution.

In the spring of 2000, NHDES Shellfish Program staff met with the NHCP staff who led the 1999 shoreline surveys to discuss their findings and plan follow-up action. Follow up sampling was conducted in the summer of 2000. Table 3 lists those potential sources for which follow-up investigation was deemed appropriate based on initial sampling results, field observations, or other information. Follow up sampling results are also included in Table 3. Permitted point sources are not included in Table 3, but are discussed in Section C. of this chapter.

Table 3: Potential and Actual Pollution Sources

Property ID	Source ID	Source Type	Source Impact	Potential Pollution Source	Samp1 FC/100ml	Samp2 FC/100ml	Samp3 FC/100ml
AC/RYE/19.4/56	PS1	Potential	indirect	Tidal creek/possible malfunc. Septic system	314	15980	
AC/RYE/17.3/28	PS2	potential	indirect	tidal creek	380	7	200
AC/RYE/17.3/29	PS3	potential	indirect	tidal creek	>1000	110	320
AC/RYE/17.3/5	PS4	Potential	indirect	active straight pipe	18500	>8000	
AC/RYE/17.4/PARSONS	PS5	actual	direct	Stream (Parsons Creek)	44	170	300
AC/RYE/5.0/EELPOND/A	PS6	potential	direct	Culvert/pond discharge	18	<20	<20
AC/RYE/5.0/EELPOND/B	PS7	actual	direct	Wildlife (gulls)	60	900	
AC/RYE/2/69	PS8	potential	direct	Active pipe/wetland discharge	353	~27360	29
AC/RYE/2/73	PS9	potential	direct	Active pipe/wetland discharge	197	440	
AC/RYE/2/84	PS10	actual	direct	Stream	209	420	
AC/NHM/5/9	PS11	Actual	direct	Stream (Chapel Brook)	218	180	350
AC/NHM/1/LITTLERIVER	PS12	actual	direct	Stream (Little River)	16.7	440	1060
AC/HMP/267/51	PS13	potential	direct	seep/tidepool	2	140	
AC/RYE/17.4/37	---	potential	indirect	tidal creek	57	n/a	
AC/HMP/134/	---	potential	direct	active pipe (likely stormwater)	0	40	
AC/RYE/8.4/123	---	potential	direct	Inactive straight pipe	n/a	n/a	
AC/RYE/5/6	---	potential	direct	Inactive straight pipe	n/a	n/a	
AC/RYE/2/67	---	potential	direct	Active pipe (stormwater)	119	640	
AC/RYE/17.4/44	---	potential	indirect	Inactive straight pipe	n/a	n/a	

C. Identification of Pollution Sources

The following summarizes information on specific sources of pollution. These are categorized as permitted point sources, other domestic waste, stormwater, stream/creek/wetland discharges, agricultural sources, wildlife areas, industrial waste, and marinas. All of these potential and actual sources of pollution are shown in Figure 4.

Permitted Point Sources

The Seabrook Municipal Wastewater Treatment Plant (NPDES No. 0101303) is a relatively new wastewater treatment plant, providing secondary treatment to wastewater from almost all residences and businesses in the Town of Seabrook. The treatment plant, designed for a flow of 1.8 MGD, utilizes dual oxidation units, secondary clarifiers, chlorine for effluent disinfection, scum collection, and sludge disposal. The outfall is located approximately 2,000 ft offshore of Seabrook Beach, and approximately 1,000 ft north of the New Hampshire/Massachusetts state line. The diffuser is nearly 85 ft long with 20, 2-inch diameter discharge ports. CORMIX modeling of the diffuser indicates a near-field (within 1.2 meters of the diffuser), low tide dilution factor of 72 under worst-case dilution conditions (Earth Tech, 1999). Industrial pre-treatment for the Seabrook WWTF is not required at present; however, the plant is required to notify NHDES and

EPA if/when process wastewater from a "primary industrial category" is planned. Quarterly Whole Effluent Toxicity (WET) testing for LC50, hardness, and ammonia nitrogen is required in the permit. The current five-year permit was issued in September 1999. Table 4 presents flow and coliform data from monthly Discharge Monitoring Reports (DMRs) from January 1999 to June 2000. Note that the bacterial data for November 1999 through June 2000 are fecal coliform, not total coliform.

Figure 4: actual and potential pollution sources

Table 4: Seabrook Treatment Facility Flow and Bacterial Monitoring Data

Month	1999 Flow (MGD)		1999 TC (/100ml)*		2000 Flow (MGD)		2000 FC (/100ml)*	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Jan	0.956	---	---	>400	0.804	1.043	2	282
Feb	0.859	---	---	350	0.816	1.14	<1	2
Mar	0.886	---	---	122	0.853	1.02	1	2
Apr	0.98	---	---	214	0.905	1.203	1	5
May	0.92	---	---	12000	0.888	1.486	1	8
Jun					0.925	1.089	2	15
Jul	1.12	---	---	24200				
Aug	1.06	---	---	26400				
Sep	0.939	---	---	16000				
Oct	0.849	---	---	5440				
Nov	0.818	1.121	4	69				
Dec	0.746	1.018	<1	1				
*bacterial data from 11/99 to present are fecal coliform								

In December 1997, NHDES issued an Administrative Order to the Town of Seabrook due to the Town's failure to comply with the Total Residual Chlorine and Total Coliform Bacteria limits in its November 1992 permit. The Town continues to work towards a solution to the problem, which includes a pilot program to demonstrate the effectiveness of proposed chlorination/dechlorination improvements. When Seabrook's new NPDES permit was issued in September 1999, the bacterial limits were changed from limits on total coliform (70/100ml) to limits on fecal coliform (14/100ml), although total coliform testing (weekly, instead of daily) continues.

The Wallis Sands Wastewater Treatment Plant (NPDES Permit No. NH0020966) operates seasonally (May through September). The system provides secondary treatment to sanitary waste from the bathing houses/restrooms of Wallis Sands State Park in Rye, New Hampshire. The system, designed for a flow of 0.006 MGD, includes the use of a sand filter and ultraviolet disinfection to treat the effluent, which is discharged directly to the Atlantic Ocean on the north side of Wallis Sands Beach (approximately 180 ft seaward of the high tide line). Its current five-year discharge permit was issued in February 1996. Table 5 presents flow and total coliform data from monthly Discharge Monitoring Reports (DMRs) from January 1999 through June 2000.

Table 5: Wallis Sands Treatment Facility Flow and Bacterial Monitoring Data

Month	1999 Flow (MGD)		1999 TC (/100ml)		2000 Flow (MGD)		2000 TC (/100ml)	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Jan	---	---	---	---	---	---	---	---
Feb	---	---	---	---	---	---	---	---
Mar	---	---	---	---	---	---	---	---

Apr	---	---	---	---	---	---	---	---
May	0.0017	0.0021	<2	<2	0.0021	0.0027	<2	<2
Jun	0.0017	0.0021	42.4	900	0.0015	0.0018	3.98	8
Jul	0.0013	0.0016	<2	<2				
Aug	0.0008	0.0012	2	4				
Sep	0.0023	0.0032	2	2				
Oct	---	---	---	---	---	---	---	---
Nov	---	---	---	---	---	---	---	---
Dec	---	---	---	---	---	---	---	---

The Star Island Wastewater Treatment Plant (NPDES Permit No. NH0101028) operates seasonally (June through September). The system provides secondary treatment to sanitary waste from the seasonal facilities on Star Island, Isles of Shoals. The system, designed for a flow of 15,000 GPD, is a sequential batch reactor system which has the capacity to retain up to 40,000 gallons of treated sewage (storage is typically used during system maintenance periods). The system uses chlorine for effluent disinfection. Treated effluent is generally discharged each day in five 1-2 hour periods directly to the Atlantic Ocean. Its current five-year discharge permit was issued on November 18, 1996. DMR reports for this plant are not shown here because at the time this report was being written, some calculations for past DMRs were under revision.

Other Domestic Wastes

Four potential, indirect sources were identified upstream of the Parsons Creek sampling site (AC6). These include:

AC/RYE/17.3/5 (active 6"straight pipe).
AC/RYE/19.4/56 (tidal creek/possible malfunctioning septic system).
AC/RYE/17.3/28 (tidal creek/possible malfunctioning septic system).
AC/RYE/17.3/29 (tidal creek/possible malfunctioning septic system).

The first two sites have exhibited very high FC counts, and are currently under investigation by NHDES Nonpoint Source staff. It is presumed that some/all of these four sources contribute to the high and variable FC levels observed at Site AC6.

Site AC/HMP/267/51 (groundwater seep/possible sewage contamination) was also sampled as possible source of pollution because of sewage odor in the vicinity of a weak groundwater seep on the immediate (rocky) shoreline. However, the initial and follow-up FC levels (2/100ml; 140/100ml) do not indicate sewage contamination.

Stormwater

The shoreline survey revealed relatively few stormwater conveyances that discharge directly to the growing waters. Surface water discharges from streams, ponds, and wetlands appear to be the greatest wet weather concern, as they have shown elevated

FC levels and increased flows following storm events. These sources are discussed in the next section.

Stream, Creek, and Wetland Discharges.

Parsons Creek (AC/RYE/17.4/PARSONS) is a confirmed, actual, direct source of pollution to the growing waters. This tidally-influenced stream is routinely sampled in the ambient monitoring program (Site AC6), and high FC coliform levels have been observed under both wet and dry conditions. Several potential sources of pollution have been identified upstream of the site, and are currently being investigated by NHDES Nonpoint Source staff. Low tide discharge is estimated to be in the range of 10-20 cfs. These high flows and high FC levels degrade water quality in the vicinity of the discharge and warrant an evaluation of the spatial extent of Parson Creek's impact to the growing waters. This evaluation is described in the next section and detailed in Appendix 2.

Chapel Brook (AC/NHM/5/9) is a confirmed, actual, direct source of pollution to the growing waters. This tidally-influenced stream has shown high FC coliform levels (218/100ml, 180/100ml; 350/100ml) under both wet and dry conditions. Low tide discharge is estimated to be in the range of 10-20 cfs. The existing high flows and high FC levels degrade water quality in the vicinity of the discharge and warrant an evaluation of the spatial extent of Chapel Brook's impact to the growing waters. This evaluation is described in the next section and detailed in Appendix 2.

Little River (AC/NHM/1/LITTLERIVER) is a confirmed, actual, direct source of pollution to the growing waters. This tidally-influenced stream has shown high FC coliform levels (440/100ml, 1040/100ml) under both wet and dry conditions. Low tide discharge is estimated to be in the range of 10-20 cfs. A salt marsh restoration project at this site, planned for the fall of 2000, will substantially increase the tidal flushing of the Little River Marsh. It is unclear how this augmented tidal flow will affect FC levels. The existing high flows and high FC levels degrade water quality in the vicinity of the discharge and warrant an evaluation of the spatial extent of Little River's impact to the growing waters. This evaluation is described in the next section and detailed in Appendix 2.

Eel Pond (AC/RYE/5.0/EELPOND/A) is located on the west side of Route 1A. Pond levels are regulated by a small dam, and discharge over the dam travels under Route 1A through a double culvert and discharges directly on the beach. FC levels have been typically low (<20/100ml), although on one occasion a count of ~1600/100ml was observed. That sample, however, was taken when flows were less than five gallons per minute, and downstream sampling in the ocean showed little impact to growing waters. Eel Pond itself does not appear to be a source of concern; however, large flocks of seagulls tend to congregate on the beach between the culvert discharge and the Atlantic Ocean. These gulls are of concern, as described in the "Wildlife" section.

Two wetland discharges (AC/RYE/2/73 and AC/RYE/2/69) have exhibited highly variable FC results. Each has been referred to the NHDES Nonpoint Source section for further investigation.

Site AC/RYE/2/84 is an unnamed stream discharge which is conveyed under Route 1A in the vicinity of Bass Beach through a 30-inch concrete pipe. This direct source has exhibited relatively high flow and FC levels of 209/100ml and 420/100ml. The flow characteristics and fecal coliform levels are very similar to those of Chapel Brook, and its discharge flows directly to the Atlantic Ocean near the discharge of Chapel Brook.

Agricultural Waste

No significant sources of agricultural waste were identified in the study area.

Wildlife Areas

The Atlantic Coastal waters, as well as the saltmarshes along the shoreline, provide valuable habitat to a variety of wildlife. Several types of birds, including various species of gulls, cormorants, terns, shorebirds, and ducks are commonly observed during ambient monitoring. Gulls and cormorants are most commonly seen, with large flocks often observed in the fall. Although large numbers of birds can, in theory, pose a threat the growing area water quality, such occurrences are very difficult to document. However, one site on the coast has shown excessively high FC associated with birds.

The beach downstream of the Eel Pond discharge (AC/RYE/5.0/EELPOND/B) is a regular gathering area for large flocks of gulls. Nearby residents indicate that the gulls wade in and around the Eel Pond discharge nearly all year. Flocks of over 100 birds are often observed, although well over 500 birds have been counted in the late summer and fall. The large number of birds, and their feces, on the beach prompted sampling of the ocean waters just downstream of the gull area. FC levels in the ocean water of 60/100ml and 900/100ml were detected. These levels cannot be attributed to Eel Pond itself, as concurrent sampling of the Eel Pond discharge above the gull area showed FC levels under 20/100ml. The high FC levels in the ocean water warrant an evaluation of the spatial extent of this site's impact to the growing waters. This evaluation is described in the next section and detailed in Appendix 2.

Industrial wastes

No significant sources of industrial waster were identified in the study area.

Marinas

No marinas or significant mooring fields were identified in the study area.

D. Evaluation of Pollution Sources

Based on FC results, discharge estimates, and available water for dilution near the discharge, some of the identified actual, direct pollution sources were determined to have a significant impact on the water quality of the growing waters. These sources include Chapel Brook, the unnamed Creek near Chapel Brook/Bass Beach, Little River, Parsons Creek, and the gull area downstream of Eel Pond. The spatial extent of the impact of these sources must be determined in order to delineate Prohibited Zones around them. To determine the size of the Prohibited Zone needed to dilute the discharge water to a FC concentration of 14/100ml, a three-step process was employed:

1. Desktop dilution calculations to estimate the size of the zone needed.
2. Transect sampling (designed from #1) to establish Prohibited Zone boundaries.
3. Ongoing ambient monitoring to verify the boundaries established in #2.

Desktop calculations involve assumptions about discharge rate, FC of the discharge, time of discharge, and mixing zone dimensions. These calculations are conservative in three respects: 1) it was assumed that the discharge plume would move away from the source through a rectangular area of uniform width (i.e., no lateral dispersion), and that FC would be uniformly mixed throughout the zone; 2) it was assumed that no bacterial die-off would occur; and 3) no consideration was given to mixing with additional volumes of high tide waters, even though the typical loading time of six hours straddles periods of high and low water. The key result of these calculations was an estimate of the distance needed to dilute the discharge to a FC of 14/100ml. This information was then used to establish the locations of sampling sites on either side of the discharge. These transect sites were sampled under wet and dry conditions to determine actual dilution of FC. Sites with consistently low FC were then considered for the boundary of the Prohibited Area, and would be incorporated into long-term ambient monitoring. The distance (from the source) needed to achieve sufficient dilution was then used as a radius around the source. This was done to account for the fact that current directions along the Atlantic Coast are not unidirectional throughout the year. The calculations and transect sampling results, and preliminary conclusions on the size of the Prohibited Zone needed for each significant source, are presented in Appendix 2.

In addition to the above Prohibited Zones, NSSP guidelines require that Prohibited "safety zones" must be delineated around the Seabrook, Wallis Sands, and Star Island wastewater treatment plants. These zones must be sized to provide minimal dilution to wastewater effluent under normal conditions, and must also be sized to delineate the area that would be affected by a discharge of untreated/partially treated sewage during the time period between the occurrence of the event and the cessation of harvesting by state authorities. The methodology used to delineate these zones is presented in Appendix 2.

Table 6 summarizes the minimum dilution areas for each source (from Appendix 2), and the recommended radius of each Prohibited Zone. The primary reason for expanding the Prohibited Zones beyond the minimum radii determined in Appendix 2 was to enhance enforceability. The New Hampshire Fish and Game/Law Enforcement Division felt that to the maximum extent practicable, Prohibited Zones should be of similar size to facilitate compliance with and enforceability of the closures lines. This not only would provide for a more reasonable management approach, but would also provide for additional dilution around each pollution source. NHDES concurs with New Hampshire Fish and Game's sentiment and has equalized the size of each recommended Prohibited Zone where reasonable and practical.

Table 6: Recommended Size of Prohibited Zones for Significant Pollution Sources

Source	Minimum Radius (ft) of Dilution Area	Recommended Radius (ft) of Prohibited Area	Comments
Parsons Creek	329	750	
Eel Pond	150	750	
Chapel Brook	129	750	
Unnamed Creek (Rye/Bass Beach)	108	750	
Wallis Sands WWTF	339	750	Seasonal discharge, year round Safety Zone
Seabrook WWTF	6468	8440	Safety Zone northern edge extends to jetty at the southern end of Hampton Beach
Star Island WWTF	3939	4000	Seasonal discharge, year round Safety Zone

V. Hydrographic and Meteorological Characteristics

A. Tides

Coastal New Hampshire experiences a mixed, semi-diurnal tide, with diurnal inequalities that are more pronounced on spring tides. National Ocean and Atmospheric Administration data for stations in or near the coastal waters indicate (Table 7) similar tidal range characteristics.

Table 7: Tidal Characteristics of Atlantic Coast Waters

Station	Mean Tidal Range (ft)	Spring Tidal Range (ft)	Mean Tide Level (ft)
Jaffrey Point, New Castle	8.7	10.0	4.7
Hampton Harbor, Hampton	8.3	9.5	4.5
Gosport Harbor, Isles of Shoals	8.5	9.8	4.5

According to Normandeau Associates Incorporated (NAI) (1975), the flow of water in the Gulf of Maine is strongly influenced by the tides, and under most conditions, tidal currents comprise a significant part of total water movement. Other factors that influence the movement of water (e.g., winds) are described in other sections of this report. NAI (1975) specifically describe currents in the waters off of Hampton Beach. The following summarizes current information:

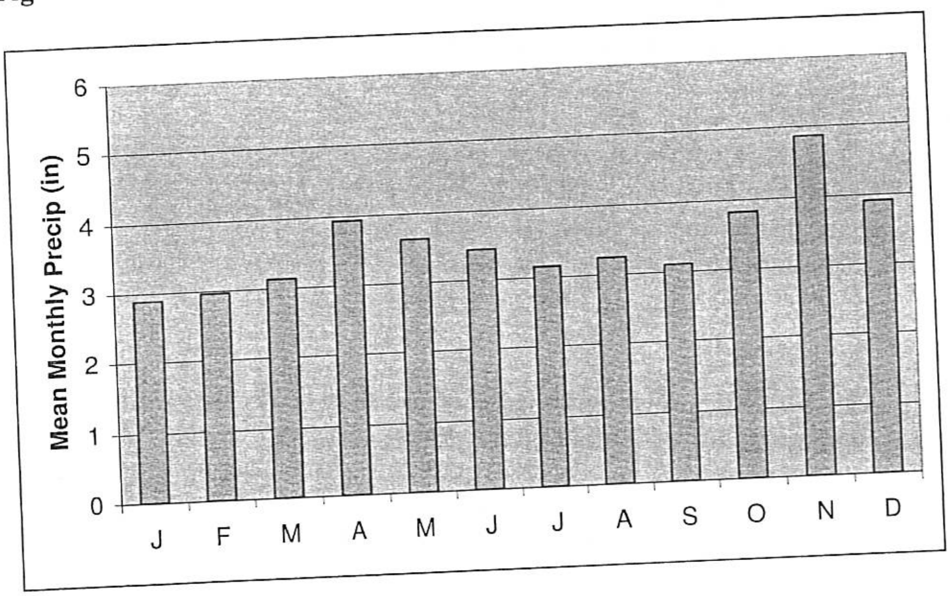
> Ebb Tide: Waters generally flow seaward and southward or southwesterly, parallel to the coast, at 0.2 to 0.3 knots. High winds can mask, and in some cases reverse these currents, causing them to flow in a northerly direction. Currents weaken at low water.

Flood Tide: Waters generally flow landward and northward, parallel to the coast, at speeds of 0.15 to 0.25 knots. Winds that reverse this flow to a south/southwest direction generate currents of 0.1 to 0.15 knots. Currents weaken at low water.

B. Rainfall

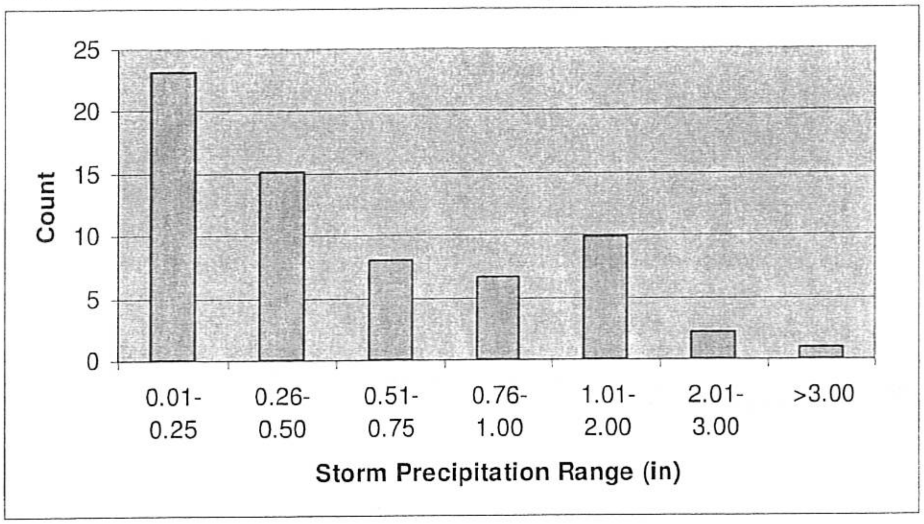
Coastal New Hampshire receives an average of approximately 42 inches of precipitation annually, as measured at the Durham, New Hampshire, National Weather Service site. Precipitation is not evenly distributed throughout the year, with spring and fall having higher monthly averages of precipitation than other months (Figure 5).

Figure 5: Mean Monthly Precipitation, Durham, New Hampshire



An analysis of precipitation events recorded at the Durham, New Hampshire Station over a 10-year period from 1988 to 1997 was used to construct a histogram of the average number of storms of a given size (where size is defined as total precipitation of the storm) in a given year (Figure 6).

Figure 6: Annual Distribution of Precipitation Events by Total Precipitation (based on data from Durham, New Hampshire, 1988-97)



Large storms (i.e., those with totals over three inches) occur on average once per year. A review of the ambient monitoring data suggests that these types of storms can be expected to have large-scale detrimental effects on water quality, and are therefore significant in terms of proper classification of the Atlantic Coast growing waters.

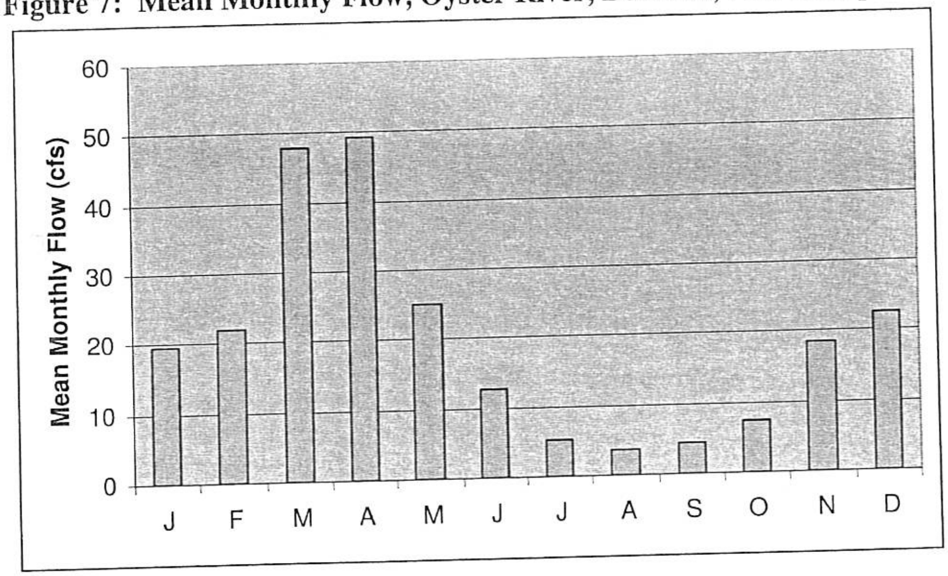
C. Winds

According to NAI (1975), winter winds and storms can play an important role in circulation patterns off Hampton Beach, often masking tidal effects. Winter winds are typically from the west and northwest, and the most common currents are to the north at speeds of 0.16 to 0.30 knots. However, weaker southerly currents also do occur. In the spring, winds and storms continue to play a significant role in driving currents, but tidal effects begin to increase in importance. Predominant winds are from the northwest, but northeast and southeast winds become more important during this season. Winds from these directions, although less frequent, are typically stronger than winds from the northwest. Currents to the north have been recorded as high as 0.28 knots, while flows to the south have been recorded as high as 0.35 knots. In the summer, wind effects on currents lessen, and tidal effects become more apparent. Winds tend to be from either the southwest and northwest or southeast and are weaker than at other times of the year. Predominant currents are to the south and southwest at 0.15 to 0.24 knots; however, with strong tidal effects at this time of year, currents can in fact move in quite variable directions. During the fall, storms intensify and wind effects become more important. Northward currents exhibit average speeds of 0.22 to 0.25 knots, while southerly flows (slightly less common) exhibit average speeds of 0.18 to 0.20 knots.

D. River discharges

Streamflow in southeastern New Hampshire exhibits seasonal variation, with the highest flows occurring in the spring (due to snowmelt, spring rains, and low evapotranspiration) and the mid-to late fall (due to fall rains and low evapotranspiration). To illustrate the seasonality of streamflow in southeastern New Hampshire, mean monthly flow for the Oyster River, Durham, New Hampshire, gaged by the U.S. Geological Survey, is plotted in Figure 7. The reader should note that the Oyster River does not discharge to the study area—its flow data are presented merely to illustrate the seasonality of streamflow from a relatively small stream in the region.

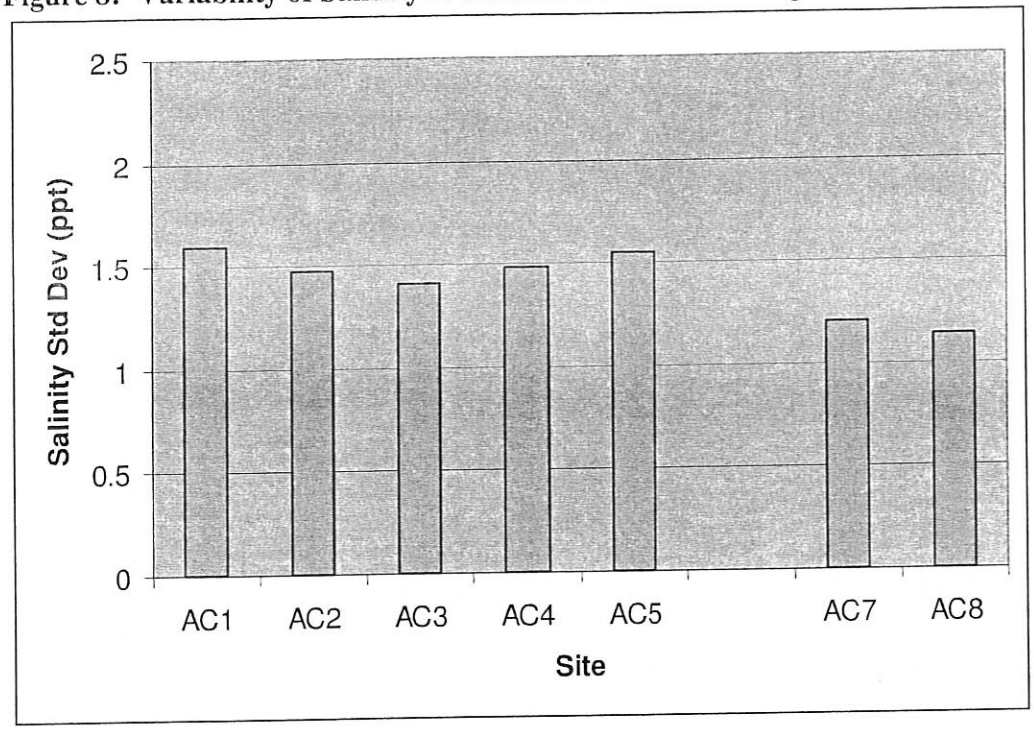
Figure 7: Mean Monthly Flow, Oyster River, Durham, New Hampshire



The land area of the coastal drainage basin is relatively small, and there are no large streams discharging directly to the ocean. The largest streams flow first into the Hampton/Seabrook Estuary, which discharges directly to the Atlantic Ocean. Flow data on the small streams that do discharge to the ocean are not available, as neither the U.S. Geological Survey nor any other state/federal agency maintain streamflow gages in the area. However, salinity data from the ambient monitoring sites provide some information on the extent of freshwater influence on nearshore coastal waters.

All ambient monitoring sites show a year-round mean salinity of approximately 31 parts per thousand (the only exception to this is Site AC6, located in Parsons Creek itself, which exhibits a mean salinity of 22 parts per thousand). Differences in mean values among the ocean sites is small, on the order of 0.1 to 0.2 ppt. Perhaps more interesting is the variability of salinity, expressed as standard deviations, among the sites (Figure 8). To enhance comparison among the ocean sites, Site AC6 (located in Parsons Creek) is not shown in this figure because it exhibits much higher variability, with a standard deviation of over 8 ppt.

Figure 8: Variability of Salinity at Atlantic Coast Monitoring Sites



AC1 shows the highest variability of all the sites. Two data points contribute to this station's relatively large variability – a salinity of 26 ppt on May 24, 1999, and a salinity of 35 ppt on September 28, 1999. The May 1999 value likely illustrates the effects of the nearby Hampton/Seabrook Estuary (the estuary's entrance is to the north of Site AC1, and current direction is generally in a southerly direction), while the September 1999 value may illustrate the relatively dry summer of 1999. Site AC5 also shows relatively higher variability, primarily due to a sample collected on April 24, 2000. Over four inches of rain fell in the coastal area on April 21 and April 22, prompting a closure of all NH shellfish waters. The April 24, 2000 salinity reading of 25 ppt is no doubt due to this rainfall event. Overall, the salinity data shows low variability, indicating that the influence of freshwater discharge on nearshore Atlantic coastal waters is minimal.

Although the salinity of Atlantic coastal waters is relatively stable, freshwater inputs, especially those in late winter/spring, exert considerable influence on the general circulation patterns of the Gulf of Maine. NAI (1975) summarizes how this pattern varies through the year. In the spring, freshwater runoff is discharged into the Gulf of Maine, setting in motion a large eddy that ultimately (by late May) develops into a large-scale, counterclockwise gyre throughout the entire Gulf. Along the coast, this generates a typically southerly flow. In the summer, the gyre decreases in strength, and nearly deteriorates by fall. Thus, for most of the year, the net flows along the Atlantic Coast are southerly in direction. Pronounced northerly flows are more common in winter and early spring, primarily due to winds. The effects of winds are described in a previous section.

E. Stratification

NAI (1975) have conducted intensive offshore studies in the vicinity of Hampton Beach, primarily for the siting of the Seabrook Station's cooling water intakes and discharge locations. Most of these studies have shown little in the way of salinity stratification of coastal waters, although some stratification is evident during periods of high runoff. Temperature stratification routinely develops in the coastal waters during the spring and summer months. This stratification deteriorates in the fall, so that a nearly homogeneous water mass exists from surface to bottom. Interestingly, radiational cooling in winter can create a layer of colder water in the upper water column. NAI (1975) data and other studies of the Gulf of Maine indicate a thermocline typically develops at a depth of 10-20 meters. NHDES Shellfish Program staff constructed a series of temperature/salinity profiles at a sampling location approximately 1 nautical mile south of White Island, Isles of Shoals, in the summer of 2000 and found similar results.

F. Summary discussion concerning actual or potential transport effects on pollution to the harvest area

Information on the wide variety of factors that can influence current speed and direction, which in turn affects the transport of pollution to harvesting areas, suggest that multiple current speeds and directions must be considered in evaluating pollution source impacts. Although predominant flows along the coast are to the south, wind and tidal effects can clearly generate northerly flows as well. In terms of actual impacts of specific pollution sources, on site observations are more important than the general circulation patterns of the Gulf of Maine. Even during seasons when general circulation is in a southerly direction, visual observation and salinity measurements at sampling sites to the north and south of some discharges (e.g., Parsons Creek) indicated the near-field impacts are predominantly to the north. The causes for these localized "anomalies" were not investigated, although factors such as the orientation of the discharge, nearshore bathymetry, and the presence of flow obstructions (e.g., bedrock outcrops) likely play a role. It is these local flow patterns that are critical to evaluating impacts of specific, direct sources of pollution, and to the siting of sampling stations to monitor their impact on a long-term basis. The methodology to account for these patterns is described in Section IV (D) of this report.

VI. Water Quality Studies

A. Sampling Stations

A network of eight shoreline sampling stations, to be used for classification, were initially established in 1999 (Table 8; Figure 9). All sites are located on the ocean with the exception of AC6, which is located in Parsons Creek itself.

Table 8: Ambient Shoreline Sampling Stations

Site	Latitude	Longitude	General Description	Rationale for Selection
AC1	42°53.45' N	70°48.72' W	North End of Seabrook Beach, Seabrook	Potential WWTF impacts
AC2	42°54.21' N	70°48.60' W	South End of Hampton Beach, Hampton	Stormwater and Potential WWTF impacts
AC3	42°55.27' N	70°47.90' W	South end of North Beach, Hampton	Document general water quality
AC4	42°57.20' N	70°46.97' W	North Hampton Beach, North Hampton	Document general water quality
AC5	42°58.67' N	70°45.89' W	Rye Beach Club, Rye	Document general water quality
AC6	43°01.03' N	70°43.98' W	Parsons Creek/Concord Point, Rye	Document water quality of Parsons Creek discharge
AC7	43°01.66' N	70°43.64' W	Wallis Sands Beach, Rye	Potential WWTF impacts
AC8	43°02.77' N	70°42.89' W	Odiorne Point, Rye	Document general water quality

Additionally, another eight stations, paired with each shoreline site, were established in offshore locations (Table 9, Figure 9). The purpose of this paired sampling was not only to develop water quality information in the offshore areas (where presumably most harvesting would occur), but also to confirm that the greatest water quality influence (i.e., higher and more variable FC levels) would be found at the shoreline sites, which are closer to the actual and potential pollution sources.

Table 9: Ambient Offshore Sampling Locations

Site	Latitude	Longitude	Description
ACB1	42°53.37' N	70°48.35' W	Approx. 300 ft off northern end of Seabrook Beach
ACB2	42°54.02' N	70°43.28' W	Approx. 400 ft off southern end of Hampton Beach
ACB3	42°55.43' N	70°47.63' W	Approx. 300 ft off southern end of North Beach
ACB4	42°57.22' N	70°46.40' W	Approx. 500 ft offshore and 900 ft south of N. Hampton Beach
ACB5	42°58.88' N	70°45.26' W	Approx. 500 ft off Rye Beach Club, Rye Beach
ACB6	43°01.09' N	70°43.49' W	Approx. 300 ft off of Concord Point
ACB7	43°01.51' N	70°43.22' W	Approx. 200 ft off northern end of Wallis Sands Beach
ACB8	43°02.90' N	70°42.73' W	Approx. 100 ft off Odiorne Point

The shoreline sites AC1-AC8 are considered the most important for classification, as their proximity to land-based pollution sources will provide the best information on pollution source impacts to the growing waters. Hence, these sites were sampled much more intensively than sites offshore.

Figure 9: Ambient Monitoring Stations

Data from 1999 showed unacceptably high fecal coliform levels at AC6 (Parsons Creek), and pointed to the need for a Prohibited Area around the discharge location. A ninth shoreline sampling location, intended to test the placement of the prohibited line in this area, was established in 2000. The location of this new site, named AC6F, is approximately 550 ft north of the discharge of Parsons Creek. Sampling results indicate that under most conditions, FC levels at AC6F were low. However, under high flow/high FC conditions in Parsons Creek, especially following moderate to heavy rainfall events, the FC levels at AC6F were too high. It is recommended that another site, named AC6G, located 750 ft north of the discharge of Parsons Creek, be established for long term monitoring.

B. Sampling plan and justification

Like all New Hampshire growing area sampling sites, Atlantic Coast sites are sampled using a Systematic Random Sampling strategy. The Systematic Random strategy is favored over the Adverse Condition strategy because it provides for a better evaluation of the effects of intermittent, random sources of pollution. New Hampshire's classification procedures account for the significant impacts of major point source pollution to shellfish growing areas through the establishment of Prohibited Zones around the discharges. These zones define the area of impact of the discharges; therefore, ambient monitoring need not be designed to evaluate water quality within these zones, as they are closed to all harvesting. The primary concern for the ambient program is detecting random, intermittent occurrences of pollution, and the Systematic Random Sampling Strategy is better suited for this purpose. The Systematic Random Strategy should also detect the impacts of any unidentified, chronic sources of pollution (point and nonpoint) that might affect growing area water quality.

For Atlantic Coastal waters, the Systematic Random Sampling Strategy is modified per NSSP guidelines to be targeted on low tide conditions. The rationale for this modification relies on the premise that most, if not all, of the pollution sources affecting the growing waters in the study area would be located on land. Ambient monitoring under low tide conditions would more likely reveal the influence of pollution sources on growing area water quality – the impacts of land-based sources would be transported seaward (toward the sampling stations) on an ebbing tide, and these impacts are more likely to be detected in the absence of the high volumes of clean ocean waters delivered on a flooding tide.

Per the NSSP guidelines for Systematic Random Sampling, a monitoring schedule was established at the start of the year to ensure sample collection under a variety of environmental (seasonal, meteorological, etc.) conditions. Sampling runs were rescheduled only when conditions were deemed unsafe. The primary causes of run rescheduling were heavy seas/high winds or dense fog. Postponed runs were rescheduled as soon as practical, typically within the month. All samples were analyzed for fecal coliform MPN/100ml (5-tube method) by the NH Department of Health and Human Services/Public Health Laboratory.

In order to generate a data set of sufficient size to enable classification, an intensive monitoring schedule of 40 sampling days, prescheduled through all months of the year, was implemented for the shoreline sites (AC1-AC8) in 1999. Sampling intensity was scaled back to 13 sampling days in 2000. Additional sampling at the offshore sites was begun in 1999, but was mostly accomplished in 2000.

C. Sample Data Analysis and Presentation

All fecal coliform and salinity data for the period of January 1999 to August 2000 are presented in Appendix 3. NSSP statistics for the shoreline site data are presented in Table 10. Statistics are typically calculated for the most recent 30 samples; however, the entire data set is used to construct the statistics in Table 10. This was done because although the existing data set has over 30 samples, the data was collected over a relatively short period of time. Restricting the analysis to the most recent 30 samples could result in a less accurate representation of overall water quality in the growing area by eliminating data that might reveal the effects of seasonal influences and inter-annual variability in meteorological conditions. Indeed, 1999 and 2000 summer weather conditions were quite different – the summer of 1999 can be generally characterized as hot and dry, while summer of 2000 was generally much more cool and somewhat wet. Thus, the entire data set was used to calculate statistics in order to present the most representative picture of water quality in the growing area. As the data set grows larger over the next few years, statistical calculations will be performed only on the most recent 30 samples.

Table 10: NSSP Statistics for Shoreline Sites

	AC1	AC2	AC3	AC4	AC5	AC6	AC7	AC8
Count	49	49	49	49	48	48	49	49
Geomean	4.7	4.0	3.1	4.0	3.0	31.1	3.3	3.4
Est 90th	18.5	18.8	11.9	19.0	9.0	329.3	11.3	12.5
Log stdev	0.466	0.527	0.45	0.529	0.368	0.8	0.422	0.442
Classification	Apprv.	Apprv	Apprv	Apprv	Apprv	Prohib.	Apprv	Apprv

NSSP guidelines stipulate that Approved Areas must exhibit geometric means below 14 FC MPN/100ml, and estimated 90th percentiles below 43 FC MPN/100 ml (for the 5-tube MPN test). With the exception of site AC6, all sites meet these criteria under a variety of seasons and meteorological conditions. In fact, the variability exhibited by these sites, expressed as the standard deviation of FC logarithms, is nearly as low as that imparted by the MPN method itself, suggesting excellent and uniform water quality at these sites. Site AC6 is the only site not located on the Atlantic Ocean, but rather is located in the flow of Parsons Creek itself. As described in Section IV of this report, a number of actual pollution sources were confirmed, and some others suspected but not yet confirmed, along the banks of Parsons Creek on properties upstream of Site AC6. These sources are likely contributors to the high FC observed under both dry and wet conditions at this site.

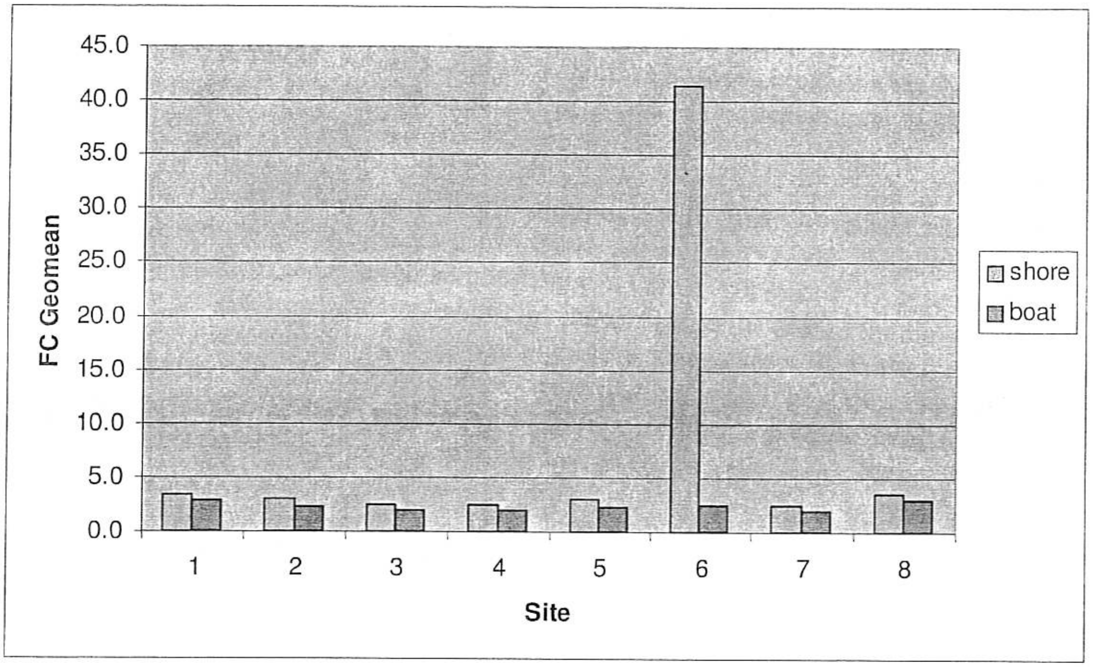
Per a recommendation by the US Food and Drug Administration, the federal agency that provides oversight of NSSP implementation in individual states, offshore sampling sites were established and paired with the shoreline sites. This was done to not only provide documentation of water quality in offshore locations where shellfish harvesting may occur, but also to test the hypothesis that fecal coliform geometric means and measures of variability would be higher at the shoreline sites, which are closer to the sources of pollution. Testing this hypothesis was important in order to guide the design of future monitoring efforts. Data for paired sampling are presented in Table 11 and Figure 10.

Table 11: Shoreline vs. Offshore FC Data

	AC1	ACB1	AC2	ACB2	AC3	ACB3	AC4	ACB4	AC5	ACB5	AC6	ACB6	AC7	ACB7	AC8	ACB8
03/24/99	11.0	1.8	2.0	1.8	1.8	1.8	1.8	2.0	1.8	1.8	4.5	1.8	1.8	2.0	1.8	
08/31/99	7.8	17.0	4.5	4.5	1.8	2.0	13.0	1.8	4.5	2.0	46.0	6.8	2.0	1.8	1.8	13.0
09/20/99	4.5	1.8	1.8	4.5	1.8	1.8	1.8	1.8	1.8	4.5	540.0	2.0	4.0	2.0	2.0	
12/13/99	4.5	6.8	2.0	2.0	1.8	1.8	2.0	1.8	1.8	1.8	110.0	2.0	4.0	2.0	4.5	
05/23/00	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	23.0	2.0	13.0	2.0	2.0	2.0	2.0	2.0
05/31/00	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	7.8	2.0	2.0	2.0	2.0	2.0
06/19/00	2.0	2.0	33.0	2.0	6.8	2.0	4.5	2.0	9.1	2.0	240.0	2.0	6.8	2.0	17.0	7.8
07/10/00	2.0	2.0	6.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	17.0	2.0	2.0	2.0	2.0	2.0
07/24/00	4.5	4.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	7.8	2.0	2.0	2.0	79.0	2.0
08/09/00	2.0	2.0	2.0	2.0	6.8	2.0	2.0	2.0	2.0	2.0	120.0	2.0	2.0	2.0	2.0	2.0
08/21/00	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	4.5	130.0	7.8	2.0	2.0	2.0	2.0
Geomean	3.3	2.9	3.1	2.3	2.4	1.9	2.5	1.9	3.0	2.3	41.4	2.5	2.5	2.0	3.6	3.0
Stdev	3.0	4.6	9.3	1.0	2.0	0.1	3.3	0.1	6.4	1.0	160.1	2.2	1.6	0.1	23.1	4.1

These data not only demonstrate that offshore water quality meets Approved criteria, but that as expected, offshore samples generally exhibit lower geometric means and measures of variability than shoreline sites. Future monitoring efforts will therefore emphasize sample collection at the shoreline sites. Offshore sites will continue to be sampled as well, but with less frequency.

Figure 10: Comparison of Shoreline/Offshore FC Geometric Means



One other offshore ambient site was added to the program in early 2000. This site, ACB20, is located approximately one nautical mile south of White Island, Isles of Shoals. This site was added to evaluate the sanitary quality of waters being used for a University of New Hampshire demonstration project on blue mussel aquaculture. The ambient data (Table 12) show very little variability. The reader should note that the FC result of "<1.8" does not appear after mid March 2000 due to a change in laboratory reporting convention. The new convention stipulates the use of "<2."

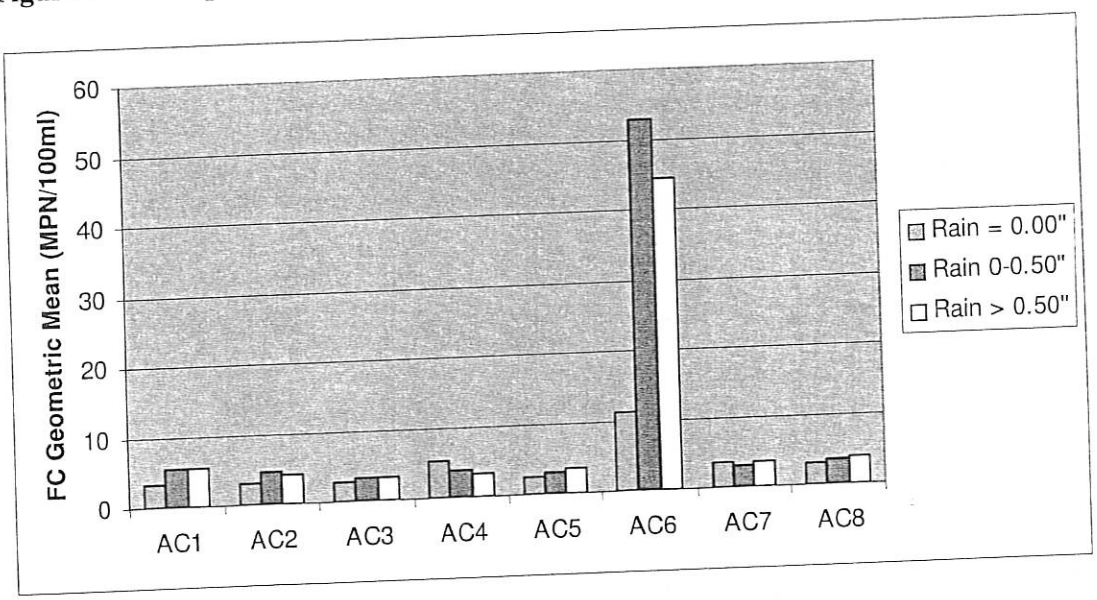
Table 12: Ambient Fecal Coliform and Salinity Data for Site ACB20

Date	FC (MPN/100ml)	Salin (ppt)	Date	FC (MPN/100ml)	Salin (ppt)
01/19/00	<1.8	no data	06/08/00	<2	31
01/30/00	<1.8	no data	06/19/00	<2	30
02/22/00	<1.8	no data	07/10/00	<2	32
03/06/00	<1.8	32	07/24/00	<2	31
03/09/00	<1.8	32	08/09/00	<2	31
03/23/00	<2	32	08/21/00	<2	32
04/13/00	<2	no data	08/22/00	2.0	31
05/15/00	<2	30	09/06/00	<2	31
05/23/00	<2	32	09/19/00	<2	31

This site demonstrates excellent water quality, as the FC levels are consistently low with very little variability. In fact, this site likely meets the criteria for a "Remote" site, which is an NSSP designation for shellfish growing areas that have no human habitation and are not impacted by any actual or potential pollution sources. The closest pollution source to this site is the Star Island wastewater treatment plant, which is more than one nautical mile to the north. An evaluation of this seasonal pollution source (Appendix 2) shows that the potential zone of influence of that plant is less than one nautical mile.

The water quality of many New Hampshire shellfish growing waters is adversely impacted by rainfall events. Given that the shoreline survey revealed pollution sources that show increased FC following rainfall events, it seemed prudent to investigate whether or not rainfall events adversely impact Atlantic Coast water quality. For this analysis, the data set of 49 samples was split into three subsets: days with no rain in the previous three days (15 samples), days with previous three-day rainfall between 0.01 and 0.50 inches of rain (22 samples), and days with previous three-day rainfall greater than 0.50 inches (12 samples). The geometric means of these data subsets are plotted in Figure 11.

Figure 11: Comparison of "Dry Weather" Data to "Wet Weather" Data

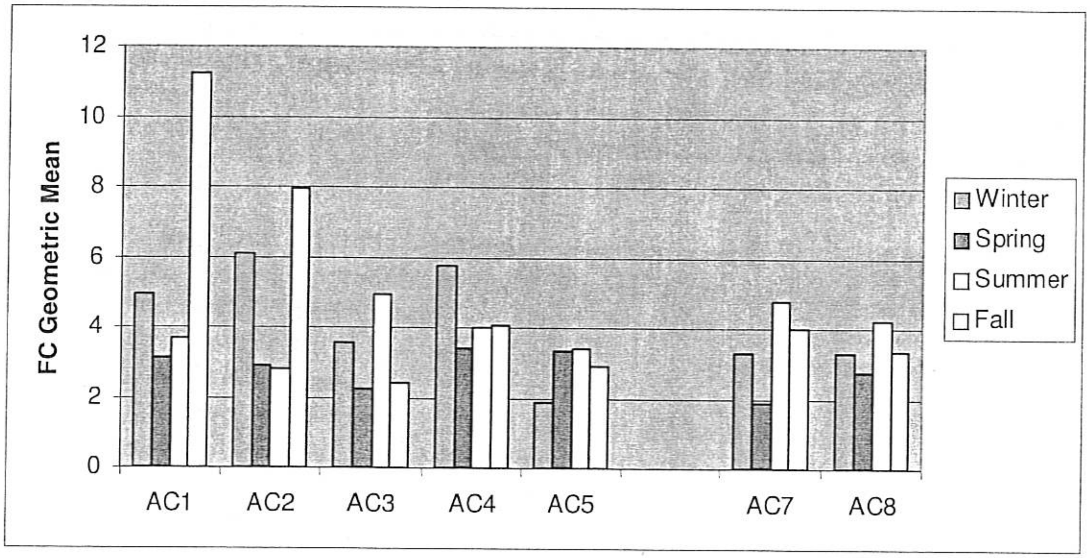


Some sites show slightly increased FC geometric means for the data set containing wet weather, while others show the opposite. However, even for those sites with higher wet weather geometric means, no sites show geometric means that approach the Approved criterion of 14 FC/100ml. The only exception to this is Site AC6, which shows much higher geometric means during wet weather. A similar pattern is evident in a comparison of variability statistics (estimated 90th percentile), in that no site shows an exceedence of the Approved criteria of 43 FC/100ml except Site AC6, which exceeds the criteria under both wet and dry conditions. An inspection of the individual data points (Appendix 3) shows that perhaps the only type of storm that has adversely impacts water quality is a storm of >3 inches. Fecal coliform data were elevated at three of seven ocean ambient sites on April 24, 2000 (AC4, AC5, and AC8, with FC counts of 49, 33, and 79, respectively), two days after a rainfall event of nearly four inches. High rainfall events

(>3 inches) have been found to consistently degrade water quality at nearly all other sampling stations in New Hampshire tidal waters. These events, which occur on average once per year, trigger automatic closures of all estuarine tidal waters. Although data on these storms' effects on Atlantic Coastal waters are limited, the sampling results from April 24, 2000 suggest that similar automatic closures would be appropriate for coastal waters as well.

Seasonal effects on FC levels were also investigated. Figure 12 illustrates geometric means at each site for each season (each geometric mean is constructed from seven to 16 data points).

Figure 12: Seasonal Geometric Means



No definitive pattern is evident, although many sites show higher geometric means in summer and/or fall. This is especially true for Sites AC1 and AC2. The high fall geometric means at these sites appear to be caused by one data point from September 9, 1999 (FC at AC1 and AC2 were 240/100ml and 49/100ml, respectively). To enhance comparability among ocean sites, data from Site AC6 is not shown in Figure 12. This site shows a definite seasonal pattern, with summer and fall geometric means (54/100ml and 108/100ml) being much higher than winter and spring geometric means (20/100ml and 9/100ml).

VII. Interpretation of Data in Determining Area Classification

The ambient water quality data from all shoreline sampling sites show statistical characteristics that are consistent with the Approved Classification. The only site that does not meet Approved criteria is Site AC6, which is located in Parsons Creek. This creek, along with several other surface water discharges such as Little River, Chapel Brook, an unnamed creek near Chapel Brook, and a seagull gathering area downstream of the Eel Pond discharge, exhibit consistently high fecal coliform levels, under all meteorological conditions, but especially following rainfall events. Prohibited zones around these discharges are necessary and are sized according to loading under wet conditions. Although treatment/disinfection failures are rare, permanently closed safety zones around the wastewater treatment plants of Seabrook, Wallis Sands, and Star Island are necessary to protect public health from the adverse effects of discharges of raw or partially treated effluent. Each of these safety zones is based on conservative estimates of the volume of water needed to dilute the effluent to 14FC/100ml. The zones are also sized to account for a variety of flow directions around the outfall.

Open ocean sites (ACB sites) exhibit very low fecal coliform levels and variability, reflecting the significant diluting effects of the Atlantic Coast waters. The shoreline sites (AC sites) also show low FC levels and variability, although geometric means and variability statistics at the AC sites are slightly higher than the open ocean ACB sites. This general characteristic is a result of all AC sites being closer to the land based sources of pollution that have the potential to affect water quality, and is also the result of the sampling design which stipulated water sample collection at low tide. Pollution source evaluations, as well as the ambient data, suggest that the effects of land-based pollution sources are highly localized. Very limited sampling following extreme rainfall events (rainfall > three inches) suggest that this is the only meteorological condition that may produce larger scale water quality impacts along the coast, although the seaward extent of such impacts has not been delineated through water quality sampling.

Sites ACB1-8 are generally located within 500 feet of the low tide shoreline, and exhibited virtually no effects of human-related pollution sources. This is especially true of Site ACB20 (one nautical mile south of White Island, Isles of Shoals). NSSP guidelines note that sites located in areas without human habitation and without the impacts of potential or actual pollution sources may be classified as Approved/Remote. From the data collected to date, it appears that a good deal of the open ocean waters under the state's jurisdiction could be classified as Approved/Remote. However, such a designation would be premature at this time.

The seaward extent of negative water quality impacts from rare events such as rainstorms greater than three inches, or wastewater treatment plant failures, needs to be determined through water sampling after such events, or through other dilution/hydrographic studies. Sampling results from April 24, 2000 (two days after a storm greater than three inches) confirmed that at least some of the ocean waters in the nearshore environment are adversely impacted by such events, but the seaward extent of these impacts has not yet been defined. When this area of influence is more clearly defined, the location of the line delineating a Conditionally Approved Area near the shore may be modified, and a seaward Approved/Remote classification for the waters outside of that zone of influence can be considered. Until such data are collected, a conservative adoption of a Conditionally Approved Area from the low tide shore to 1.5 miles seaward is recommended. The 1.5 mile distance is derived from the worst-case scenario of a wastewater treatment plant failure at the Seabrook wastewater treatment plant and resultant recommendation for a Safety Zone radius of 8440 ft. All other waters seaward of the 1.5 mile line, with the exception of the closed Safety Zone around the Star Island wastewater treatment plant, are classified as Approved. The classification of Atlantic Coastal Waters landward the 1.5 mile line as Conditionally Approved, and waters seaward of the 1.5 mile line, is based on the statistical results from approximately 50 water samples from sites AC1-AC8, as well as the shoreline survey and pollution source evaluation data.

The conditions under which the Conditionally Approved Area will be placed in the closed status are as follows:

- Severe meteorological events (rainstorms of 3 inches or greater), as measured by the meteorological observation station at the North Atlantic Energy Service Corporation/Seabrook Station plant in Seabrook, New Hampshire. Data from other coastal New Hampshire weather stations such as those located in Durham, New Hampshire or at the Pease International Tradeport Airport in Portsmouth, New Hampshire, may also be used to institute a closure.

- Significant discharges of raw or partially treated sewage, resulting in a violation of National Pollutant Discharge Elimination System (NPDES) permit limits, from the Seabrook, Wallis Sands, and/or Star Island wastewater treatment facilities. Determination of discharge significance will be primarily based on discharge flow rate, duration, and total volume. Such determinations will be made by NHDES Shellfish Program staff. Closures may also be instituted as a result of discharges of raw or partially treated sewage, resulting in a violation of National Pollutant Discharge Elimination System (NPDES) permit limits, from the Portsmouth and/or Hampton wastewater treatment facilities, depending on the significance of the discharge and its potential impact to Atlantic Coastal waters as determined by NHDES.

- Any other conditions that NHDES deems a threat to public health.

VIII. Conclusions

The Atlantic Coast tidal waters under the jurisdiction of the State of New Hampshire are classified as either Conditionally Approved or Approved for shellfish harvesting, with the exceptions noted below. The Conditionally Approved Area extends from the low tide shore to a point 1.5 miles from the low tide shoreline. The Approved Area extends from the 1.5-mile line seaward to the limit of state jurisdiction. For the purposes of this classification, the Atlantic Coast waters under the jurisdiction of the State are defined as all waters from Frost Point in Rye, New Hampshire (43°03.12' N, 70°43.15'W) to the New Hampshire/Massachusetts border (42°52.35' N, 70°48.95'W). The seaward extent of the State's jurisdiction is three miles from (to the east of) the mainland, and includes a three-mile radius around that portion of the Isles of Shoals which lies in the State of New Hampshire. The northern and southern boundaries of the seaward lines are marked by the New Hampshire/Maine and New Hampshire/Massachusetts state lines, respectively.

Some of the Atlantic Coastal waters are classified as Prohibited for harvesting. These Prohibited Areas include:

All waters within 750 feet of the low tide seaward extent of the discharge of Little River (42°57.41' N, 70°46.71'W) in North Hampton, New Hampshire.

All waters within 750 feet of the low tide seaward extent of the discharge of Chapel Brook (42°57.96' N, 70°46.28'W) in North Hampton, New Hampshire.

All waters within 750 feet of the low tide seaward extent of the discharge of the unnamed creek in the vicinity of Chapel Brook/Bass Beach (pollution source AC/RYE/2/84; 42°58.20' N, 70°46.18'W) in Rye, New Hampshire.

All waters within 750 feet of the low tide seaward extent of the discharge of Parsons Creek (43°01.08' N, 70°43.89'W) in Rye, New Hampshire.

All waters within 750 feet of the low tide seaward extent of the discharge of Eel Pond (42°58.85' N, 70°45.78'W) in Rye, New Hampshire.

Some of the Atlantic Coastal waters are classified as Prohibited/Safety Zones.

These include:

All waters within 8440 feet of the Seabrook municipal wastewater treatment plant outfall (42°52.40' N, 70°48.55'W), including all of the inlet (waters east of the Route 1A bridge) to Hampton/Seabrook Harbor in Seabrook, New Hampshire.

All waters within 750 feet of the Wallis Sands wastewater treatment plant outfall (43°01.65' N, 70°43.58'W) in Rye, New Hampshire.

All waters within 4000 feet of the Star Island wastewater treatment plant outfall (42°58.58' N, 70°36.95'W) in Rye, New Hampshire.

All Conditionally Approved waters will be placed in the closed status, per emergency closure protocols, when rainfall events of three inches or greater are measured at the Seabrook Station weather station. Such emergency closures may also be triggered by rainfall measurements at other coastal New Hampshire weather stations, including but not limited to the Portsmouth/Pease International Tradeport weather station, the Durham, New Hampshire National Weather Service station, or the Greenland, New Hampshire National Weather Service Station. Waters will remain in the closed status until water samples from appropriate ambient monitoring stations exhibit FC levels of 14FC/100ml or less, or until NHDES determines that sufficient time has elapsed to allow for FC to return to safe levels.

At the discretion of NHDES, some or all of the Conditionally Approved waters will be placed in the closed status, per emergency closure protocols, when a discharge of raw or partially treated sewage occurs at the Seabrook municipal wastewater treatment plant, the Wallis Sands wastewater treatment plant, or the Star Island wastewater treatment plant. The size of the area to be closed will be based on the discharge characteristics of each event. Waters will remain in the closed status until water samples from the ambient monitoring stations exhibit FC levels of 14FC/100ml or less, or until NHDES determines that sufficient time has elapsed to allow for FC to return to safe levels. Discharges of raw or partially treated sewage from the Hampton wastewater treatment plant or from the Portsmouth wastewater treatment plant may also trigger closures of the Conditionally Approved Atlantic Coastal waters, because of these plants' proximity to Atlantic Coastal Waters.

Some or all Atlantic Coastal waters, regardless of classification, will be placed in the closed status, per PSP closure protocols, when PSP toxin levels in blue mussels and/or other shellfish species from Hampton/Seabrook Harbor or from other monitoring stations are greater than or equal 80 µg toxin/100g edible tissue. Waters may also be closed, at the discretion of NHDES, when toxin levels from blue mussels and/or other shellfish species from Hampton/Seabrook Harbor or from other monitoring stations are between 44 and 80 µg toxin/100g edible tissue, especially when toxin levels from nearby Maine and Massachusetts stations indicate rising and/or high levels of PSP toxins. Waters will remain in the closed status at least until three successive weekly tests of mussels and/or other shellfish species from Hampton/Seabrook Harbor, or from other locations as deemed appropriate by NHDES, exhibit toxin levels below 80 µg toxin/100g edible tissue.

Figure 13: new classification

Recommendations for Sanitary Survey Improvement

1. Develop adequate hydrographic information to revise (if necessary) the Seabrook WWTF safety zone, as this zone is rather large in size and does not take into account the diluting effects of lateral dispersion of effluent.

2. Although Site AC1 is located inside a WWTF Safety Zone, sampling at that site should continue. Once the Prohibited/Safety Zone for the Seabrook WWTF is refined, this site may no longer be inside of the safety zone. If it is still inside the safety zone, it should be moved to the zone boundary.

3. Once impacts of significant rainfall and/or WWTF failures can be more clearly delineated through water sampling of actual events or other means, consideration should be given to modifying the location of the 1.5 mile Conditionally Approved/Approved line, and possibly reclassifying Approved open ocean waters seaward of the zone of influence to Approved/Remote.

4. Discontinue sampling at AC4 and establish a new site (AC4B) at the Approved/Prohibited line approximately 750 ft south of the Little River discharge.

5. Discontinue sampling at AC5 and establish a new site (AC5A) at the Approved/Prohibited line approximately 750 ft south of the Eel Pond discharge/gull area.

6. Discontinue sampling at AC6 and establish a new site at the Approved/Prohibited line at AC6G, located approximately 750 ft north of the Parsons Creek discharge.

7. Discontinue sampling at AC7, which is now inside the Wallis Sands Prohibited/Safety Zone, and establish a new site (AC7B) at the Approved/Prohibited line, approximately 300 ft south of the northern Wallis Sands Beach jetty.

8. Establish a new site (AC10) to the Approved/Prohibited line at the unnamed stream north of Chapel Brook/Bass Beach, approximately 750 ft north of the discharge.

9. Integrate monitoring of Parsons Creek, Eel Pond gull area, Chapel Brook, unnamed stream north of Chapel Brook/Bass Beach, and Little River into the ambient monitoring program at least four times per year (minimum of one sample per season) to provide data which assures that sufficiently low FC occurs at the closure lines even when high FC is observed at the pollution sources. Ongoing monitoring of these pollution sources will also provide data on changes in bacteria levels as water quality restoration projects are completed.

IX. References

Earth Tech, September 1999. Hydrodynamic Mixing Study, Seabrook Wastewater Treatment Plant, Town of Seabrook, New Hampshire (Final Report).

NAI (Normandeau Associates, Inc.), September 1975. Summary Report of Hydrographic Studies off Hampton Beach, New Hampshire, Including the Hampton Harbor Estuary and the Western Gulf of Maine; September 1972 to March 1975 (Technical Report VI-8).

Rubin, Fay and Jennifer Merriam, May 1998. Critical Lands Analysis: Final Report to the New Hampshire Estuaries Project.

U.S. FDA (Food and Drug Administration), March 1999. Applied Concepts in Sanitation Surveys of Shellfish Growing Areas (Training Course Source Book).

Appendix 1: Shoreline Survey Data

Property ID	PropCity	LandUse	Sewage Disposal	InspDate	Potential Pollution Source	Samp1 FC/100ml
AC/HMP/134	Hampton	Beach	n/a	05/27/99	active straight pipe	0
AC/HMP/266/50	Hampton	Vacant (rocky shore)	n/a	06/10/99	Seep	0
AC/HMP/266/52	Hampton	Residential	sewer	06/10/99	Seep	0
AC/HMP/267/51	Hampton	Residential (seasonal)	septic	06/10/99	seep/tidepool	2
AC/NHM/1/130	N. Hampton	Residential	septic	05/27/99	salt marsh pool	0
AC/NHM/1/LITTLERIVER	N. Hampton	Vacant (Little River)	n/a	05/27/99	steady stream (Little River)	16.7
AC/NHM/5/9	N. Hampton	Vacant (rocky shore)	n/a	05/20/99	steady stream (Chapel Brook)	218
AC/RYE/2/22	Rye	Comm/Ind. (seasonal)	sewer	05/12/99	inactive straight pipe	n/a
AC/RYE/2/67	Rye	Beach	n/a	05/20/99	Active pipe/stormwater	119
AC/RYE/2/69	Rye	Beach	n/a	05/20/99	Active pipe/stream discharge	353
AC/RYE/2/73	Rye	Beach	n/a	05/20/99	Active pipe/wetland discharge	197
AC/RYE/2/84	Rye	Vacant (rocky shore)	n/a	05/20/99	steady stream	209
AC/RYE/5/6	Rye	Residential (seasonal)	septic	05/12/99	inactive straight pipe	n/a
AC/RYE/5.0/EELPOND	Rye	Beach	n/a	05/12/99	Culvert	18
AC/RYE/5.0/EELPOND	Rye	Beach	n/a	08/03/00	wildlife (gulls)	60
AC/RYE/8.4/123	Rye	Residential	unknown	05/12/99	inactive straight pipe	n/a
AC/RYE/9.2/15	Rye	Vacant (marsh)	n/a	05/12/99	salt marsh pool	0
AC/RYE/17.3/5	Rye	Comm/Ind. (seasonal)	septic	06/24/99	active straight pipe	18500
AC/RYE/17.3/28	Rye	Residential	septic	06/24/99	Tidal creek	380
AC/RYE/17.3/29	Rye	Residential	septic	06/24/99	Tidal creek	>1000
AC/RYE/17.3/64	Rye	Residential	septic	05/06/99	Unknown	n/a
AC/RYE/17.4/13	Rye	Comm/Ind. (motel)	unknown	05/06/99	active straight pipe	1
AC/RYE/17.4/37	Rye	Vacant (marsh)	n/a	05/06/99	Tidal creek	57
AC/RYE/17.4/44	Rye	Residential	septic	05/06/99	inactive straight pipe	n/a
AC/RYE/17.4/PARSONS	Rye	Vacant (Parsons Creek)	n/a	05/06/99	steady stream (Parsons Crk)	44
AC/RYE/19/	Rye	State Park (Beach)	on site WWTF	04/28/99	Unknown	0
AC/RYE/19.4/56	Rye	Comm/Ind.	septic	06/24/99	possible malfunc septic	314
AC/RYE/23/7	Rye	Residential	septic	04/22/99	stagnant pool/malfunc septic?	0
AC/RYE/23/7	Rye	Residential	septic	04/22/99	stagnant pool/malfunc septic?	0
AC/RYE/23/7	Rye	Residential	septic	04/22/99	salt marsh pool	28
AC/RYE/23/10	Rye	Vacant (marsh)	n/a	04/22/99	Road drain	0
AC/RYE/23.1/29	Rye	Residential	septic	04/28/99	Unknown	0
AC/RYE/23.1/29	Rye	Residential	septic	04/28/99	Unknown	0
AC/RYE/25/11	Rye	State Park (rocky shore)	septic	04/22/99	Seep	0
AC/RYE/25/11	Rye	State Park (rocky shore)	septic	04/22/99	inactive straight pipe	0

Appendix 2
Delineation of Prohibited Zones for Selected Pollution Sources

PARSONS CREEK

<u>Transect Sampling</u>

Using the dimensions developed from the desktop calculations, a transect sampling scheme was devised to measure the dilution of FC around the mouth of Parsons Creek. Observations of water movement at the site indicate that of the angle of wave attack and direction of longshore drift tends to be from south to north along the immediate shoreline, although the reverse is certainly possible. Shoreline sampling stations were established in Parsons Creek, at the mouth, and to both the north and south of the mouth:

Site	Description
AC6	In Parsons Creek, 475 ft upstream of the mouth
AC6A	475 ft south of mouth, on Concord Point.
AC6B	300 ft south of mouth, between Concord Point and Parsons Creek mouth
AC6C	At Parsons Creek mouth
AC6D	215 ft north of mouth
AC6E	In Parsons Creek, 100 ft upstream of the mouth
AC6F	550 ft north of mouth

Because the data collected from these sampling locations were intended to guide the selection of a new ambient monitoring station (located on the prohibited zone boundary), sites selection was based not only based on distance from the mouth (per the dilution calculations), but also on proximity to easily recognizable (and enforceable) landmarks.

In order to increase the likelihood of observing high FC in Parsons Creek, sampling was performed by NHDES Shellfish Program staff following moderate to heavy rainfall events. Observations made during each sampling run included water temperature, salinity, FC MPN, air temperature, wind speed and direction, direction of wave attack, wildlife, and any other relevant activities around the sampling sites. Water temperature and salinity were measured with a calibrated YSI meter, wind and air temperature observations were made with a Kestrel pocket meter, and FC analyses were performed by the NHDES laboratory using the 5-tube MPN method. On virtually all days sampled, the direction of wave attack and longshore drift was from south to north. Salinity and bacterial data confirm that the discharge plume was moving from the mouth to the north.

Date	AC6		AC6A		AC6B		AC6C		AC6D		AC6E		AC6F	
	FC	Salin	FC	Salin	FC	Salin	FC	Salin	FC	Salin	FC	Salin	FC	Salin
5/25/00	500	15	8	30	7	30	300	15	13	28	500	14	---	---
7/18/00	500	27.1	<2	31.6	<2	31.6	80	21.8	50	31.2	240	27	27	31.3
7/27/00	>1600	12.8	13	31.4	17	31.3	>1600	14.1	170	30.5	>1600	13.5	---	---
8/3/00	170	25.7	<2	31.1	---	---	---	---	---	---	---	---	130	31.7

8/14/00	300	25.4	---	---	---	---	240	28.7	---	---	400	25.8	20	31.3

The bacterial data indicate that a new ambient monitoring site would best be sited to the north of the mouth (either at AC6D or AC6F). AC6D would be a poor choice, because both the desktop calculations and the monitoring results from 7/18 and 7/27 show unacceptably high levels of FC. AC6F may be an acceptable choice; however, the 8/3/00 sample showed unacceptably high levels. Thus, the new sampling location should be located farther to the north (e.g., 600 ft) of the discharge than Site AC6F.

LITTLE RIVER

Transect Sampling

Using the dimensions developed from the desktop calculations, a transect sampling scheme was devised to measure the dilution of FC around the mouth of Little River. Observations of water movement at the site indicate that of the angle of wave attack and direction of longshore drift tends to be from north to south along the immediate shoreline, although the reverse is certainly possible. Shoreline sampling stations were established at the discharge, at the discharge/ocean intersection, and to both the north and south of the discharge:

Site	Description
NHM/1/L.R./A	Little River Discharge
NHM/1/L.R./B	150 ft downstream of discharge, at intersection with Atl Ocean
NHM/1/L.R./C	250 ft south of mouth of Little River
NHM/1/L.R./D	1000 ft south of mouth of Little River
NHM/1/L.R./E	20 ft north/east of mouth of Little River

Because the data collected from these sampling locations were intended to guide the selection of a new ambient monitoring station (located on the prohibited zone boundary), sites selection was based not only based on distance from the mouth (per the dilution calculations), but also on proximity to easily recognizable (and enforceable) landmarks.

Sampling was performed by NHDES Shellfish Program staff in dry weather and following moderate to heavy rainfall events. Observations made during each sampling run included water temperature, salinity, FC MPN, air temperature, wind speed and direction, direction of wave attack, wildlife, and any other relevant activities around the sampling sites. Water temperature and salinity were measured with a calibrated YSI meter, wind and air temperature observations were made with a Kestrel pocket meter, and FC analyses were performed by the NHDES laboratory using the 5-tube MPN method. On virtually all days sampled, the direction of wave attack and longshore drift was from north to south.

	NHM/1/LR/A		NHM/1/LR/B		NHM/1/LR/C		NHM/1/LR/D		NHM/1/LR/E	
Date	FC	Salin	FC	Salin	FC	Salin	FC	Salin	FC	Salin
8/3/00	440	11	---	---	---	---	---	---	---	---

8/14/00	1060	22.1	---	---	---	---	---	---	---	---
8/30/00	140	27.4	13	30.7	7	32.1	27	32	<2	31.8
9/14/00	152	27	118	27.1	<10	29.5	<10	32	<10	32

The bacterial data indicate rapid dilution of FC. With the generally southern drift of water from the discharge, the closure line (and new sampling site) should be located to the south of the discharge.

CHAPEL BROOK

Transect Sampling

Using the dimensions developed from the desktop calculations, a transect sampling scheme was devised to measure the dilution of FC around the mouth of Chapel Brook. Observations of water movement at the site indicate that of the angle of wave attack and direction of longshore drift tends to be directly on shore or variable, as this discharge is located in a well-defined cove. Shoreline sampling stations were established at the discharge, at the discharge/ocean intersection, and to both the north and south of the discharge:

Site	Description
NHM/5/9/A	Chapel Brook Discharge
NHM/5/9/B	50 ft downstream of discharge, at intersection with Atl Ocean
NHM/5/9/C	1100 ft north of the mouth of Chapel Brook
NHM/5/9/D	225 ft south of the mouth of Chapel Brook
NHM/5/9/E	375 ft south of the mouth of Chapel Brook

Because the data collected from these sampling locations were intended to guide the selection of a new ambient monitoring station (located on the prohibited zone boundary), sites selection was based not only based on distance from the mouth (per the dilution calculations), but also on proximity to easily recognizable (and enforceable) landmarks.

Sampling was performed by NHDES Shellfish Program staff in dry weather and following moderate to heavy rainfall events. Observations made during each sampling run included water temperature, salinity, FC MPN, air temperature, wind speed and direction, direction of wave attack, wildlife, and any other relevant activities around the sampling sites. Water temperature and salinity were measured with a calibrated YSI meter, wind and air temperature observations were made with a Kestrel pocket meter, and FC analyses were performed by the NHDES laboratory using the 5-tube MPN method. On virtually all days sampled, the direction of wave attack and longshore drift was either directly onshore or variable, as this discharge is located in a well defined cove.

	NHM/5/9/A		NHM/5/9/B		NHM/5/9/C		NHM/5/9/D		NHM/5/9/E	
Date	FC	Salin	FC	Salin	FC	Salin	FC	Salin	FC	Salin
5/20/99	218	---								
8/3/00	180	18.3								

8/14/00	350	28.5								
8/30/00	500	31.9	30	32	2	32	4	31.9	2	32.2
9/14/00	210	31.6	185	31.7	82	32	<10	32.3	<10	32.2

The bacterial data indicate rapid dilution of the discharge. A new sampling site should be located to the north of the discharge.

The unnamed creek near Chapel Brook/Bass Beach exhibited flow and FC data similar to the discharge of Chapel Brook. A closure zone around this source, sized identically to that around Chapel Brook, would be appropriate.

EEL POND GULL AREA

The highest FC level observed in the Atlantic Ocean waters just downstream of the gull congregation area is 900/100ml on 8/14/00. Approximately 100 gulls were observed on that day. On the day of observation, longshore drift was in a north to south direction, and FC concentration at a site 100 ft south of the 900/100ml observation was 66/100ml (dilution factor of 13.6). Using these figures, another 100 ft of dilution would result in a FC of less than 5/100ml. Thus, a distance of 200 ft would appear to provide a sufficient amount of dilution. However, given that up to 500 birds have been observed at this site, FC levels could be higher, and the dilution area would perhaps need to be larger.

WALLIS SANDS WASTEWATER TREATMENT FACILITY

This treatment facility discharges seasonally (May through September) a few times per week. Design flow for the system is 0.006 MGD, although monthly DMRs report maximum monthly flows of 1/3 to ½ of the design flow. The system routinely achieves adequate bacterial kill in its UV system. In fact, monitoring of the pre-disinfection effluent by DES Shellfish Program staff have shown FC MPN values of <2 per 100ml. In June of 1999 a total coliform level of 900 was reported. No cause for this problem could be identified, and the high count was attributed (by the operator) to possible sampling error or laboratory contamination.

Given the low flows of this plant, and the fact that it discharges to the Atlantic Ocean (considered to be a high-dilution environment), it is likely that dilution, rather than time of travel of insufficiently diluted effluent, will control the size of the Prohibited/Safety Zone around the outfall. To calculate the size of the area needed to achieve sufficient dilution, the following assumptions were used:

Fecal Coliform Conc.: 10,000 MPN/100ml (two orders of magnitude larger than observed values, but smaller than other WWTFs because of the sand filter treatment employed by this plant)
Discharge: 0.0032 MGD (largest daily flow reported in 1999)
Mixing Zone Water Depth: 3 feet (general low tide water depth for mixing zone width)
Width of Mixing Zone: 75 feet (minimal lateral dispersion)
Time of Loading: 6 hours (dead high to dead low tide)

Using the above assumptions, FC/per hour would be:

$(100{,}000\ FC/100ml)*(133\ gal/hr)*(1\ ft^3/7.48gal)*(28320ml/\ ft^3) = 5.04 \times 10^8\ FC/hr$

When this rate is applied over six hours, Wallis Sands would discharge 3.02×10^9 FC. This load would require 2.16×10^{10} ml, or $7.62 \times 10^4\ ft^3$, of water to dilute the bacterial load to 14 FC/100ml. Assuming a rectangular dilution volume with a depth of 3 feet and a width of 75 feet, the required volume could be achieved with a rectangular length of 339 feet.

Given that currents are generally not unidirectional in this area, this minimum length should be applied as a radius from the discharge to all waters around the discharge.

This discharge is seasonal, so the above mentioned safety zone need only be implemented for the period of May through September. However, the safety zone cannot be completely eliminated for other months of the year because concerns with potential long-term viral contamination of the nearby area. USFDA (1999) recommends minimal dilutions of 1000:1 for WWTFs using chlorine disinfection, and 320:1 for WWTFs using UV disinfection. Using the above assumptions, a 320:1 zone would be achieved 23 feet from the outfall, while a 1000:1 zone would be achieved 71 feet from the outfall. After discussing the enforceability of a seasonal and a separate, year round closure zone with staff from NHF&G, the best choice appears to be one year round closure zone. The zone itself is comparatively small and is not expected to significantly impact harvesting opportunities. Should this expectation prove to be false, institution of a dual closure zone will be revisited in the future.

SEABROOK MUNICIPAL WASTEWATER TREATMENT FACILITY

This treatment facility discharges directly to the Atlantic Ocean, approximately 2000 ft offshore. Design flow for the system is 1.8 MGD. The system uses chlorine for disinfection.

Although this plant discharges to a relatively high dilution environment, it is not clear whether or not the size of the safety zone would be governed by distance for adequate dilution, or time of travel. This question arises because of the significant potential for bacterial loading – the plant has a large flow, and pre-chlorination effluent FC levels have been measured by Shellfish Program staff as high as 1,700,000/100ml. To calculate the size of the area needed to achieve sufficient dilution, the following assumptions were used:

Fecal Coliform Conc.: 23,611 MPN/100ml (based on the highest measured pre-chlorination value of 1,700,000/100ml, reduced by the diffuser dilution factor of 72. The dilution factor is calculated to be achieved 1.2 meters from the diffuser (Jeff Andrews, NHDES, 9/21/00 personal communication); however, for these purposes the dilution factor is assumed to be applicable 500 ft away from the outfall/diffusers. This extra distance is added to account for possible re-entrainment of discharged effluent that may occur when relatively fresh water effluent rises to the surface and is transported back toward the outfall by surface currents that can run opposite to currents at depth.

Discharge: 75,000 gallons/hr (based on design flow of 1.8 MGD)
Mixing Zone Water Depth: 20 feet (general low tide water depth for mixing zone width)
Width of Mixing Zone: 85 feet (length of diffuser pipe)
Time of Loading: 6 hours (dead high to dead low tide)

Using the above assumptions, FC/per hour would be:

$(23{,}611 \text{ FC}/100\text{ml})*(75{,}000 \text{ gal/hr})*(1 \text{ ft}^3/7.48\text{gal})*(28320\text{ml}/\text{ ft}^3) = 6.7 \times 10^{10} \text{ FC/hr}$

When this rate is applied over six hours, Seabrook would discharge 4.02×10^{11} FC. This load would require 2.87×10^{12} ml, or 1.02×10^{7} ft^3, of water to dilute the bacterial load to 14 FC/100ml. Assuming a rectangular dilution volume with a depth of 20 feet and a width of 85 feet, the required volume could be achieved with a rectangular length of 5,968 feet (1.13 miles). When the assumed 500 ft initial mixing zone (to achieve initial dilution of 72) is added, the total length from the outfall pipe is 6468 feet (1.22 miles).

Given that currents are generally not unidirectional in this area, this minimum length should be applied as a radius from the discharge to all waters around the discharge.

This safety zone is possibly larger than necessary, given the assumption of no lateral dispersion of effluent. This safety zone should be re-evaluated once more detailed hydrographic information can be developed.

STAR ISLAND WASTEWATER TREATMENT FACILITY

This treatment facility discharges seasonally (June through September) Design flow for the system is 15,000 GPD. Given the low flows of this plant, and the fact that it discharges to the Atlantic Ocean (considered to be a high-dilution environment), it is likely that dilution, rather than time of travel of insufficiently diluted effluent, will control the size of the Prohibited/Safety Zone around the outfall. To calculate the size of the area needed to achieve sufficient dilution, the following assumptions were used:

Fecal Coliform Conc.: 1,100,000 MPN/100ml (highest prechlorination effluent FC level measured by DES staff)
Discharge: 15,000 GPD (design flow for the plant), or an average of 625 gallons per hour.
Mixing Zone Water Depth: 50 feet (mean depth of summer thermocline)
Width of Mixing Zone: 200 feet (minimal lateral dispersion)
Time of Loading: 6 hours (dead high to dead low tide)

Using the above assumptions, FC/per hour would be:

$(1,100,000 \text{ FC/100ml})*(625 \text{ gal/hr})*(1 \text{ ft}^3/7.48\text{gal})*(28320\text{ml/ ft}^3) = 2.61 \times 10^{10} \text{ FC/hr}$

When this rate is applied over six hours, Star Island would discharge 1.56×10^{11} FC. This load would require 3.94×10^7 ft^3, of water to dilute the bacterial load to 14 FC/100ml. Assuming a rectangular dilution volume with a depth of 50 feet and a width of 200 feet, the required volume could be achieved with a rectangular length of 3939 feet. It is possible that this closure area is oversized, as the calculations only minimally account for lateral dispersion of effluent.

Given that currents are generally not unidirectional in this area, this minimum length should be applied as a radius from the discharge to all waters around the discharge.

This discharge is seasonal, so the above mentioned safety zone need only be implemented for the period of June through September. However, the safety zone cannot be completely eliminated for other months of the year because concerns with potential long-term viral contamination of the nearby area. USFDA (1999) recommends minimal dilutions of 1000:1 for WWTFs using chlorine disinfection. This zone would be located well within the 3939 ft radius delineated above. After discussing the enforceability of a seasonal and a separate, year round closure zone with staff from NHF&G, the best choice appears to be one year round closure zone. The zone itself is comparatively small and is not expected to significantly impact harvesting opportunities. Should this expectation prove to be false, institution of a dual closure zone will be revisited in the future.

Appendix 3: Ambient Fecal Coliform and Salinity Data (Shoreline Stations)
Precipitation data from Seabrook Station, Seabrook, NH

	ACO1		AC02		AC03		ACO4							
	FC	Salin	FC	Salin	FC	Salin	FC	Salin	PRECIP0	PRECIP1	PRECIP2	PRECIP3	PRECIP 4	PRECIPCOMMENTS
02/03/99	11.0	30	11.0	29	17.0	29	79.0	30	1.26	0.38	0.00	0.00	0.00	no data
02/08/99	2.0	29	<1.8	30	<1.8	30	<1.8	30	0.00	0.00	0.00	0.00	0.24	no data
02/22/99	1.8	30	2.0	32	<1.8	30	<1.8	30	0.00	0.00	0.00	0.00	0.59	no data
03/08/99	2.0	30	49	31	14	31	1.8	31	0.00	0.22	0.38	0.00	0.27	no data
03/15/99	<1.8	29	2.0	30	2.0	30	7.8	31	0.47	0.00	0.00	0.25	0.01	no data
03/24/99	11	30	2.0	31	<1.8	28	<1.8	32	0.09	0.00	0.42	0.02	0.00	no data
03/29/99	4.5	29	2.0	30	<1.8	30	2.0	28	0.01	0.83	0.00	0.00	0.42	no data
04/06/99	<1.8	30	<1.8	30	<1.8	30	<1.8	28	0.00	0.00	0.00	0.00	0.00	no data
04/12/99	<1.8	30	<1.8	30	<1.8	31	<1.8	30	0.00	0.00	0.00	0.00	0.00	no data
04/19/99	<1.8	30	1.8	30	<1.8	31	<1.8	30	0.04	0.00	0.25	0.25	0.00	no data
04/28/99	<1.8	30	<1.8	30	<1.8	30	1.8	30	0.00	0.06	0.08	0.00	0.00	no data
05/03/99	6.8	30	6.8	30	<1.8	30	6.8	30	0.00	0.00	0.00	0.00	0.00	no data
05/11/99	<1.8	32	<1.8	31	<1.8	32	<1.8	32	0.00	0.00	0.01	0.11	0.00	no data
05/18/99	2.0	31	11.0	31	4.5	31	17.0	32	0.00	0.00	0.00	0.00	0.00	no data
05/24/99	13.0	26	<1.8	30	<1.8	30	4.0	30	1.38	0.09	0.00	0.00	0.98	no data
06/02/99	17	30	<1.8	30	33	30	13	30	0.05	0.00	0.00	0.00	0.00	no data
06/08/99	<1.8	31	<1.8	31	<1.8	31	<1.8	31	0.00	0.00	0.00	0.00	0.00	no data
06/08/99	<1.8	32	<1.8	32	13	31	7.8	32	0.00	0.00	0.00	0.00	0.00	no data
06/15/99	7.8	31	<1.8	32	<1.8	32	79	27	0.00	0.00	0.00	0.00	0.00	no data
06/21/99	<1.8	32	<1.8	30	<1.8	32	6.8	29	0.00	0.00	0.00	0.00	0.00	no data
07/06/99	4.5	32	<1.8	31	4	31	4	32	0.30	0.00	0.01	0.00	0.53	no data
07/20/99	<1.8	31	<1.8	31	170	31	<1.8	31	0.01	0.22	0.00	0.00	0.00	no data
07/27/99	23	31	7.8	31	33	31	<1.8	31	0.00	0.01	0.43	0.22	0.03	no data
08/02/99	7.8	31	<1.8	31	<1.8	30	<1.8	31	0.00	0.00	0.00	0.00	0.00	no data
08/09/99	1.8	33	2.0	33	<1.8	32	<1.8	34	0.00	0.19	0.01	0.25	0.31	no data
08/31/99	7.8	31	4.5	31	<1.8	31	13	31	0.00	0.01	0.06	0.01	0.02	no data
09/07/99	240	31	49	31	<1.8	31	2.0	31	0.42	0.05	0.00	0.00	0.00	no data

09/20/99	4.5	32	<1.8	30	<1.8	32	<1.8	32	0.00	0.00	0.18	0.79	0.18	no data
09/28/99	7.8	35	79	35	2.0	31	<1.8	31	0.00	0.00	0.00	0.11	0.00	no data
10/05/99	33	30	<1.8	32	<1.8	32	7.8	30	0.03	0.50	0.00	0.00	0.00	no data
10/12/99	13.0	32	23	32	13	33	220	32	0.00	0.00	0.19	0.01	0.00	no data
10/19/99	1.8	32	<1.8	32	<1.8	32	2.0	32	0.00	0.80	0.00	0.00	0.00	no data
10/27/99	23	32	7.8	32	<1.8	33	7.8	33	0.00	0.00	0.00	0.88	0.00	no data
11/02/99	<1.8	33	<1.8	32	4.5	33	4.5	32	0.02	0.00	0.00	0.00	0.00	no data
11/15/99	4.5	33	<1.8	32	2.0	33	<1.8	33	0.00	0.11	0.06	0.11	0.01	no data
11/16/99	23	33	4.5	33	<1.8	33	<1.8	33	0.00	0.00	0.11	0.06	0.11	no data
11/30/99	13	33	130	33	<1.8	33	<1.8	33	0.00	0.00	0.00	0.33	0.16	no data
12/13/99	4.5	33	2.0	33	<1.8	33	2.0	33						no data
12/20/99	11.0	33	7.8	33	<1.8	33	<1.8	32						no data
12/28/99	4.5	33	46	33	<1.8	33	49	33						no data
01/11/00	7.8	32	11.0	32	22.0	32	4.5	32	0.02	0.74	0.00	0.00	0.00	precip on 1/10 started 3-4 pm, and was all rain
04/24/00	11.0	30	2.0	31	<2	30	49.0	29	0.02	0.44	2.45	1.50	0.01	rainfall on Day-2 triggered emergency closure of GB, LB, and HH
05/23/00	<2	29	<2	27	<2	27	<2	30	0.14	0.00	0.02	0.00	0.17	precip on day 1 was from 2 am to 5am
05/31/00	<2	30	<2	29	<2	30	<2	30	0.00	0.00	0.00	0.00	0.00	None
06/19/00	<2	28	33.0	27	6.8	28	4.5	29	0.01	0.07	0.23	0.01	0.00	None
07/10/00	<2	32	6.8	32	2.0	31	<2	31	0.01	0.63	0.00	0.08	0.00	None
07/24/00	4.5	31	<2	31	<2	31	2.0	30	0.00	0.00	0.37	0.23	0.00	precip on day2 and day3 was the same storm (total of 0.60 inches)
08/09/00	<2	31	<2	32	6.8	32	<2	32						
08/21/00	<2	32	<2	32	<2	32	<2	32						

	ACO5		AC06		AC07		AC08							
	FC	Salin	FC	Salin	FC	Salin	FC	Salin	PRECIP0	PRECIP1	PRECIP2	PRECIP3	PRECIP4	PRECIPCOMMENTS
02/03/99	<1.8	31	79.0	14	<1.8	30	2.0	30	1.26	0.38	0.00	0.00	0.00	no data
02/08/99	2.0	29	13.0	7	<1.8	29	2.0	28	0.00	0.00	0.00	0.00	0.24	no data
02/22/99	2.0	30	<1.8	25	<1.8	31	3.7	30	0.00	0.00	0.00	0.00	0.59	no data
03/08/99	2.0	30	4.5	8	2.0	30	<1.8	31	0.00	0.22	0.38	0.00	0.27	no data
03/15/99	4.5	30	49	20	2.0	30	<1.8	30	0.47	0.00	0.00	0.25	0.01	no data
03/24/99	<1.8	30	4.5	16	<1.8	30	<1.8	30	0.09	0.00	0.42	0.02	0.00	no data
03/29/99	4.5	28	<1.8	12	<1.8	28	<1.8	30	0.01	0.83	0.00	0.00	0.42	no data
04/06/99	2.0	28	4.0	18	<1.8	28	<1.8	28	0.00	0.00	0.00	0.00	0.00	no data
04/12/99	<1.8	30	<1.8	25	<1.8	30	<1.8	29	0.00	0.00	0.00	0.00	0.00	no data
04/19/99	2.0	31	<1.8	28	<1.8	30	<1.8	30	0.04	0.00	0.25	0.25	0.00	no data
04/28/99	<1.8	30	<1.8	29	1.8	29	<1.8	29	0.00	0.06	0.08	0.00	0.00	no data
05/03/99	2.0	30	4.0	29	<1.8	30	<1.8	30	0.00	0.00	0.00	0.00	0.00	no data
05/11/99	<1.8	30	4.0	21	<1.8	31	<1.8	32	0.00	0.00	0.01	0.11	0.00	no data
05/18/99	7.8	31	22.0	30	2.0	30	17.0	30	0.00	0.00	0.00	0.00	0.00	no data
05/24/99	<1.8	30	1600	7	<1.8	30	2.0	30	1.38	0.09	0.00	0.00	0.98	no data
06/02/99	<1.8	30	350	28	110	28	6.8	31	0.05	0.00	0.00	0.00	0.00	no data
06/08/99	<1.8	31	22.0	28	<1.8	32	1.8	31	0.00	0.00	0.00	0.00	0.00	no data
06/08/99	17	32	33	32	4	32	7.8	32	0.00	0.00	0.00	0.00	0.00	no data
06/15/99	2.0	32	240	31	7.8	31	2.0	32	0.00	0.00	0.00	0.00	0.00	no data
06/21/99	<1.8	31	<1.8	31	4.0	32	<1.8	31	0.00	0.00	0.00	0.00	0.00	no data
07/06/99	13	32	79	32	4.5	32	6.8	32	0.30	0.00	0.01	0.00	0.53	no data
07/20/99	<1.8	31	170	26	2	31	2	31	0.01	0.22	0.00	0.00	0.00	no data
07/27/99	33	31	170	31	33	31	33	31	0.00	0.01	0.43	0.22	0.03	no data
08/02/99	<1.8	31	27	31	<1.8	31	<1.8	31	0.00	0.00	0.00	0.00	0.00	no data
08/09/99	<1.8	33	33	32	23	32	2.0	32	0.00	0.19	0.01	0.25	0.31	no data
08/31/99	4.5	31	46	31	2	31	<1.8	31	0.00	0.01	0.06	0.01	0.02	no data
09/07/99	<1.8	31		31	33.0	31	**23.0**	31	0.42	0.05	0.00	0.00	0.00	no data
09/20/99	<1.8	30	540.0	8	4.0	30	2.0	30	0.00	0.00	0.18	0.79	0.18	no data
09/28/99	4.0	31	350	30	<1.8	31	14	31	0.00	0.00	0.00	0.11	0.00	no data

10/05/99	<1.8	30	140	27	<1.8	30	2.0	30	0.03	0.50	0.00	0.00	0.00	no data
10/12/99	4.5	32	70	22	23	31	<1.8	32	0.00	0.00	0.19	0.01	0.00	no data
10/19/99	7.8	32	130	11	<1.8	32	<1.8	32	0.00	0.80	0.00	0.00	0.00	no data
10/27/99	<1.8	33	70	18	6.8	32	4.5	32	0.00	0.00	0.00	0.88	0.00	no data
11/02/99	2.0	33	17	25	2.0	32	2.0	32	0.02	0.00	0.00	0.00	0.00	no data
11/15/99	<1.8	33	79	12	2.0	32	<1.8	32	0.00	0.11	0.06	0.11	0.01	no data
11/16/99	2.0	33	70	17	2.0	33	4.5	32	0.00	0.00	0.11	0.06	0.11	no data
11/30/99	11	33	130	29	4.5	32	2.0	32	0.00	0.00	0.00	0.33	0.16	no data
12/13/99	<1.8	33	110	14	4.0	32	4.5	32	0.00	0.00	0.00	0.08	0.00	no data
12/20/99			7.8	29	13.0	32	2.0	31	0.30	0.00	0.00	0.00	0.06	Day0 began 9pm
12/28/99	<1.8	33	2.0	25	6.8	32	6.8	32	0.00	0.00	0.00	0.00	0.00	no data
01/11/00	1.8	32	350.0	8	2.0	32	4.5	32	0.02	0.74	0.00	0.00	0.00	precip on 1/10 started 3-4 pm, and was all rain
04/24/00	33.0	25	170.0	3	2.0	30	79.0	29	0.02	0.44	2.45	1.50	0.01	rainfall on Day-2 triggered emergency closure of GB, LB, and HH
05/23/00	23.0	30	13.0	24	<2	30	<2	30	0.14	0.00	0.02	0.00	0.17	precip on day 1 was from 2 am to 5am
05/31/00	<2	30	7.8	22	<2	29	<2	29	0.00	0.00	0.00	0.00	0.00	none
06/19/00	9.1	30	240.0	27	6.8	30	17.0	30	0.01	0.07	0.23	0.01	0.00	none
07/10/00	<2	31	17.0	27	<2	31	<2	31	0.01	0.63	0.00	0.08	0.00	none
07/24/00	<2	31	7.8	28	<2	31	79.0	31	0.00	0.00	0.37	0.23	0.00	precip on day2 and day3 was the same storm (total of 0.60 inches)
08/09/00	<2	32	120.0	10	<2	30	2.0	32	0.00	0.00	0.21	0.05	0.00	none
08/21/00	<2	32	130.0	29	<2	32	2.0	32	0.00	0.00	0.03	0.05	0.00	none