Sanitary Survey
Westecunk Creek to Little Sheepshead Creek

(BB4 – An Estuarine Shellfish Growing Area within Little Egg Harbor)

2000 - 2004

Department of Environmental Protection
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State Of New Jersey
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SANITARY SURVEY

SHELLFISH GROWING AREA BB4

WESTECUNK CREEK TO LITTLE SHEEPSHEAD CREEK

2000 - 2004

March 2009

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New Jersey Department of Environmental Protection
MARK MAURIELLO
ACTING COMMISSIONER

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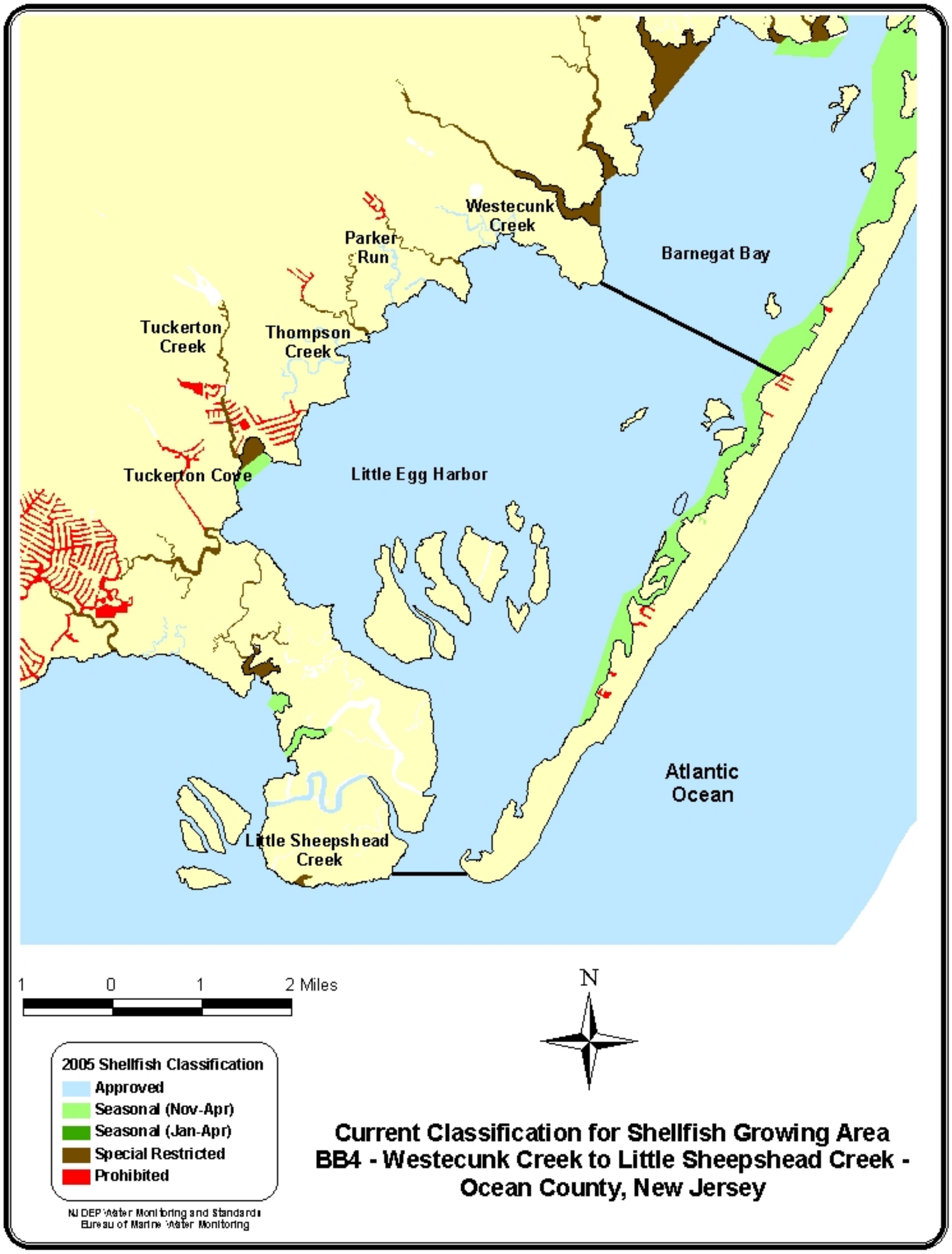
EXECUTIVE SUMMARY

Shellfish Growing Area BB4 – Westecunk Creek to Little Sheepshead Creek covers the shellfish growing waters of Little Egg Harbor. BB4 consists of all the back bay waters that extend six miles from Westecunk Creek in the North, then East across the bay to Beach Haven Terrace, then South to the southerly extent of the Forsythe National Wildlife Refuge on Long Beach Island, and then West and ending at the southern base of Little Sheepshead Creek

In total, there are 13,698 shellfish growing water acres in BB4. The majority of the shellfish growing waters present in this area are classified as *Approved* with several small sections of *Seasonally Approved, Special Restricted*, and *Prohibited* waters. The acreage by classification at the time this report was written equated to 12,781 *Approved*, 595 *Seasonal* (Nov – Apr), 195 *Special Restricted* and 127 *Prohibited.* Current Shellfish growing water classifications for BB4 can be viewed in the figure that follows.

BB4 does not have direct discharge(s) that provide an influence on water quality. As such, BB4 is sampled utilizing the Systematic Random Sampling (SRS) strategy. There is potential for non-point source inputs, such as those that might emanate from streams, creeks, lagoon/bayfront properties, marinas or storm water outfalls located within the waters of BB4. However, the waters that surround such inputs are appropriately classified to protect public health and these classifications will remain in effect for this reporting period.

For this Sanitary Survey, the results of water quality analyses for samples collected between October 2000 and August 2004 indicate classifications in this shellfish growing area will remain as currently designated. In addition, there are no sampling or monitoring changes recommended at this time. This decision was derived by utilizing National Shellfish Sanitation Program (NSSP) classification practices; a current analysis for total coliform (TC) – using 3 tube multiple dilution analysis, and an SRS review of 30 or more samples.



CURRENT CLASSIFICATION - SHELLFISH GROWING AREA BB4

INTRODUCTION

PURPOSE

This shellfish growing area report is part of a series of studies having a dual purpose. The first and primary purpose is to comply with the guidelines of the National Shellfish Sanitation Program (NSSP), which are established by the Interstate Shellfish Sanitation Conference (ISSC). Reports generated under this program form the basis for classifying waters for shellfish harvesting while insuring public health and safety with regard to human consumption of those harvests.

The second purpose is to provide input to the Integrated Water Quality Monitoring and Assessment Report, which is prepared pursuant to Sections 305(b) and 303(d) of the Federal Clean Water Act (P.L. 95-217). The information contained in the growing area reports is used for the 305b portion of the Integrated Report, which provides an assessment to Congress every two years of current water quality conditions in the State's major rivers, lakes, estuaries, and ocean waters. The growing area reports provide valuable information for the 305(b) portion, which describes the waters that are attaining state designated water uses and national clean water goals; the pollution problems identified in surface waters, and the actual or potential sources of pollution. Similarly, the growing area reports utilize relevant information contained in the 305(b) portion of the Integrated Report, since the latter assessments are based on instream monitoring data (temperature, oxygen, pH, total and fecal coliform bacteria, nutrients, solids, ammonia, and metals), land-use profiles, drainage basin characteristics, and other pollution source information.

From the perspective of the Shellfish Classification Program, the reciprocal use of water quality information from reports represent two sides of the same coin: the growing area report focuses on the estuary itself, while the 305(b) portion of the report describes the watershed that drains to that estuary.

The Department participates in the cooperative National Environmental Performance Partnership System (NEPPS) with the USEPA which emphasizes ongoing evaluation of issues associated with environmental regulation, including assessing impacts on waterbodies and measuring improvements in various indicators of environmental health. The shellfish growing area reports are intended to provide a brief assessment of the growing area, with particular emphasis on those factors that affect the quantity and quality of the shellfish resource. The shellfish growing area reports provide valuable information on the overall quality of the saline waters in the most downstream sections of each major watershed. In addition, the reports assess the quality of the biological resource and provide a reliable indicator of potential areas of concern and or areas where additional information is needed to accurately assess watershed dynamics.

BACKGROUND

As a brief history, the NSSP developed from public health principles and program controls formulated at the original conference on shellfish sanitation called by the Surgeon General of the United States Public Health Service in 1925. This conference was called after oysters were implicated in causing over 1500 cases of typhoid fever and 150 deaths in 1924. The tripartite cooperative program (federal, state, and shellfish industry) has updated the program procedures and guidelines through workshops held periodically until 1977. Because of concern by many states that the NSSP guidelines were not being enforced uniformly, a delegation of state shellfish officials from 22 states met in 1982 in Annapolis, Maryland, and formed the ISSC. The first annual meeting was held in 1983 and continues to meet annually at various locations throughout the United States.

The NSSP *Guide for the Control of Molluscan Shellfish* sets forth the principles and requirements for the sanitary control of shellfish produced and shipped in interstate commerce in the United States. It provides the basis used by the Federal Food and Drug Administration (FDA) in evaluating state shellfish sanitation programs. The five major points on which the state is evaluated by the FDA include:

l. The classification of all actual and potential shellfish growing areas as to their suitability for shellfish harvesting.
2. The control of the harvesting of shellfish from areas that are classified as *Restricted*, *Prohibited*, or otherwise closed.
3. The regulation and supervision of shellfish resource recovery programs.
4. The ability to restrict the harvest of shellfish from areas in a public health emergency, and
5. Prevent the sale, shipment, or possession of shellfish that cannot be identified as being produced in accordance with the NSSP and have the ability to condemn, seize, or embargo such shellfish.

FUNCTIONAL AUTHORITY

The authority to carry out these functions is divided between the Department of Environmental Protection (DEP), the Department of Health and Senior Services, and the Department of Law and Public Safety. Water Monitoring & Standards (WM&S) Bureau of Marine Water Monitoring (BMWM), under the authority of N.J.S.A. 58:24, classifies the shellfish growing waters and administers the special resource recovery programs. Regulations delineating the growing areas are promulgated at N.J.A.C. 7:12 and are revised annually. Special Permit rules are also found at N.J.A.C. 7:12 and are revised as necessary.

The Bureau of Shellfisheries, in the Division of Fish and Wildlife, issues harvesting licenses and leases for shellfish grounds under the Authority of N.J.S.A. 50:2 and N.J.A.C. 7:25. Both that bureau and WM&S/BMWM administer the Hard Clam Relay Program.

The Bureau of Law Enforcement, in the DEP Division of Fish and Wildlife, and the Division of State Police, in the Department of Law and Public Safety, enforce the provisions of the statutes and rules mentioned above.

The Department of Health and Senior Services is responsible for the certification of wholesale shellfish establishments and works, in conjunction with WM&S/BMWM, to administer the depuration program. The division of authority between the three agencies can be seen in Figure 1.

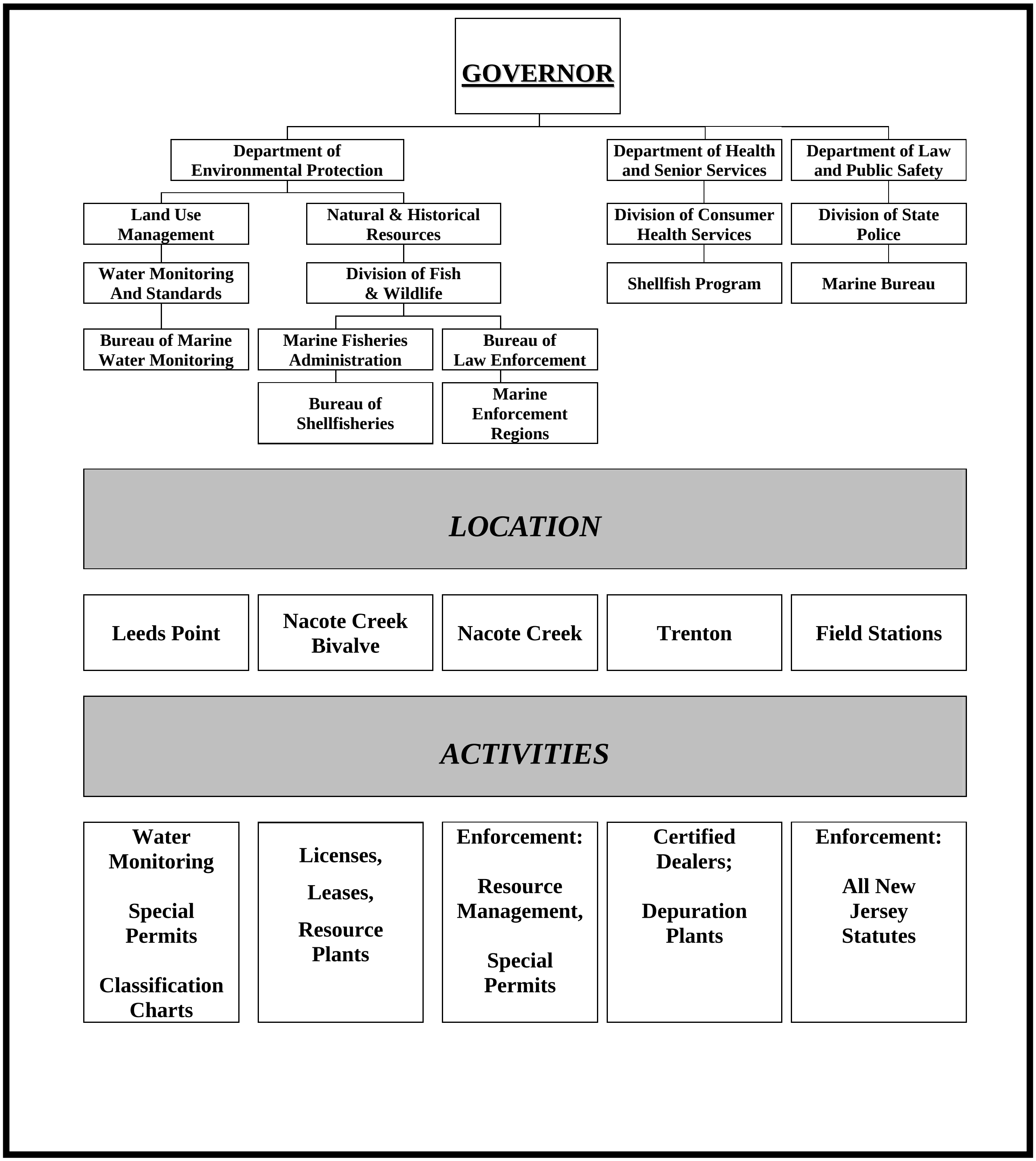


FIGURE 1: STATE OF NEW JERSEY SHELLFISH AGENCIES

IMPORTANCE OF SANITARY CONTROL OF SHELLFISH

Emphasis is placed on the sanitary control of shellfish because of the direct relationship between pollution of shellfish growing areas and the transmission of diseases to humans. Shellfish-borne infectious diseases are generally transmitted via a fecal-oral route. The pathway is complex and quite circuitous. The cycle usually begins with fecal contamination of the shellfish growing waters. Sources of such contamination are many and varied. Contamination reaches the waterways via runoff and direct discharges.

Clams, oysters and mussels 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 microbes and toxic heavy metals/chemicals. It is imperative that a system is in place to reduce the human health risk of consuming shellfish from areas of contamination.

Accurate classifications of shellfish growing areas are completed through a comprehensive sanitary survey. The principal components of the sanitary survey report include:

1. An evaluation of all actual and potential sources of pollution,
2. An evaluation of the hydrology of the area and
3. An assessment of water quality. Complete intensive Sanitary Surveys are conducted every 12 years with interim narrative evaluations or Reappraisals completed on a three-year basis. If major changes to the shoreline or bacterial quality occur, then the intensive report is initiated prior to its l2 year schedule.

The following narrative constitutes WM&S/BMWM's assessment of the above mentioned components to comply with the 12 year Sanitary Survey.

PROFILE

LOCATION

Shellfish Growing Area BB4 – Westecunk Creek to Little Sheepshead Creek covers the waters of Little Egg Harbor. It extends along 6 miles of back bay waters encompassing Westecunk Creek in the North, East to Beach Haven Terrace, South to the southerly extent of the Forsythe National Wildlife Refuge on Long Beach Island, and then West and ending at the southern base of Little Sheepshead Creek (see Figure 2). (Note: all references to "miles" in this report are in Nautical Measure, whereby, one Nautical Mile equates to 6,086 feet). This area is also displayed on charts #5 and #6 of the 2006 Shellfish Growing Water Classification Charts.

BB4 consists of 13,698 acres. The acreage, by shellfish growing water classification, is as follows: *Approved* – 12,781, *Seasonal* (Nov-Apr) – 595, *Special Restricted* – 195, and *Prohibited* – 127.

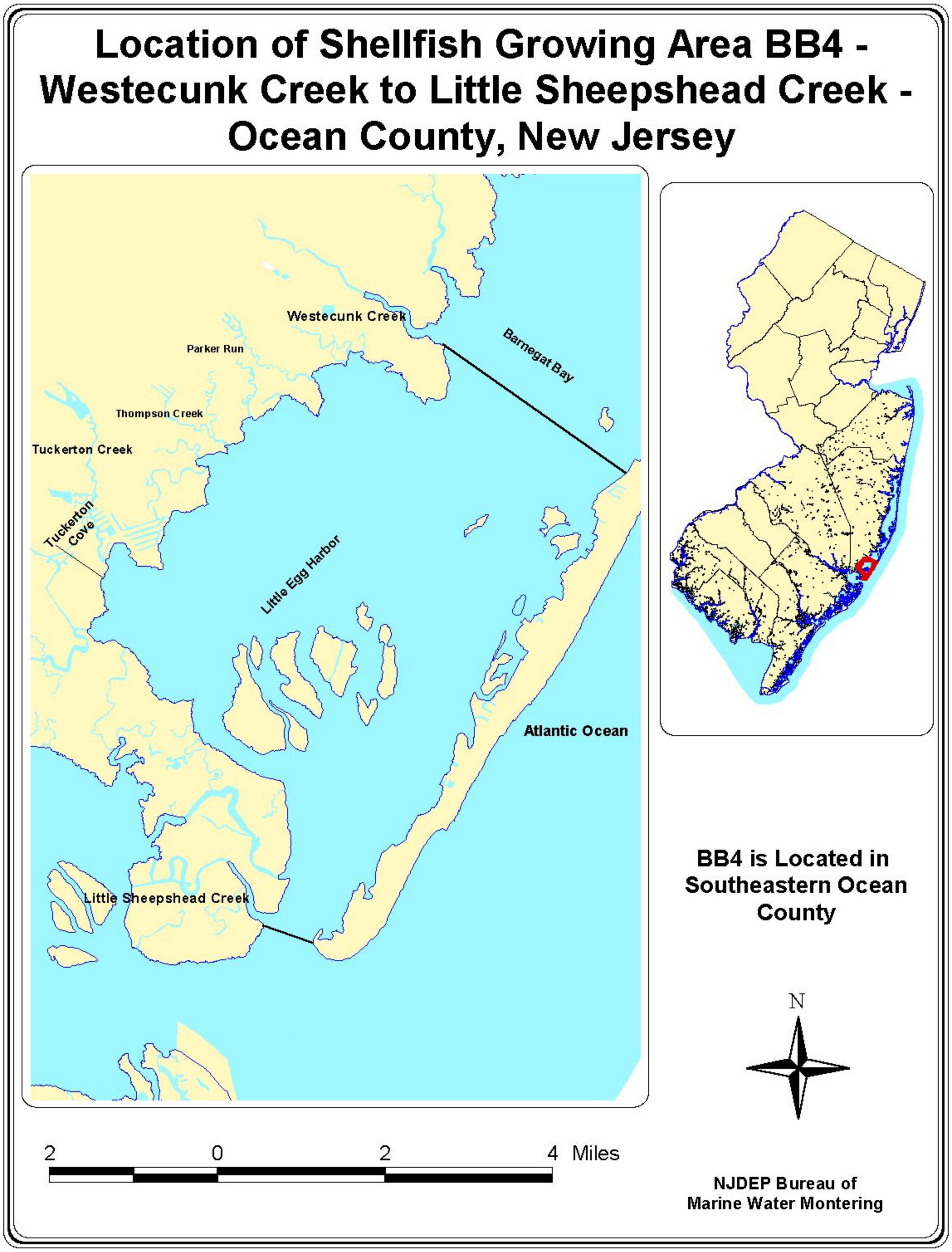


FIGURE 2: LOCATION OF SHELLFISH GROWING AREA BB4 - WESTECUNK CREEK TO LITTLE SHEEPSHEAD CREEK - OCEAN COUNTY, NEW JERSEY

DESCRIPTION

The majority of the shellfish growing waters present in this area are classified as *Approved* with several small sections of *Seasonally Approved, Special Restricted*, and *Prohibited* waters, which act as buffers for the developed sections of shoreline along the bay (see Figure 3).

Several smaller creeks such as Tuckerton Creek, Thompson Creek, Parker Run, and Westecunk Creek feed into the general body of water that comprises this shellfish growing area (Little Egg Harbor). Little Egg Harbor and a portion of Great Bay, located south west of BB4 are often considered to be the southerly portion of what many consider Barnegat Bay. The waters of this area eventually flow toward the Atlantic Ocean by way of the Little Egg Inlet.

There is a mixture of year-round and seasonal communities that surround this shellfish growing area. As a result, this area experiences greater population density during the late spring, summer, and early fall. Commercial development within this shellfish growing area is extremely limited. Although the area is not heavily populated, there has been an increase in residential development within the towns that comprise the western shoreline since the last report was written in 2002. This was evident during the recently conducted shoreline survey.

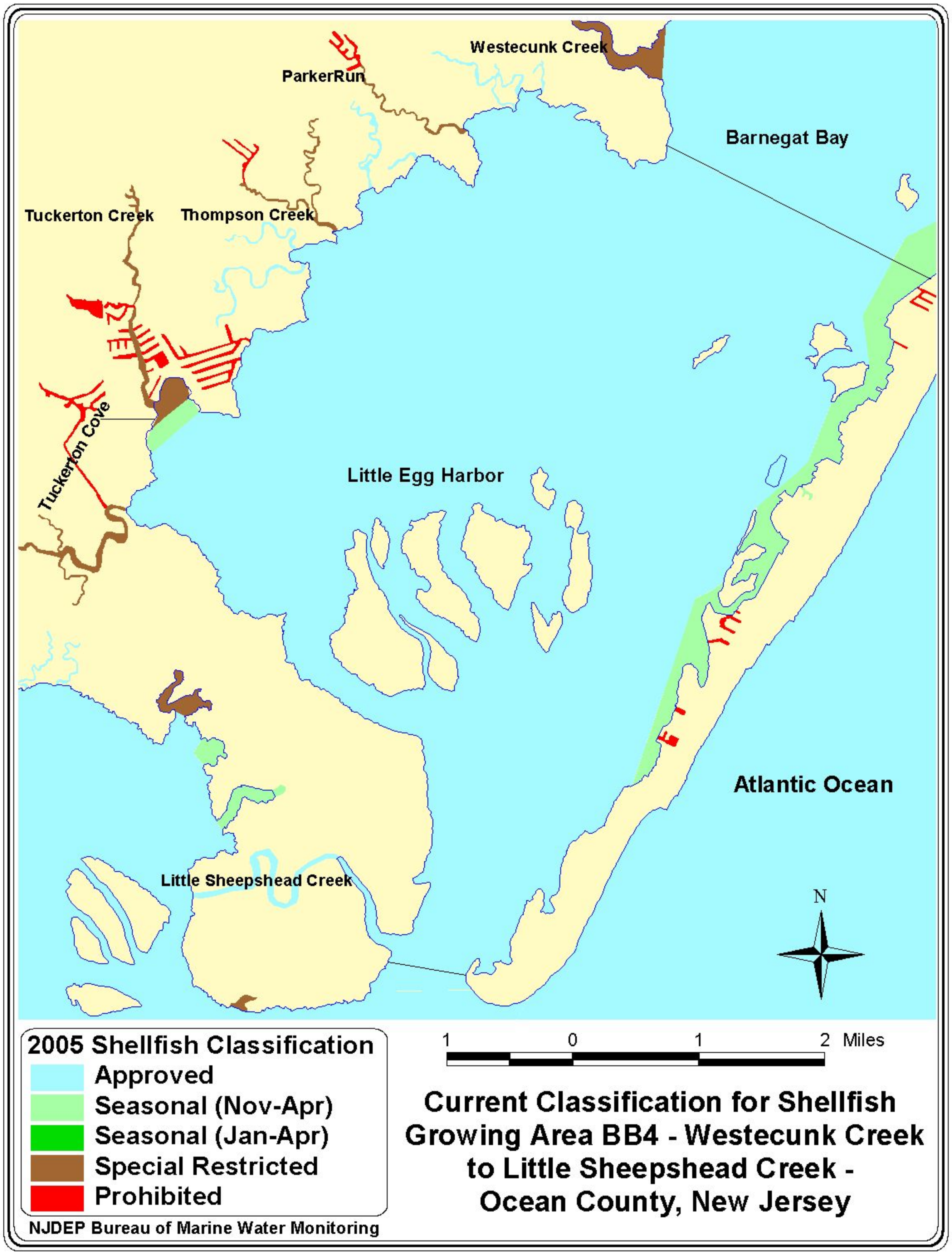


FIGURE 3: CURRENT CLASSIFICATION - SHELLFISH GROWING AREA BB4

HISTORY

Historically, baymen working the *Approved* and *Seasonally Approved* sections of this shellfish growing area have harvested hard clams (*Mercenaria mercenaria*) and soft shelled clams (*Mya arenaria*). However, the dominant molluscan shellfish species in this area is the hard clam, as minimal numbers of soft shelled clams are present.

Hard clams yielded 1,518,949 pounds of meat or 689.0 metric tons, and an exvessel value of $6,303,638 dollars in 2004, as reported to the National Marine Fisheries Service (NMFS).

Were shellfish to be harvested from *Special Restricted* waters, they would have to undergo either depuration or relay processes. Depuration is a process by which shellfish harvested from areas classified as *Special Restricted* are brought to a depuration plant where they are placed in a controlled environment supplanted by ultraviolet light in order to remove coliform bacteria. Relay involves a process in which shellfish can be harvested from areas classified as *Special Restricted.* Shellfish would then be brought or relayed to leased plots in waters classified as *Approved.* During relay, hard clams are required to remain in *Approved* waters for a minimum of 30 days in order to purge coliform bacteria from their systems. However, baymen have shown little interest in working the *Special Restricted* waters of BB4 within recent years.

The last Sanitary Survey covering this area was performed in 1993. The last Reappraisal was completed in 2000. There was a Partial Sanitary Survey completed in 2002. At the time the latter report was written, 45 acres at the mouth of Tuckerton Cove were upgraded to *Seasonal* (Nov – Apr) from *Seasonal* (Jan – Apr). The data analyzed in the above reports lent support to the current classifications shown for Shellfish Growing Area BB4, and these classifications remain unchanged for this reporting period.

METHODS

Water sampling was performed in accordance with the Field Procedures Manual (NJDEP, 1992). 3539 water samples were collected for total coliform bacteria between 2000 and 2004 and analyzed by the three tube MPN method according to APHA (1970).

Figure 4 shows the Shellfish Growing Water Quality Monitoring Stations from Westecunk Creek to Little Sheepshead Creek. There were 95 surface stations monitored during the time frame used for this reporting period. Water quality sampling, shoreline and watershed surveys were conducted in accordance with the NSSP *Guide for the Control of Molluscan Shellfish,* 2003.

Data management and analysis were accomplished using database applications developed for WM&S/BMWM. Mapping of pollution data was performed with the Geographic Information System (GIS: ARCMAP).

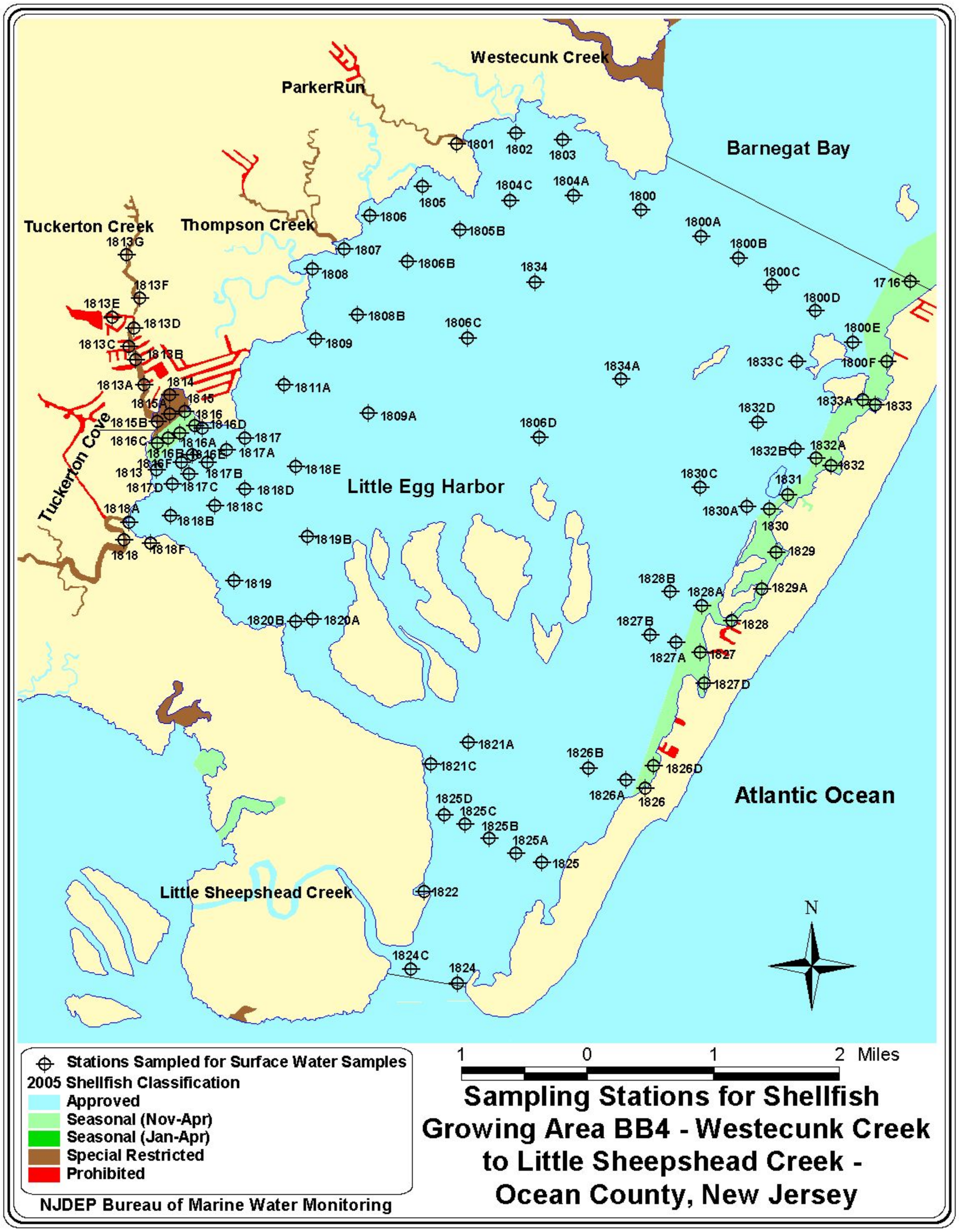


FIGURE 4: SAMPLING STATIONS - SHELLFISH GROWING AREA BB4

BACTERIOLOGICAL INVESTIGATION AND DATA ANALYSIS

The water quality of each growing area must be evaluated before an area can be classified as *Approved*, *Seasonally Approved, Seasonal Special Restricted,* or *Special Restricted.* In New Jersey, these classifications are stated as *Approved*, *Seasonal* (Nov-Apr), *Seasonal* (Jan-Apr), and *Special Restricted*.

Evaluation of *Prohibited* areas is not necessary unless a state intends to upgrade that area. Criteria for bacterial acceptability of shellfish growing waters are provided in the *NSSP Guide for the Control of Molluscan Shellfish,* 2003.

SAMPLING STRATEGY – NSSP CRITERIA

Each shellfish-producing state is directed to adopt either the total coliform or fecal coliform criterion for classifying shellfish growing waters. Combinations of these classification programs may also be used. Presently, New Jersey's growing water classifications for the back bay are based on total coliform data and analysis while the State's ocean waters are examined using NSSP criteria for analyzing fecal coliform data.

The primary reason for differentiation in our monitoring programs for coastal and back bay waters concerns the effluent discharged by wastewater treatment facilities off the coast of New Jersey. Total coliform can and will be present in effluent receiving waters surrounding wastewater treatment outfalls. However, WM&S/BMWM utilizes fecal coliform as a more species-specific bacteria associated with the influent that is treated and eventually discharged as effluent from these types of outfalls.

NSSP sampling strategies and analytical criteria were developed to ensure that shellfish harvested from the designated waters would be free of pathogenic (disease-producing) bacteria. The State Shellfish Control Authority also has the option of choosing one of two water monitoring strategies for each growing area. They are utilized in determining classifications for growing areas.

The strategies are Adverse Pollution Condition (APC) and Systematic Random Sampling (SRS). Each classification criterion is composed of a measure of the statistical 'central tendency' (geometric mean) and the relative variability of the data set.

For the APC Sampling Strategy, variability is expressed as the percentage that exceeds the variability criteria. For the SRS Strategy, variability is expressed as the 90^{th} percentile. Tables 1 and 2 are based on the 3-tube decimal dilution test and the statistical criterion for both APC and SRS strategies.

The APC Strategy requires that a minimum of five samples be collected each year under conditions that have historically resulted in elevated levels of coliform for the particular growing area. The results must be evaluated by adding the individual station sample results to the preexisting bacteriological sampling results to constitute a data set of at least 15 samples for each station.

Adverse pollution conditions are usually related to tide and rainfall although they could be from a point source of pollution or variation occurring during a specific time of the year. Under this strategy, for *Approved* waters, the total coliform median or geometric mean MPN of the water shall not exceed 70 per 100 mL and not more than 10% of the samples can exceed an MPN of 330 per 100 mL with the 3-tube decimal dilution test. For *Special Restricted* waters, the total coliform median or geometric mean MPN of the water shall not exceed 700 per 100 mL and not more than 10% of the samples can exceed an MPN of 3300 per 100 mL with the 3-tube decimal dilution test. Areas to be *Seasonally* classified must be sampled and meet the *Approved* criterion during the time of the year that they are approved for the harvest of shellfish.

The SRS Strategy requires that a random sampling plan be in place before field sampling begins. This strategy can only be used in areas that are not affected by point sources of contamination. A minimum of six samples per station are to be collected each year and added to the database to obtain a sample size of 30 for statistical analysis.

When considering 3-tube decimal dilution with regard to this strategy, the bacteriological quality of every sampling station in *Approved* areas shall have a total coliform median or geometric mean MPN not exceeding 70 per 100 mL and the estimated 90th percentile shall not exceed an MPN of 330 per 100 mL. The same criteria for *Seasonal* classifications are utilized with regard to time of year *Approved* for shellfish harvests. For *Special Restricted* areas, the bacteriological quality for SRS sampling strategies shall not exceed a total coliform median or geometric mean MPN of 700 per 100 mL and the estimated 90th percentile shall not exceed an MPN of 3,300 per 100 mL when utilizing the 3-tube decimal dilution test.

Shellfish Growing Area BB4 is an estuarine shellfish growing area within Little Egg Harbor that is sampled under the Systematic Random Sampling Strategy. This sampling strategy is utilized for BB4 because there are no wastewater treatment facility discharge pipes contributing influence or presenting the potential to routinely impact receiving waters. Historically, BB4 has shown statistically significant relationships for coliform levels relative to rainfall, tidal variations, and seasonal variations. However, impact has not been exhibited to an extent that warrants a change in sampling strategy from SRS to APC.

TABLE 1: CRITERIA FOR ADVERSE POLLUTION CONDITION SAMPLING STRATEGY

	Total Coliform Criteria		Fecal Coliform Criteria	
	Geometric mean (MPN/100 mL)	**No more than 10% can exceed** (MPN/100 mL)	**Geometric mean** (MPN/100 mL)	**No more than 10% can exceed** (MPN/100 mL)
Approved Water Classification	70	330	14	49
Special Restricted Water Classification	700	3300	88	300

TABLE 2: CRITERIA FOR SYSTEMATIC RANDOM SAMPLING STRATEGY

	Total Coliform Criteria		Fecal Coliform Criteria	
	Geometric mean (MPN/100 mL)	**Maximum 90th percentile** (MPN/100 mL)	**Geometric mean** (MPN/100 mL)	**Maximum 90th percentile** (MPN/100 mL)
Approved Water Classification	70	330	14	49
Special Restricted Water Classification	700	3300	88	300

MARINE BIOTOXINS

The Department collects samples at regular intervals throughout the summer to determine the occurrence of marine biotoxins. These data are evaluated weekly by WM&S/BMWM in accordance with the NSSP requirements. An annual report is compiled and is available electronically at *www.state.nj.us/dep/wms/bmw*.

In New Jersey's back bay and estuarine waters, there are occurrences of algal blooms although toxic species are not common in large numbers as evidenced by recent monitoring undertaken by the WM&S/BMWM. Algal blooms of non-toxic species, however, can occur at all times of the year.

The adverse effects of algal blooms on New Jersey's back bay waters primarily focus on aesthetics (e.g. non-toxic Brown Tides – causing water discoloration), and the potential for lost revenues in tourism. Brown Tides usually start up in the back bays during early to mid-spring. As these tides grow in size, they frequently work their way toward the ocean via inlets. This usually occurs during late spring or early summer.

There are no known threats to human health from Brown Tides. However, brown tides can create aesthetically unpleasant circumstances with regard to discoloration and the general appearance of our intercoastal water resources. This in turn, negatively impacts recreational activities such as swimming, boating, and fishing. Additionally, brown tide algal blooms can reduce shellfish growth via an inhibitory substance on the cell surface, which reduces feeding response in some molluscan shellfish such as the hard clam. Aquaculturalists involved in farming the hard clam have noted the loss of clam seed as per this inhibition of feeding or filtering response.

Brown tides can also reduce habitat important to many marine organisms. As the algal population grows, it reduces the available light normally provided to marine vegetation. This loss of light causes the flora (especially eelgrass) to die off. This, in turn, disrupts the food web causing a reduction in finfish and shellfish populations.

Again, it is more frequently the discoloration of the water that causes issues along New Jersey's coastal waters rather than the toxicity of the phytoplankton. However, as noted above, New Jersey does incorporate marine water monitoring for potential toxicity in shellfish with regard to any notable presence of toxic marine phytoplankton. No occurrences of algal blooms connected with the presence of biotoxins have been recorded for the time period covered by this report.

SHORELINE SURVEY

EVALUATION OF BIOLOGICAL RESOURCES

Approximately 98% of BB4 shellfish growing waters are currently classified as *Approved or Seasonally Approved* for the harvest of shellfish. Areas designated as *Seasonally Approved* can only be harvested during winter months. The specific months during which a *Seasonally Approved* area can be harvested are November through April (six months) or January through April (four months), depending on the variation of water quality within these time frames. At present, there are no waters in BB4 that are classified as *Seasonal* (Jan – Apr).

The percentage presented in the preceding paragraph implies that there are a substantial amount of waters currently available or classified for direct harvest of shellfish in BB4. For this and many other reasons, the Barnegat Bay Estuary, which contains the waters of BB4 or Little Egg Harbor, is considered a very valuable ecological, biological, recreational, and commercial resource. As a result of its natural and economic value, the Barnegat Bay was made a part of the National Estuary Program in July of 1995 by the USEPA.

There are many species of flora and fauna that integrally comprise this estuary. Together, these plants and animals provide NJ with a very unique estuarine community. This presents the task of creating a conservative balance between the species (plant, animal, and human) that live and interact within and about the system.

Currently, the two most important shellfish species from a recreational and commercial standpoint are the blue crab (*Callinectes sapidus*) and the hard clam (*Mercenaria mercenaria*). For the purpose of this report, the focus is predominately placed on the hard clam.

As noted in the Profile section, there have been several other shellfish species of historical importance within BB4. However, as suggested in that part of the report, the numbers of hard clams taken from these and other waters of the Barnegat Bay Estuary, in conjunction with that species' ex-vessel value, make this one of today’s most important shellfish species from an economic perspective for New Jersey.

The numbers reported by NMFS for total pounds of clam meat landed or reported as landed for New Jersey waters seems to have remained relatively the same (near 1.5 million pounds/year) for the 2000 – 2004 time frame utilized in this report. However, the consensus through conversation with participants in the local clamming industry suggests populations of hard clams in New Jersey's back bay waters, including the waters of BB4, are dwindling.

It is not clear what has caused the decline in hard clam populations within the State. Perhaps the numbers of hard clams are growing smaller from over fishing. It is also possible that non point inputs, coupled with the increase in development within and around the estuarine system, are to blame. As residential and commercial development increases, degradation and depletion to ground water sources and any number of other contributors such as stormwater runoff can be culprits in estuarine species decline. It is more likely a combination of many such variables.

Preservation of estuarine systems such as the Barnegat Bay Estuary will require ongoing monitoring and research. Specific areas of study such as non point pollution, habitat degeneration, and the potential for regeneration of species populations and species habitats should be mixed with a better understanding of citizens’ impact when utilizing the ecosystems surrounding our environment. These are important issues for monitoring and research, and topics such as non point pollution will be discussed in this report from a monitoring perspective.

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LAND USE

The vegetative communities that comprise the ecosystems surrounding this shellfish growing area are generally composed of either wetland or pineland forest species. Urban environments are interspersed and make up the primary development in the area.

There is little agriculture connected with the lands abutting this shellfish growing area. There is some light agricultural use further inland to the west and northwest. However, there is distance separating areas involved in agriculture from the waters of BB4. As such, potential impact from runoff bearing fecal waste from domesticated farm animals is not generally of concern.

On the mainland side of the bay, there are large areas of wetlands, which become forested lands further inland (see Figures 5-6). Further, substantial wetlands make up the protected lands of the Edwin B. Forsythe National Wildlife Refuge and the Great Bay Wildlife Management Area. Generally, the barrier islands that make up the eastern side of BB4 will have sporadic areas of wetlands located in or alongside the bay.

Aside from contributing to productivity, wetland and estuarine zones provide valuable habitat for many marine species during some point of their life cycle. Plants within these zones also remove excess inorganic and organic nutrients. This, in turn, provides nutrition for salt marsh vegetative species. With this, salt marsh flora can act as water purifiers by preventing some contaminants from making their way through the food chain.

Projects bordering on eco-sensitive areas are required by local, state, and federal regulations to utilize specific set-backs and buffers as a means of protecting flora and fauna specific to wetland, riparian, or estuarine locations. Feral animal populations also make their homes in salt marsh locations or utilize these areas while migrating along the coastal waters of New Jersey. This wildlife can impact state waterways by contributing increased counts of coliform bacteria through fecal waste.

Coliform bacteria increase can be observed when sampling from waters where flocks of wild birds utilize wetland locations within the State's shellfish growing areas. This occurs when fecal waste from bird populations is deposited directly into the waters or carried into the system by stormwater runoff.

The mainland side of Little Egg Harbor has dispersed urban development in Eagleswood Twp., Tuckerton Boro, and Little Egg Harbor Twp.. These municipalities can be seen in Figure 7.

Large sections of urban developed areas on the mainland side of the bay are comprised of lagoon communities. These communities consist of lanes of dredged lagoons (canals) running through developed residential communities. The canals provide access to the bay for boat traffic. Although the lagoon and bayfront communities of BB4 have a sizable year-round population, pollutants from these areas are generally more prevalent during the summer when population and utilization tend to rise in such locations.

As lagoon communities are frequently the choice for recreational boaters, this activity can provide impact to these waters. While marina pumpout stations are available, boat owners do not always utilize them. This results in human waste being discharged overboard. Further, petrochemicals are added to bay and lagoonfront waters during operation of boats, as marine engine fuels are not fully utilized by two cycle engines during combustion. Unspent fuels can collect or be most prevalent in lagoonfront communities and marinas. Petrochemicals from automotive traffic are also washed into these areas via stormwater outfalls.

Runoff can also impact lagoon communities when pollutants are concentrated over time, depending on levels of rain, wind, and tide. Because of this, lagoons are classified as *Prohibited* waters. Further, the mouths of most lagoons are classified as *Seasonally Approved* or *Special Restricted* waters, thus providing additional buffers.

Many of the urban communities associated with BB4 (including the coastal areas) have storm drains that collect runoff and convey it to outfalls, which empty into the bay. Impacts can also occur from pollutants supplied by streams and creeks located to the west.

Stormwater runoff from developed communities in outlying urban areas may contain fecal waste from domestic pets, petroleum residuals from cars, and other pollutants. Pollutants within these stormwater systems have often been held for some time before receiving enough water to flush or purge the infrastructure, thus creating stormwater impacts to bay water quality.

The barrier islands to the east of BB4 also provide input to the waters of this shellfish growing area, as noted previously. Aside from stormwater runoff, which in most cases is oriented toward the bay, barrier island communities have a substantial number of lagoonfront communities and marinas. These areas, however, are appropriately classified and buffers have been utilized for marinas and lagoonfront entrances.

Development along the coast is also urban and presents many of the same problems/challenges as those discussed in the preceding paragraphs. As populations along the shore grow during the warmer months, due to increased shore rental and homeowner use, so do the impacts to the nearby waterways and shellfish growing areas.

The communities along the shore and some of those to the west are utilizing city water and sewer. However, there are quite a number of homes on the mainland side of the bay, further west and northwest, utilizing septic and wells.

Beach Haven Inlet allows for interaction of waters of this area with the Atlantic Ocean. Ocean waters bordering this site consist of *Approved* waters and are unlikely to cause adverse impact. Rather, the tidal flow and mixing of estuarine waters with the Atlantic Ocean helps flush the waters of BB4, reducing the accumulation of pollutants.

Numerous small tidal creeks and streams also empty into these shellfish growing waters. These include Westecunk Creek (West Creek), Parker Run, Thompson Creek, Tuckerton Creek, and Little Sheepshead Creek.

Many of the creeks or streams noted above are classified as *Special Restricted*, with portions having also been delineated as *Prohibited* depending on the degree of urban development and subsequent input to the waterway. *Special Restricted* or *Seasonally Approved* buffer zones are often used at the mouths of these waterways to prevent adverse impact to the *Approved* waters of this shellfish growing area.

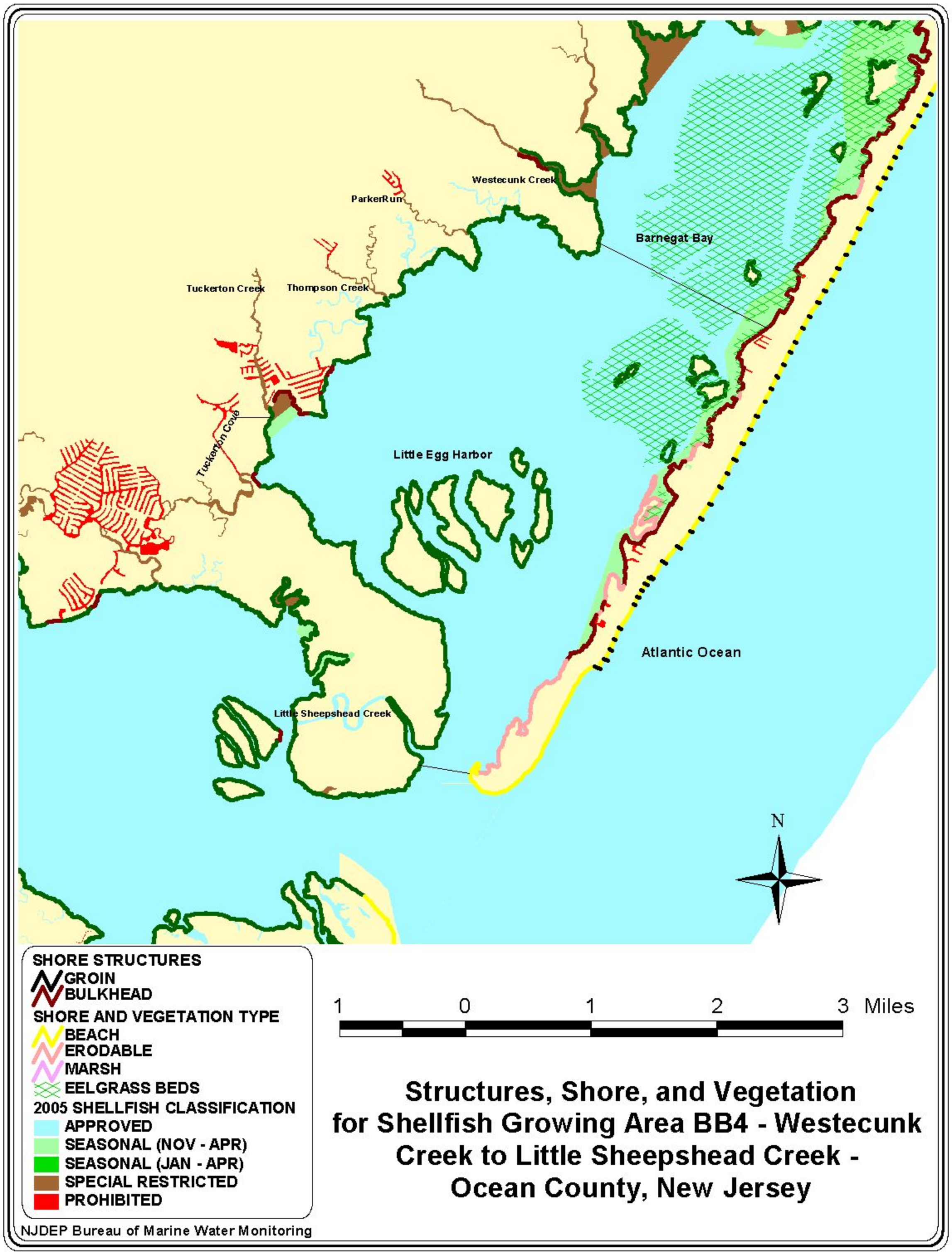

FIGURE 5: STRUCTURES, SHORE AND VEGETATION - SHELLFISH GROWING AREA BB4

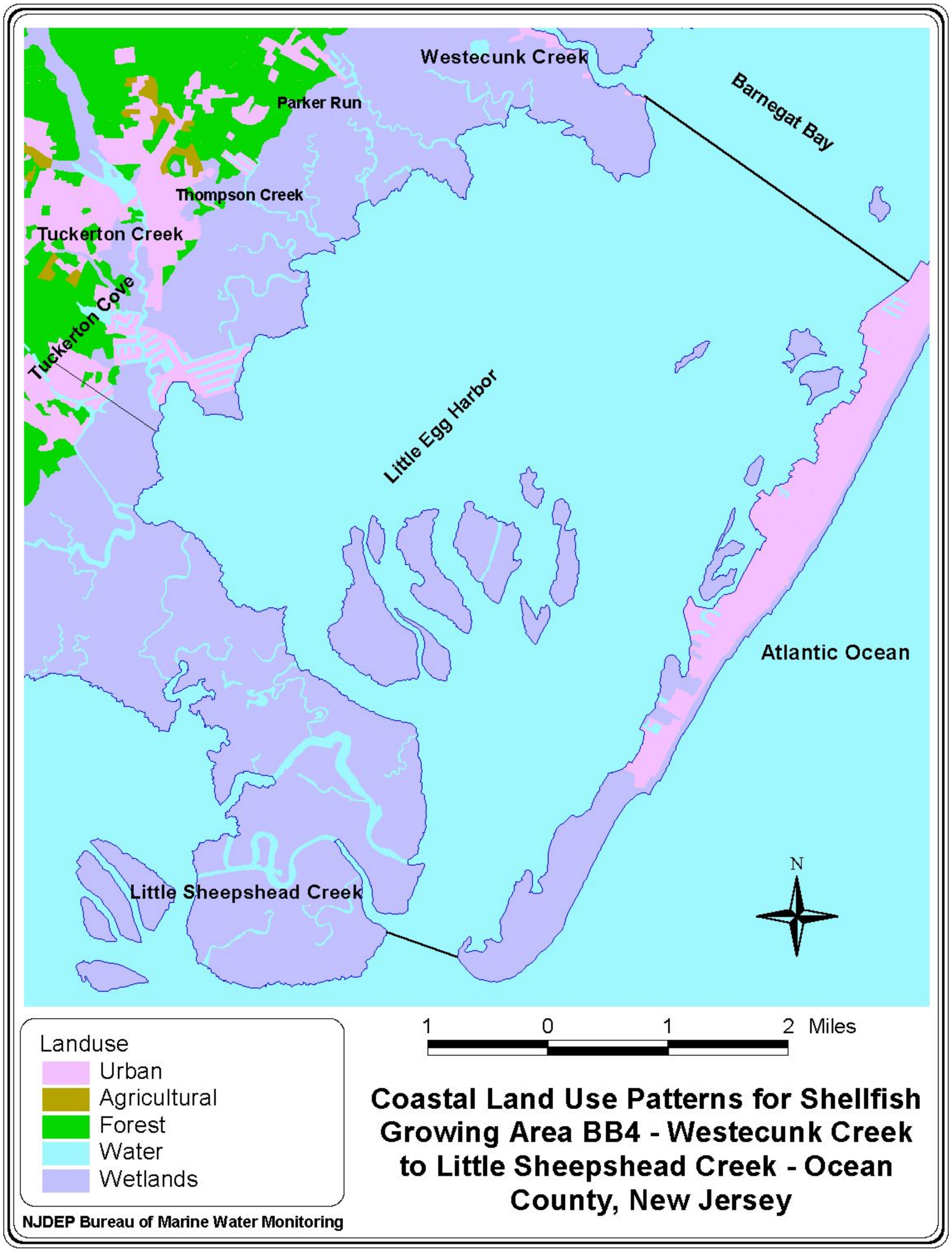

FIGURE 6: COASTAL LAND USE PATTERNS - SHELLFISH GROWING AREA BB4

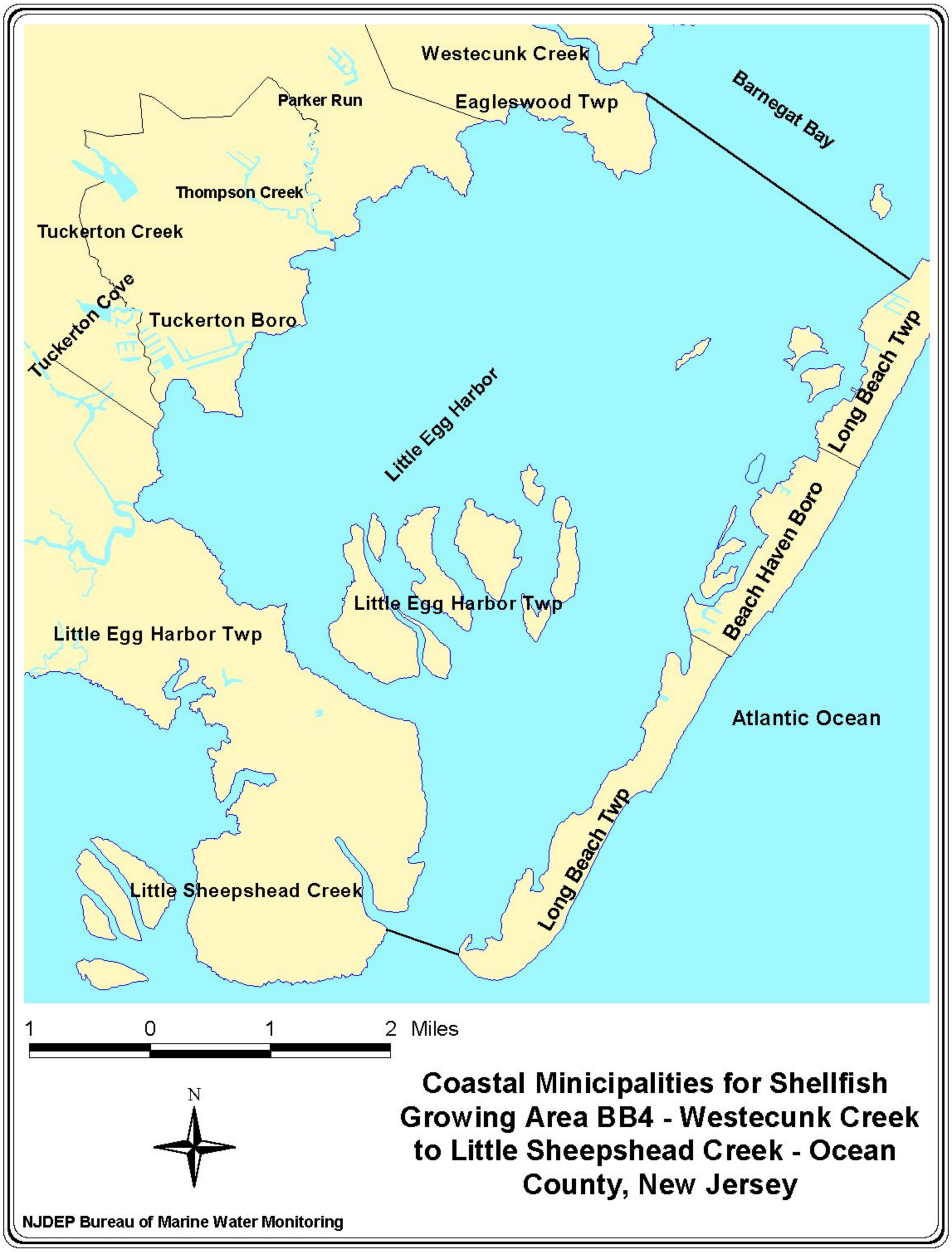

FIGURE 7: COASTAL MUNICIPALITIES - SHELLFISH GROWING AREA BB4

IDENTIFICATION AND EVALUATION OF SOURCES

DIRECT DISCHARGES

There are no direct discharges from factories, wastewater treatment facilities, or generating stations in Shellfish Growing Area BB4. Although some nearby residences utilize septic systems, wastewater from communities and businesses in this area is generally treated at the Ocean County Utilities Authority - Southern Water Pollution Control Facility. Treated effluent is then discharged into the ocean east of 5th Street in Ship Bottom. The ocean location for this discharge (or the outfall) is some distance from the bay-side location of growing area BB4. As a result, it would have no impact on the waters classified for this site.

INDIRECT DISCHARGES

Nonpoint sources contribute to indirect discharge of pollutants. With this, the source of contaminants or discharge is not specific as in the case of point or direct discharge. Nonpoint contributors include stormwater runoff, contaminated sites, individual transportation vehicles such as cars or boats, and other potential sources of contaminants. The USFDA (2001) defines Nonpoint Source Pollution as "contaminant loading received by bodies of water from sources related to the activity of humans or to natural processes in the watershed which are diffused or dispersed."

Stormwater outfalls provide the primary conduits for nonpoint sources reaching the waters of BB4, although there are other sources, which will be discussed in sections that follow.

SPILLS OR OTHER UNPERMITTED DISCHARGES

There were no spills recorded that resulted in closure of the waters of BB4 during the time period covered in this report. However, there are contaminated sites outside the growing area, and their potential to impact the waters of this site will be described within this section.

Of the contaminated sites identified for this region, few are located in close proximity to the shoreline of BB4. Any that are closer to the shoreline have primarily been identified as service stations with storage tanks that leaked.

Remedial action to eliminate any contamination is required of the responsible parties at each of these locations. WM&S/BMWM works closely with the NJDEP Site Remediation Program to ensure that potential contaminants from these sites do not reach shellfish growing waters.

Generally, the sediment surrounding underground fuel tanks will naturally attenuate (absorb) any contaminants discharged to soil from the tanks. As such, there is reduced risk for these contaminants to reach marine waters through soil absorption. Further, there is some distance from most underground storage tank locations to this shellfish growing area. If ground waters are contaminated, substantial dilution should occur between the petroleum leaching source and these growing waters.

Were petroleum products to reach the waters of this shellfish growing area, they would likely cause minimal impact to its shellfisheries during the short term. Petrochemical materials do not mix well with water, having a tendency to float on the surface. As shellfish are bottom dwellers, it could take some time for an impact to occur from petrochemical release.

In addition, an oil spill in a shellfish growing area like BB4 would probably be noted rather readily. It is likely that much of the spill could be cleaned up prior to any major contamination of the shellfishery in this growing area.

MARINAS

Marina facilities have the potential to affect the suitability of shellfish growing areas for the harvest of shellfish. The biological and chemical contamination associated with marina facilities may be of public health significance.

The State of New Jersey Shellfish Growing Water Classification Charts define a marina as "any structure (docks, floating docks, piers, that supports five or more boats) built on or near the water which is utilized for docking, storing or otherwise mooring vessels and usually but not necessarily providing service to vessels such as repairing, fueling, security or other related activities" and designates the confines of the marina as *Prohibited* for the harvest of shellfish. Adjacent waters are classified utilizing a dilution analysis formula or formulas, in conjunction with marina occupancy rates, and more specific criteria when necessary.

It is recognized by the NSSP *Guide for the Control of Molluscan Shellfish*, 2003, that there are significant regional differences in all factors that affect marina pollutant loading. The manual, therefore, allows each state latitude in applying specified occupancy and discharge rates. The NSSP guidelines assume the worst case scenario for each factor.

$$BufferRadius(ft) = \sqrt{\frac{2x10^9(FC/person/day)x2(person/boat)x[(.25slips \geq 24') + (0.065 \times slips < 24')]x2}{140000(FC/M^3)xdepth(ft)x0.3048(M/ft)x\pi x2(tides/day)}}x3.28(ft/M)$$

EQUATION 1: NJ MARINA BUFFER EQUATION (ADAPTED FROM FDA - 1989)

Explanation of terms in equation:

Fecal coliform per person per day:	2×10^9
Number of people per boat:	2
For slips able to accommodate boats > 24 feet (combination of factors yields multiplier of 0.25):	
Number of slips occupied:	50%
Number of boats occupied:	50%
For boats < 24':	6.5% discharge waste
Angle of shoreline:	180^o, which results in factor of 2
Number of tides per day:	2
Depth in meters:	depth in feet x conversion factor
Water quality to be achieved:	140000 FC/meter ^{3}
Convert meters to feet:	3.28

Marina buffer zones may be calculated using the formula above or may be determined using a dilution analysis computer program, developed by the State of Virginia and the USFDA. The formula above considers dilution and occupancy rates. The computer program is utilized for complex configurations, calculating in tidal exchange and bacterial die-off as well.

There are 31 marinas in Shellfish Growing Area BB4. Marinas and marina locations can be noted in Figures 8-9. Generally, the marinas are concentrated along the backbay waters of Long Beach Island from Beach Haven (Beach Haven Boro) to Holgate (southern end of Long Beach Twp.) and within Tuckerton Creek (Tuckerton Boro) and along Seven Bridges Road (Little Egg Harbor Twp.).

The majority of the marinas are located within or just outside developed urban areas. In addition, marinas in BB4 are located outside lagoon and bayfront communities, cove areas, and streams. There are no marinas on the most southern section of the barrier island shown in Figure 9, as that section is part of the Forsythe National Wildlife Refuge.

As mentioned before, the waters enclosed by marinas are classified as *Prohibited* (New Jersey). Depending on the size of the marina and water quality, the waters immediately adjacent to each marina may be classified as *Prohibited*, *Special Restricted*, or *Seasonally Approved* (no harvest during summer months when the marina is active).

Marina buffer zones were calculated using the NJ Marina Buffer Equation (see equation 1 above) in conjunction (when more specific parameters are necessary) with the computer model developed by the State of Virginia and the USFDA. The names of marinas, number of boat slips, and size of buffer zones are shown in Table 3.

FIGURE 8: SKINNER'S MARINA - SHELLFISH GROWING AREA BB4

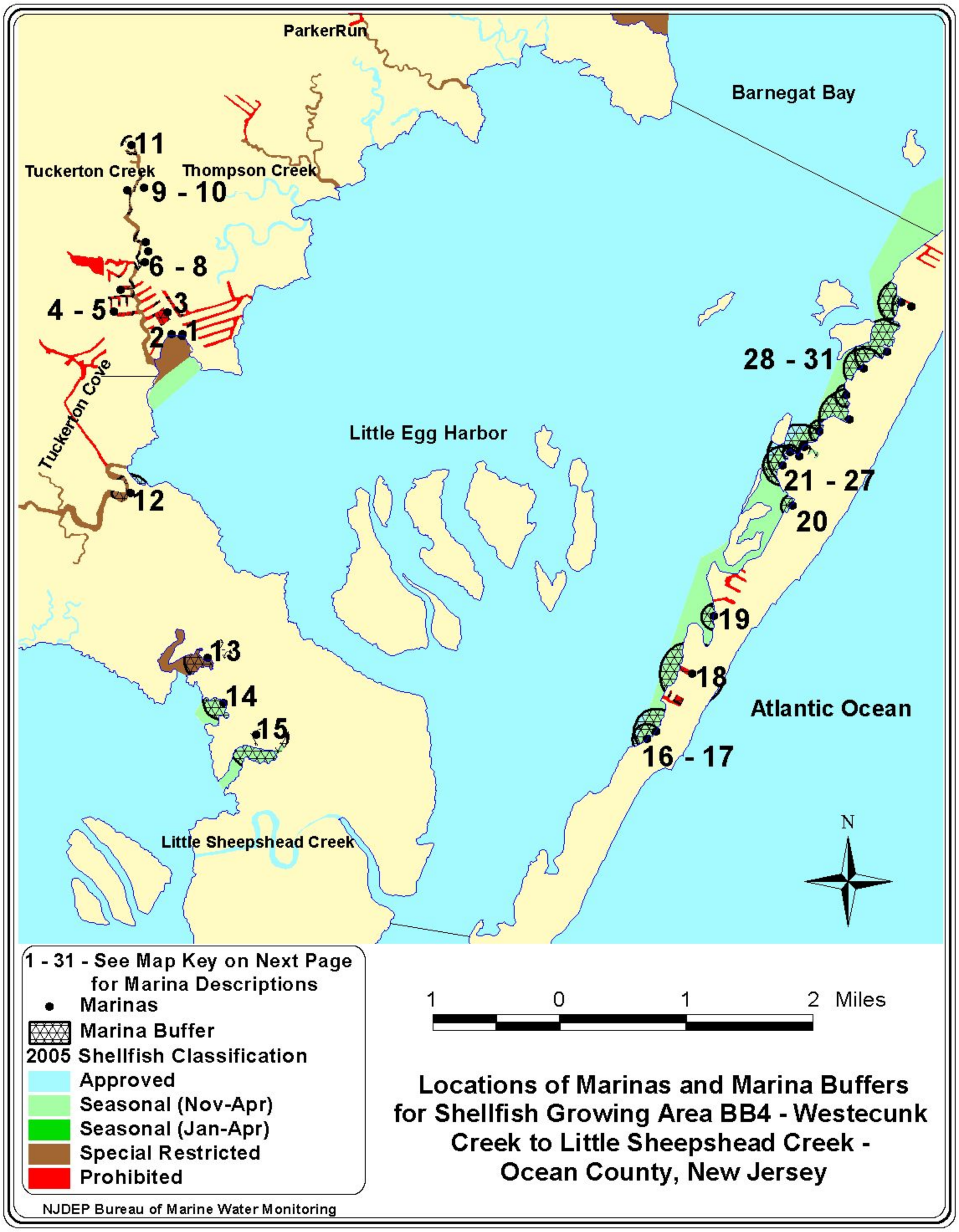

FIGURE 9: LOCATIONS OF MARINAS AND MARINA BUFFERS - SHELLFISH GROWING AREA BB4

TABLE 3: MARINA FACILITIES LOCATED IN SHELLFISH GROWING AREA BB4

Map Key	Marina Name	Total # of Boat Slips	# of Slips over 24 ft	Size of Buffer Area (radius; feet)
1	Capt. Speck's	5	0	186
2	Bill's Marina - Closed	0	0	0
3	Shelter Cove Marina	105	25	606
4	Total Marine	90	35	812
5	Schimpf's Marina	70	22	555
6	Marina 470	25	5	405
7	Tuckerton Marine Servicenter	55	8	570
8	Cedar Cove Marina	62	12	501
9	Skinner's Marina	65	35	927
10	GEB Marine	53	10	652
11	Stewart's Basin	15	5	391
12	First Bridge Marina	30	30	776
13	Cape Horn's	117	24	983
14	Rand's Boats	80	2	772
15	Capt. Mike's	62	35	1299
16	Woehr's Marine Dock	51	14	616
17	Lindy's Trailer Park & Marina	30	19	937
18	Penna's Marina	160	65	1342
19	Southgate Marina	27	10	538
20	Little Egg Harbor Yacht Club	60	3	488
21	Beach Haven Yacht Club	54	36	808
22	Black Whale Dock	10	6	307

Map Key	Marina Name	Total # of Boat Slips	# of Slips over 24 ft	Size of Buffer Area (radius; feet)
23	Morrison's Rest. & Marina	136	100	1325
24	Beach Haven Marlin & Tuna Club	8	4	225
25	Harborview Club & Marina	24	2	454
26	Shelter Harbor Marina	205	120	1277
27	Eastern Marine	35	9	459
28	Sportsman's Marina	70	12	851
29	Spray Beach Yacht Club	130	80	1366
30	Southwick's Marina	90	45	954
31	Escape Harbor Marina	66	40	791

WETLANDS

Mosquito ditching and the use of pesticides are two practices which may cause impact to the waters of this shellfish growing area. Specifically, scientists have questioned the cost, benefit, and risk of such practices. Although this report does not attempt to assess these practices, their potential impact is worth noting.

Mosquito ditching has been utilized extensively as part of insect control in this region and has been utilized in the marshlands near BB4. The design premise behind this ditching involves creating a tidal path for small fish to maneuver in order to feed on mosquito larvae concentrated in the ditches. Proponents of its design also suggest that ditching reduces the standing water associated with salt marsh ecosystems, thereby reducing the potential area mosquitoes have for breeding or propagating.

The past and present use of pesticides and their potential for impacting coastal and intercoastal ecosystems is worth noting. Again, the question of cost, benefit, and risk associated with such practices arises, and should always be weighed. Further, any introduced substance or organism added to a biosystem can cause change to that system.

LAGOON AND BAYFRONT COMMUNITIES

Shoreline surveys conducted in this shellfish growing area have helped to delineate Tuckerton Boro, Eagleswood Twp., Beach Haven Boro, and Long Beach Twp. as larger urban developments, which include lagoon and bayfront communities, in the vicinity of BB4.

Lagoon and bayfront communities like the above are of specific interest when viewing the land, development, and use of environs surrounding this shellfish growing area. The potential for indirect discharge into the surrounding waters is enhanced within these communities.

As mentioned in the previous section on Land Use, lagoon communities are residential developments which have dredged lanes (canals) or lagoons that allow access to the bay for most residents of the community. The canals in a lagoon community can contain bacterial contamination received from stormwater runoff, and generally there are numerous stormwater outfalls within these types of urban areas.

Boating also contributes its share of pollutants to the waters of lagoon and bayfront communities. Impacts can be caused by or include spills containing petroleum products utilized in motors and during fueling and reconditioning processes. Further, cleaning materials used in the maintenance of marine vessels can also contribute a source of pollution.

The preserved wood (CCA – pressure treated lumber) used to make bulkheads and docks contains various heavy metals such as arsenic, chromium, and copper. These substances can also leach into shellfish growing areas where this lumber comes in contact with the water. CCA is utilized in lagoon/ bayfront communities, marinas, and within many of the communities located along streams or creeks that feed into the waters of BB4.

As shellfish can receive bacterial contamination from indirect pollution sources within lagoon and marina proper locations, these areas are classified as *Prohibited*. In order to prevent impact to *Approved* waters outside these locations, buffers are utilized. Buffers may be *Prohibited*, *Special Restricted*, or *Seasonally Approved* classifications.

STORMWATER INPUTS

There are numerous stormwater outfalls located along the shoreline and along streams and waterways that empty into the back bay waters of BB4, as can be seen in Figure 10. Most of these outfalls are concentrated in the areas from Parker Run to Tuckerton Creek (western side of the bay), and Beach Haven (eastern side of the bay).

Runoff from rain events can carry a variety of materials including fecal waste from domestic pets, and feral animals living in or within close proximity to urban neighborhoods near these growing waters.

Stormwater runoff also contains other materials. Specifically, it is common for the remains of dead animals, petroleum by - products from cars and trucks, and fertilizers to find their way into our coastal and intercoastal water resources from stormwater outfalls.

Bird populations living in wetland and forested areas upstream deposit fecal waste which can be picked up by runoff from storms. Flocks of waterfowl can also deposit waste directly into the waters of this area.

Stormwater runoff in this area is not always channeled to storm drains but frequently flows over land, and into streams. Large wetland or wooded areas can have a cleansing effect on waters flowing through them. Generally, stormwater runoff is not as problematic in wooded and wetland regions as it is in more developed areas.

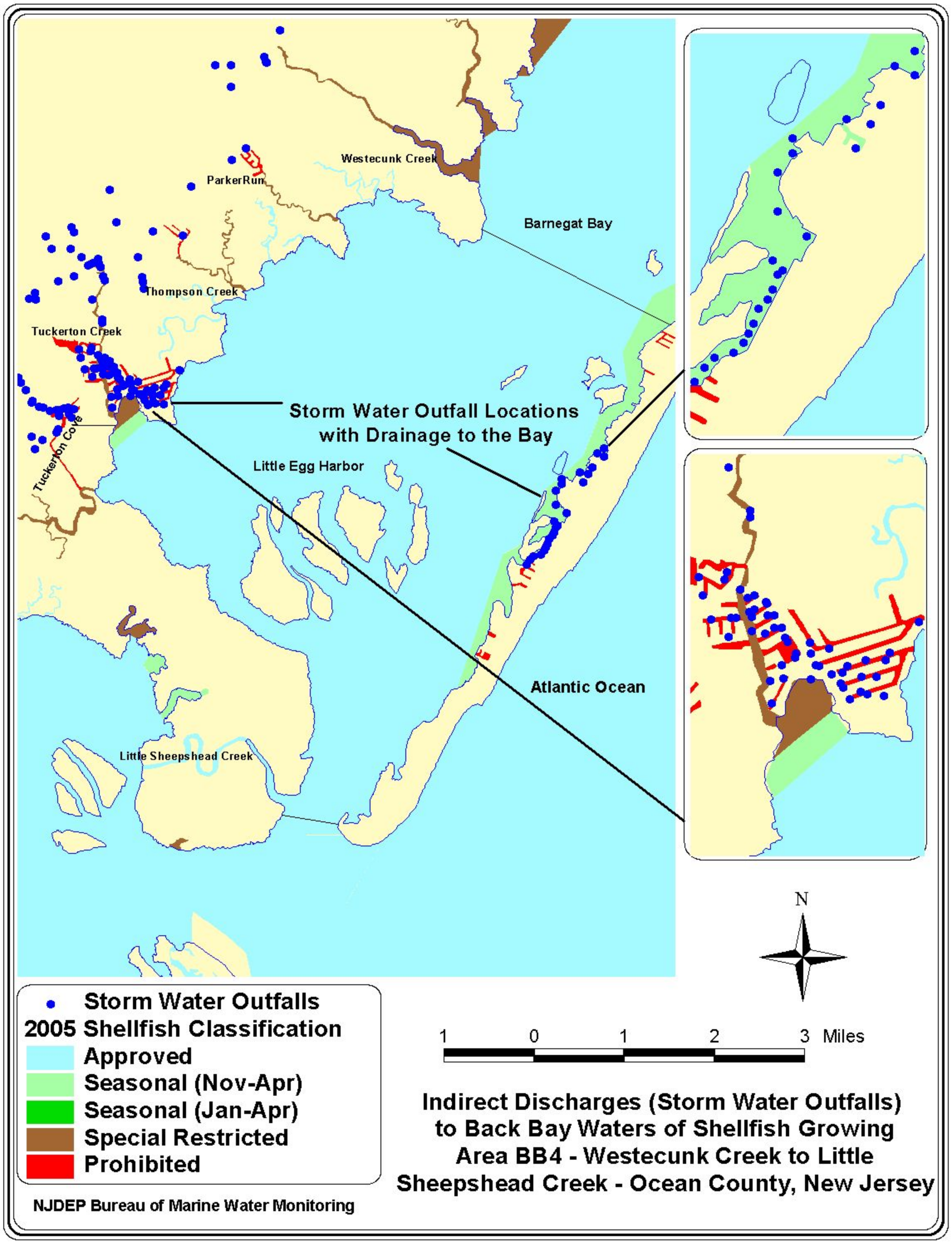

FIGURE 10: INDIRECT DISCHARGES (STORM WATER OUTFALLS) TO BACK BAY WATERS - SHELLFISH GROWING AREA BB4

STORMWATER IMPACT STUDIES

Non-point source pressures on shellfish beds in New Jersey originate in materials that enter the water via stormwater. These materials can include coliform bacteria, along with a variety of chemicals from urban runoff that enter stormwater collection systems.

Historical data comparing the difference between coliform levels measured after rainfall with those during dry periods were compared to generate New Jersey's more frequent storm impacted locations, which can be seen in Figure 11. WM&S/BMWM has begun to identify particular storm water outfalls that discharge excessive bacteriological loads during storm events. In some cases, specific discharge points can be identified. When specific outfalls are identified as significant sources, the Department works with the county and municipality to further define the source(s) of the contamination and implement remediation activities.

It should be noted that a particular short-term data set might not indicate significant rainfall effects even if the historical data indicates that a significant effect occurs in a particular area. This is due to one or more of the following factors:

- Data during the short term may consist of primarily rainfall data or dry weather data. In this case, if there are insufficient data points in each category, the test for significance can not be done.
- Data collected after rainfall in the normal sampling regime may miss the effects of the "first flush."
- Rainfall data are based on the closest established NOAA station. Since rainfall patterns along the coastline, particularly during the summer months, tend to include locally heavy rainfall, the rainfall amounts recorded at the NOAA station may not accurately reflect the rainfall at the sampling station(s).

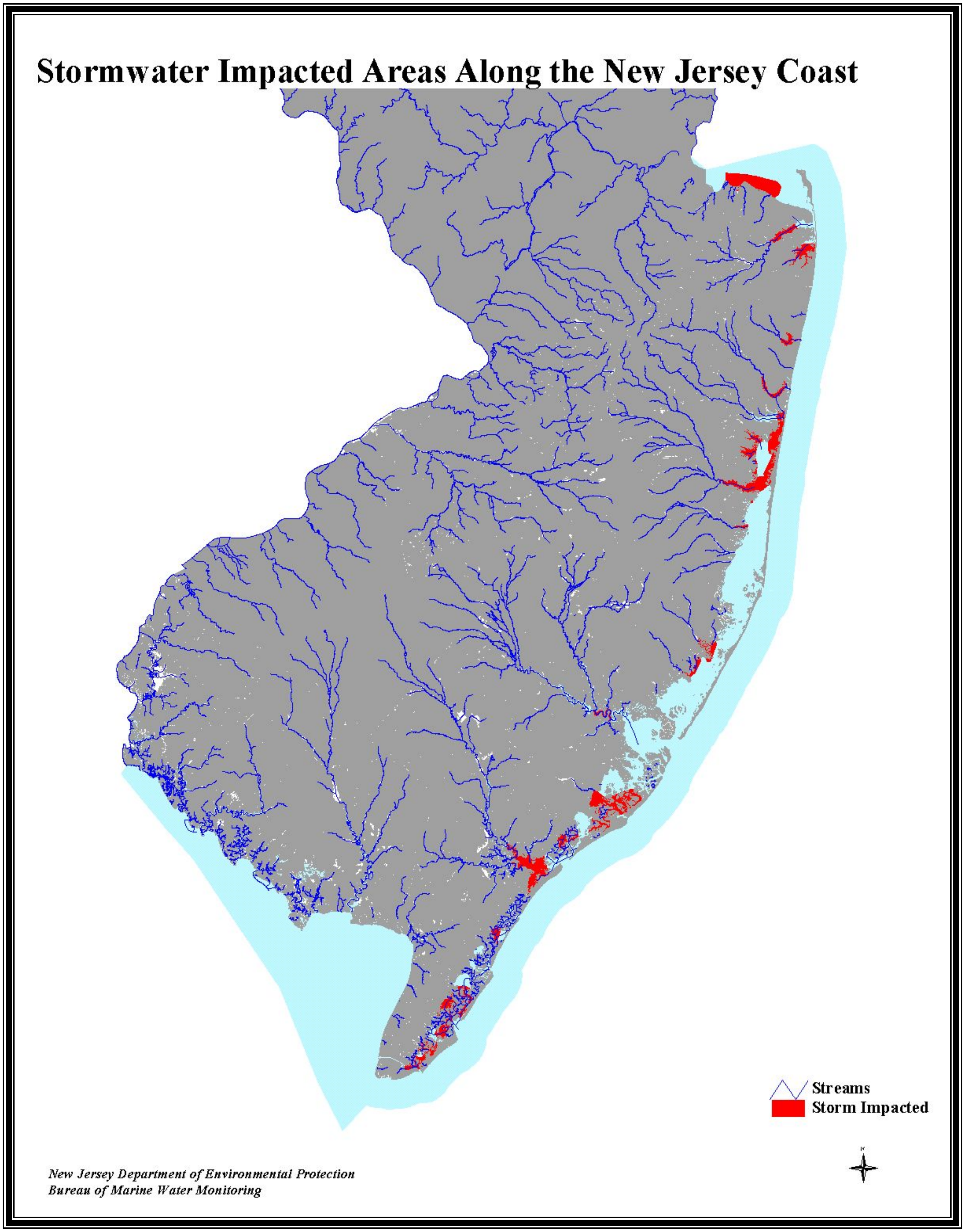

FIGURE 11: AREAS IMPACTED BY STORMWATER

HYDROLOGY AND METEOROLOGY

PATTERNS OF PRECIPITATION

Precipitation patterns such as those shown in Tables 4-5 are typical for the coastal areas of New Jersey and the Mid-Atlantic coastal region. Summer storms are localized. Winter storms are frequently linked to northeasters. Hurricanes can occur during the summer and early fall.

TABLE 4: AVERAGE MID-ATLANTIC STORM EVENT INFORMATION.
SOURCES: USEPA; US DEPARTMENT OF COMMERCE

Annual Average Number of Storms	60
Average Storm Event Duration	10 hours
Average Storm Event Intensity	0.08 – 0.09 inches/hour
Average Storm Event Volume	0.65 inches

Although the average storm event lasts approximately 10 hours, with an accumulation of 0.65 inches, it is not unusual for an individual storm volume to be 2 – 3 inches. Note the data below that shows the 2-year return, 6-hour storm event to be between two and three inches, while the 2-year, 24-hour return volume varies between three and four inches. Storm volumes greater than approximately 3.5 – 4.0 inches are much less frequent.

TABLE 5: STORM EVENT VOLUME FOR 2-YEAR STORM EVENT RECURRENCE (SOURCE: USGS)

Location	2-Year, 1-Hour Rainfall	2-Year, 6-Hour Rainfall	2-Year, 24-Hour Rainfall
Millville	1.33	2.33	3.02
Cape May	1.33	2.41	3.10
Atlantic City	1.47	2.67	3.65
Long Branch	1.55	3.02	4.15
Newark	1.21	2.34	3.25
Sandy Hook	1.37	2.73	3.68

Weather pattern change can cause drought in parts of the world and increased storm activity in other areas. These changes can be short or long in duration.

A weather altering event such as El Nino is an example of a globally or broad ranging climatological development that can cause significant change in weather. This can have an effect on hydrology (water tables, water flow, chemistry, etc.), and recorded precipitation amounts. However, alterations in weather patterns within the Mid-Atlantic region are generally not prolonged when using a time frame composed of multiple years, as is the nature of this report. With this, averages for hydrology and rainfall accumulation over a span of years tend to remain fairly constant.

PRECIPITATION ANALYSIS

New Jersey has experienced drought conditions during part of the time span for which the data in this report was reviewed (2000 – 2004). These conditions were more related to the beginning of this review period.

During annual reporting sessions, WM&S/BMWM appears to have detected situations where coliform bacteria counts will rise when areas within the State move from periods of less rainfall to more rainfall. In some cases, this circumstance may play a role in reversing what seemed to be an upward trend or stabilized trend in water quality. In such instances, poorer water quality data (higher coliform counts) can prevail, differing from data that had previously been more consistent, or upward trending.

In the case of BB4, the data represented in this report, when collectively reviewed, does not present a picture of water quality that differs greatly with regard to coliform bacteria analysis and precipitation inputs. However, that could change in the future as the data presented in forthcoming reports moves further from that reported in dryer years (providing the State receives successive years of more rainfall).

There are other situations that might prevail when reviewing the precipitation received in a shellfish growing area. For instance, it is possible that a weather pattern might move from a dryer pattern to a wetter pattern and then back to dry. In such cases, WM&S/BMWM may begin seeing higher coliform levels presented during peak accumulation periods associated with wetter rather than dryer periods. An oscillation can develop in the coliform data presentation as the periods go from dry to wet, then back to dry.

The precipitation inputs to the BB4 shellfish growing area for the period 10/03/00 through 09/27/04 are shown in Table 6. For this report, the National Oceanic and Atmospheric Administration (NOAA) weather station utilized for reporting precipitation accumulation in this region of New Jersey was # 8816 (Toms River). Secondary and, in some cases, tertiary station data can be used when data from the primary station are incomplete. This was not the case for this report.

Larger storm events, hurricanes, or winter nor'easters, can cause elevated coliform levels, or noted statistical variation within some sections of NJ's back bay growing areas. However, with BB4, correlation coefficients greater than 0.6 (required for a rainfall correlation) were not observed when reviewing coliform levels in association with rainfall analyses. This suggested a lack of specific influence by rainfall during this reporting period.

Hurricane activity in or near the waters of BB4 was absent during the 2000 – 2004 time frame. Although there have been some rather large storm events, winter nor'easters have been less intense during the time frame covered within this reporting period. As a result, there is a minimum amount of significant data collection from a period of more extreme storm intensity for this review period.

As is common in New Jersey's shellfish growing waters, areas that have or may have a propensity for rainfall impact will generally have *Seasonal*, *Special Restricted*, or *Prohibited* water designations. These classifications reflect the assessment of such impact from prior reports or constitute the assessment that there is potential for such impact, as in the case of lagoon or marina locations (see Figure 12). Again, impacts from rainfall might be noted during one reporting period and absent in the next.

Generally, the presence of significantly large regions of wetlands in this area benefits the filtering of impurities from rain events, helping to maintain water quality. They help preserve a large portion of *Approved* waters throughout the BB4 shellfish growing area.

There can be influence from runoff derived from wetland areas due to the presence of specific animal populations, however. In particular, flocks of waterfowl deposit fecal material that can raise coliform bacteria levels in the area. However, the general cleansing action of wetland plant species tends to provide a good degree of water quality maintenance for many of New Jersey's estuarine shellfish growing areas, including BB4.

The mixing of ocean and bay waters (Figure 13) can provide significant dilution to impurities received from precipitation or runoff. This type of mixing certainly occurs in the area of Little Egg Inlet/Beach Haven Inlet.

From the data, it appears the waters of BB4 did not under go significant impact from precipitation during this reporting period.

FIGURE 12: LAGOON LOCATIONS CAN CONTRIBUTE A VARIETY OF INPUTS FROM RUNOFF AS A RESULT OF STORM EVENTS

FIGURE 13: THE MIXING OF OCEAN AND BAY WATERS PROVIDES DILUTION TO INPUTS RECEIVED FROM PRECIPITATION AND RUNOFF - LITTLE EGG INLET/BEACH HAVEN INLET – SHELLFISH GROWING AREA BB4

TABLE 6: PRECIPITATION DATA - SHELLFISH GROWING AREA BB4 - RAINFALL RECORDED AT NOAA'S STATION 8816 (TOMS RIVER)

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
10/3/2000	8816	0	0	0
10/4/2000	8816	0	0	0
10/5/2000	8816	0.2	0.2	0.2
11/6/2000	8816	0	0	0
11/15/2000	8816	0.05	0.33	0.33
11/16/2000	8816	0.05	0.1	0.38
11/29/2000	8816	0.15	0.15	0.15
12/5/2000	8816	0	0	0
12/6/2000	8816	0	0	0
1/17/2001	8816	0	0	0
1/29/2001	8816	0	0	0
2/2/2001	8816	0	0	0
2/6/2001	8816	0	0	0
2/7/2001	8816	0	0	0
2/14/2001	8816	0.11	0.11	0.31
2/15/2001	8816	0.04	0.15	0.15
3/13/2001	8816	0.005	0.945	0.945
3/15/2001	8816	0	0.37	0.375
3/20/2001	8816	0	0	0
3/26/2001	8816	0	0	0

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
4/16/2001	8816	0.3	0.3	0.3
4/17/2001	8816	0	0.3	0.3
4/18/2001	8816	0	0	0.3
4/20/2001	8816	0	0.11	0.11
5/8/2001	8816	0	0	0
5/9/2001	8816	0	0	0
5/10/2001	8816	0	0	0
5/15/2001	8816	0	0	0
6/4/2001	8816	0	0	0.5
6/5/2001	8816	0	0	0
6/7/2001	8816	0	0	0
6/11/2001	8816	0	0	0
7/3/2001	8816	0	0.45	0.45
7/11/2001	8816	0	0	0
7/12/2001	8816	0	0	0
8/7/2001	8816	0.005	0.005	0.015
8/14/2001	8816	0	0	0.74
8/22/2001	8816	0	0	0
9/5/2001	8816	0.7	0.7	0.7
9/6/2001	8816	0	0.7	0.7
10/2/2001	8816	0.39	1.6	1.6

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
10/3/2001	8816	0	0.39	1.6
10/17/2001	8816	0	0	0.3
11/5/2001	8816	0	0	0.02
11/14/2001	8816	0	0	0
11/15/2001	8816	0	0	0
11/30/2001	8816	0	0.005	0.01
12/3/2001	8816	0	0	0
12/4/2001	8816	0	0	0
1/14/2002	8816	0.005	0.01	0.21
1/15/2002	8816	0	0.005	0.01
1/16/2002	8816	0	0	0.005
1/30/2002	8816	0.005	0.005	0.005
1/31/2002	8816	0.15	0.155	0.155
2/13/2002	8816	0	0	0
2/25/2002	8816	0	0	0
3/15/2002	8816	0	0	0.28
3/18/2002	8816	0	0	0
3/21/2002	8816	0	0.64	1.19
3/26/2002	8816	0.9	1.12	1.12
4/1/2002	8816	0.005	0.805	0.81
4/2/2002	8816	0	0.005	0.805

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
4/15/2002	8816	0	0	0.005
4/16/2002	8816	0	0	0
5/8/2002	8816	0	0	0.1
5/9/2002	8816	0.1	0.1	0.1
5/13/2002	8816	0.63	1.33	1.33
5/15/2002	8816	0	0.005	0.635
6/10/2002	8816	0	0	0
6/12/2002	8816	0.6	0.6	0.6
6/14/2002	8816	1.2	1.46	2.06
7/9/2002	8816	0	0	0
7/10/2002	8816	0	0	0
7/12/2002	8816	0	0	0
8/5/2002	8816	0.005	0.005	0.01
8/12/2002	8816	0	0	0
8/22/2002	8816	0.15	0.15	0.15
9/4/2002	8816	0	0	0.49
9/6/2002	8816	0	0	0
10/1/2002	8816	0	0	0
10/4/2002	8816	0.005	0.005	0.005
10/21/2002	8816	0	0	0
11/4/2002	8816	0	0	0

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
11/18/2002	8816	0	0.58	3.18
11/19/2002	8816	0.09	0.09	0.67
12/2/2002	8816	0	0	0.005
12/3/2002	8816	0	0	0
12/4/2002	8816	0.005	0.005	0.005
1/3/2003	8816	2.25	2.4	3.65
1/15/2003	8816	0	0	0
1/16/2003	8816	0.08	0.08	0.08
3/6/2003	8816	0.2	0.205	0.205
3/18/2003	8816	0	0	0
3/27/2003	8816	0.22	0.22	0.22
3/28/2003	8816	0	0.22	0.22
4/2/2003	8816	0	0.005	0.155
4/3/2003	8816	0	0	0.005
4/4/2003	8816	0.005	0.005	0.005
4/10/2003	8816	0.8	0.805	1.965
5/1/2003	8816	0	0	0
5/12/2003	8816	0	0.005	0.025
5/13/2003	8816	0	0	0.005
5/15/2003	8816	0	0	0
5/19/2003	8816	0	0	0.03

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
5/27/2003	8816	0.1	1.01	1.39
6/12/2003	8816	0.2	0.2	0.205
7/9/2003	8816	0	0	0
7/16/2003	8816	0	0	0.005
7/22/2003	8816	0.08	0.08	0.08
7/23/2003	8816	0.3	0.38	0.38
7/30/2003	8816	0	0.14	0.2
8/5/2003	8816	0.75	0.82	1.3
8/13/2003	8816	0	0	0.005
8/20/2003	8816	0	0.005	0.795
8/27/2003	8816	0	0	0
9/4/2003	8816	0.2	0.3	0.78
9/16/2003	8816	0.16	0.16	0.28
10/7/2003	8816	0	0	0
10/20/2003	8816	0	0	0
10/21/2003	8816	0	0	0
10/22/2003	8816	0	0	0
11/5/2003	8816	0.2	0.2	0.2
11/6/2003	8816	0.005	0.205	0.205
11/21/2003	8816	0	1.65	1.85
12/4/2003	8816	0	0	0

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
12/8/2003	8816	0	0.35	2.15
12/9/2003	8816	0	0	0.35
1/6/2004	8816	0.36	0.48	0.485
1/7/2004	8816	0	0.36	0.48
2/17/2004	8816	0	0	0
2/24/2004	8816	0	0	0.005
3/2/2004	8816	0	0.06	0.06
3/3/2004	8816	0.1	0.1	0.16
3/18/2004	8816	0.8	1	1.8
3/22/2004	8816	0	0.005	0.155
3/31/2004	8816	0.2	1.1	1.1
4/1/2004	8816	0.2	0.4	1.3
4/13/2004	8816	1.72	1.9	1.9
4/14/2004	8816	0.8	2.52	2.7
4/15/2004	8816	0.25	1.05	2.77
4/22/2004	8816	0.005	0.005	0.005
5/5/2004	8816	0	0.4	0.48
5/12/2004	8816	0	0	0
5/19/2004	8816	0	0.005	0.005
6/1/2004	8816	0	0	0
6/14/2004	8816	0	0.005	0.105

Sampling Date	NOAA Weather Station	Precipitation in Inches		
		Day of Sampling	24 Hours Prior	48 Hours Prior
6/15/2004	8816	0.16	0.16	0.165
6/16/2004	8816	0	0.16	0.16
6/29/2004	8816	0.16	0.16	0.165
8/10/2004	8816	0	0	0.005
8/18/2004	8816	0.2	0.88	1.03
8/26/2004	8816	0	0	0
9/10/2004	8816	0.03	0.08	0.15
9/27/2004	8816	0	0	0

TIDAL EFFECTS

Two stations are represented in Figure 14 as being influenced by tidal changes within Shellfish Growing Area BB4. As such, they had tidal components where variability in data or the t-statistic probability was < 0.05. The stations were from surface locations and are noted as follows: 1804A and 1833A. The t-statistical probabilities for these stations are shown in Table 7.

Station 1804A is located in *Approved* waters and 1833A is situated in waters classified as *Seasonal* (Nov – Apr). Station 1804A is approximately one nautical mile off the north western side of this growing area (due east of Parker Run). 1833A is located in the northeastern sector of this growing area (just to the west of Spray Beach, Long Beach Twp.).

Station 1804A showed a higher geometric mean on flood tide and 1833A was higher on the ebb tide. The waters where these stations are located remain appropriately classified as no stations exceeded NSSP criteria for the current classification on summary evaluation. The highest geometric mean recorded for TC with regard to tidal data was 8.2 MPN/100mL (station 1833A). 1833A also had the highest estimated 90th percentile at 21.7 MPN/100 mL with regard to the raw data.

The exchange of tidal waters provides a mechanism to mix impurities including bacterially-laden water with higher quality water. Significant amounts of mixing and dilution can occur for an estuarine shellfish growing area through the processes of tidal exchange. As water moves in and out of inlets, back bay waters, and tributaries, with ebbing and flooding tides, the processes of mixing and dilution occur.

Tidal exchange for BB4 incorporates a number of different processes. These processes include the waters of the Atlantic Ocean, which pass through the Little Egg Inlet/Beach Haven Inlet and, to some degree, the Barnegat Inlet may provide some mixing and dilution, as the waters of BB4 mix with its more northerly neighbor, BB3. However, the Barnegat Inlet has greater involvement with the BB3 growing area.

Exchange of tidal waters for BB4 also involves the waters from tributaries that feed this shellfish growing area and the process of their mixing with Little Egg Harbor. Whether impurities find their way indirectly into these waters by runoff or by incidental release (boat discharge, etc.), tidal exchange plays an important role in tracking and eventually reducing impact. Most frequently, perceptible influence or components of tide occur near areas where development (e.g. housing, lagoon, and marina locations) results in increased statistical variation in the data.

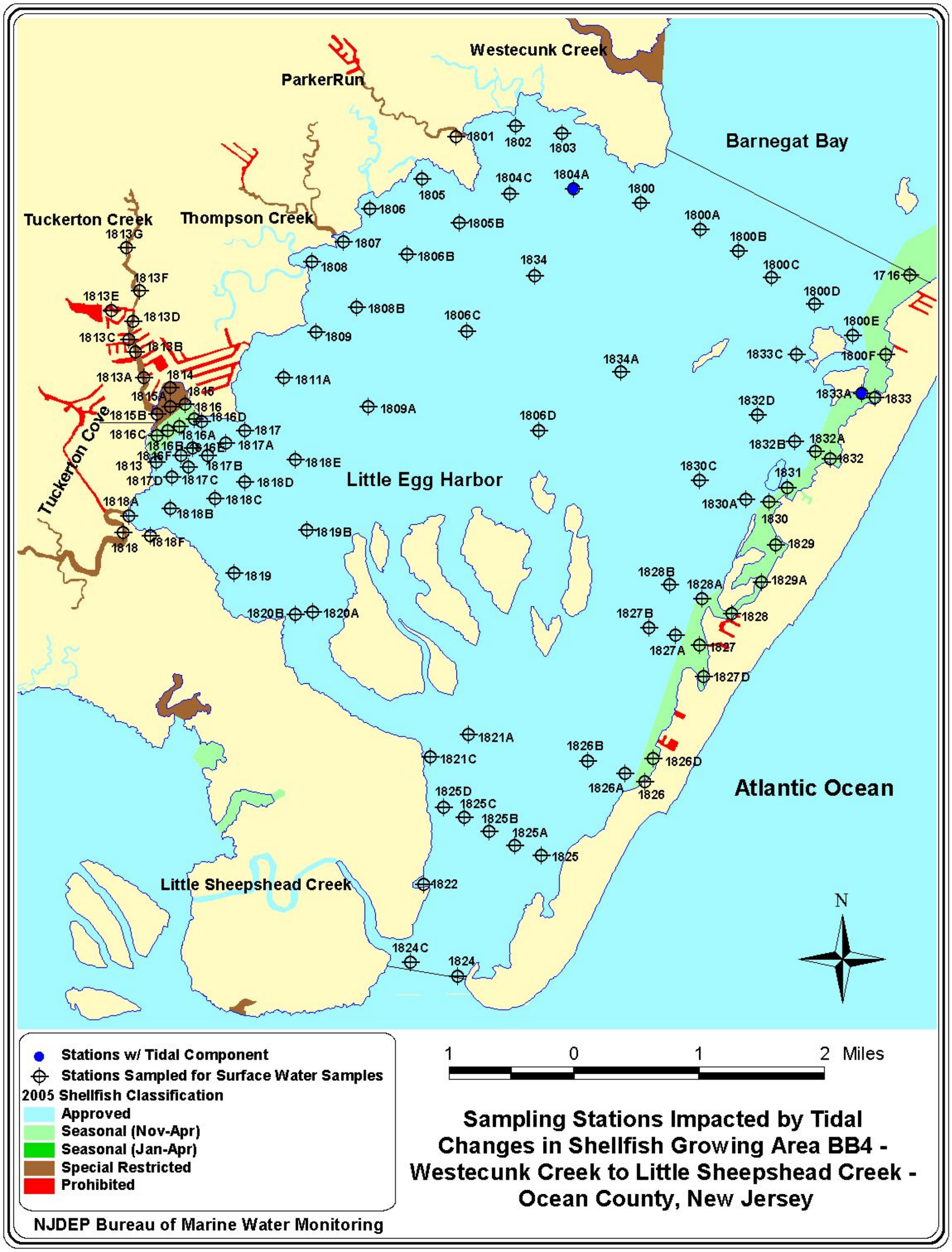

FIGURE 14: SAMPLING STATIONS IMPACTED BY TIDAL CHANGES - SHELLFISH GROWING AREA BB4

TABLE 7: SURFACE SAMPLING STATIONS SHOWING TIDAL EFFECTS (TOTAL COLIFORM) - SHELLFISH GROWING AREA BB4

Station	Classification	Depth	t-Statistic Probability	# Samples Ebb	Geometric Mean Ebb	# Samples Flood	Geometric Mean Flood
1804A	A	S	0.031	17	3.2	22	5.6
1833A	SNA	S	0.043	18	8.2	20	4.1

SEASONAL EFFECTS

A seasonal effect, or seasonal component, can be noted in the data when a comparative analysis between winter and summer seasons is performed. As with the tidal components, variability in data, or the t-statistic probability, must be < 0.05 for a seasonal component relating to coliform bacteria to be present. These components are fairly common in the waters of Little Egg Harbor and some of its tributaries.

Frequently, statistical variations relating to season are often found near more populated areas. Many of the more developed urban sectors of this area experience significant seasonal fluctuations in population. During the summer months, increased population can provide increased bacterial inputs to the waters of BB4. These inputs are not naturally occurring and are likely due to indirect sources received from stormwater runoff, or incidental discharge from commercial or recreational activities such as those that could occur in marinas (see Figure 15).

As previously discussed, runoff from storm events can carry fecal waste from domestic pets, petroleum by-products resulting from an increase in car and boat traffic, and other inputs. In addition, it is possible to see a natural relationship occur between increasing levels of coliform bacteria within some areas of New Jersey's back bay waters and seasonally expanding animal populations (migratory birds, etc.).

Many of the more developed urban sectors in the BB4 area, such as Tuckerton Cove and the western side of LBI, have *Seasonal* water classifications. *Seasonal* waters prevent shellfish harvesting during the summer months when potential bacterial contamination would be greatest in those areas. Further, all of the station sampling assignments dedicated to this shellfish growing area have *Seasonal* (Nov. – Apr.) priorities attached to them. In this regard, a great deal of sampling is done during the time frame when shellfishing within these waters would be taking place.

Figure 16 and Table 8 show stations where a statistically significant difference was found between summer and winter TC levels. Twenty-eight stations showed a seasonal component. The majority of those stations were located in Tuckerton Cove, Tuckerton Creek, and on the western side of Long Beach Island, between Beach Haven Terrace and Holgate. One station was in

Prohibited waters, five stations were in *Special Restricted* waters, eleven were in *Seasonal* – (Nov. – Apr) waters, and 11 stations were located in *Approved* waters. Of the 28 stations showing seasonal components, all but four had higher coliform counts during the summer as opposed to winter.

A number of marinas and potentially impacting infrastructure such as a large lagoonfront area within the Tuckerton Cove section exist in the locality of many of the seasonally impacted stations. In addition, many of BB4's seasonally impacted stations are located along the western shoreline of Long Beach Township. Long Beach Township is the largest borough on Long Beach Island. It is also one of the most populated areas during the summer season. Again, increases in population during the summer season appear to relate very directly to an increased seasonal variability in water quality. As the weather gets warmer, coliform counts near more populated areas have a tendency to increase.

FIGURE 15: MARINA'S CAN CAUSE IMPACT TO SHELLFISH GROWING AREAS – AS THE WEATHER WARMS, COMMERCIAL AND RECREATIONAL BOATING ACTIVITIES INCREASE WITHIN THESE LOCATIONS - PENNA'S MARINA (SPRING) - HOLGATE SECTOR - SHELLFISH GROWING AREA BB4

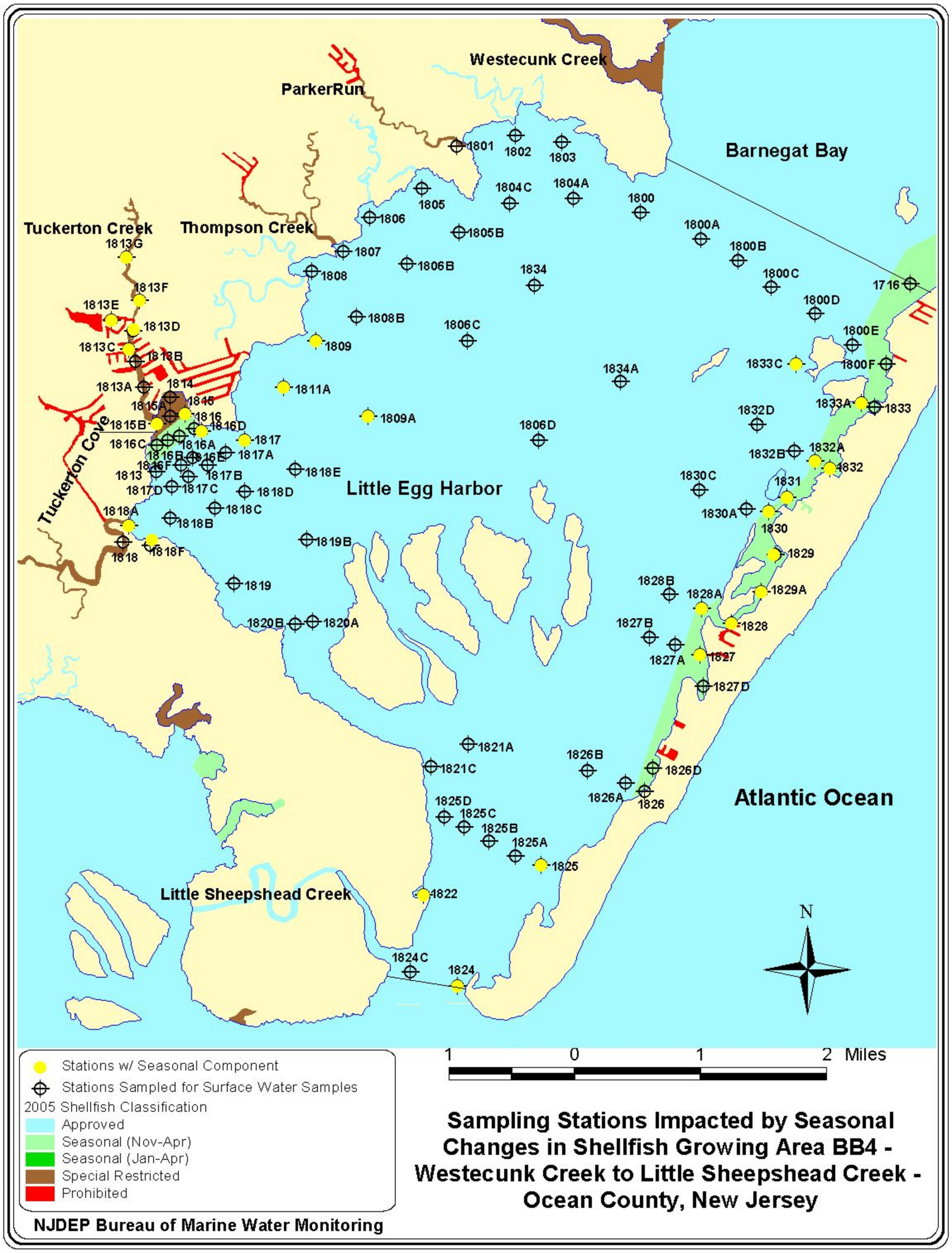

FIGURE 16: SAMPLING STATIONS IMPACTED BY SEASONAL CHANGES - SHELLFISH GROWING AREA BB4

TABLE 8: SURFACE SAMPLING STATIONS SHOWING SEASONAL EFFECTS (TOTAL COLIFORM) - SHELLFISH GROWING AREA BB4

Station	Classification	Depth	t-Statistic Probability	#Samples Summer	Geometric Mean Summer	#Samples Winter	Geometric Mean Winter
1809	A	S	0.046	24	3.8	15	6.3
1809A	A	S	0.011	24	3.3	15	5.2
1811A	A	S	0.032	24	4.3	15	8.4
1813C	SR	S	0.000	21	294.5	15	56.8
1813D	SR	S	0.001	20	377.5	15	80.8
1813E	P	S	0.002	24	315.3	15	65.6
1813F	SR	S	0.000	20	1,042.0	15	110.9
1813G	SR	S	0.000	20	931.4	15	242.7
1815	SNA	S	0.026	24	10.5	15	4.7
1815B	SR	S	0.039	24	11.1	15	4.4
1816D	A	S	0.010	24	11.1	15	4.4
1817	A	S	0.029	24	4.0	15	8.3
1818A	A	S	0.027	24	7.9	15	3.9
1818F	A	S	0.034	24	7.1	15	3.7
1822	A	S	0.028	14	4.4	20	3.2
1824	A	S	0.009	17	4.6	21	3.0
1825	A	S	0.044	17	3.7	21	3.0
1827	SNA	S	0.046	17	7.6	21	4.4
1828	SNA	S	0.001	17	11.6	21	3.5
1828A	SNA	S	0.016	17	5.3	21	3.2
1829	SNA	S	0.003	17	23.1	21	5.6
1829A	SNA	S	0.011	17	9.3	21	3.9
1830	SNA	S	0.020	17	11.7	21	4.0
1831	SNA	S	0.022	17	14.2	21	4.2
1832	SNA	S	0.004	17	35.9	21	7.0

Station	Classification	Depth	t-Statistic Probability	#Samples Summer	Geometric Mean Summer	#Samples Winter	Geometric Mean Winter
1832A	SNA	S	0.003	17	11.0	21	3.5
1833A	SNA	S	0.030	17	8.5	21	4.1
1833C	A	S	0.042	17	4.9	21	3.4

WATER QUALITY STUDIES

BACTERIOLOGICAL QUALITY

COMPLIANCE WITH NSSP APPROVED CRITERIA

There were six stations within the waters of Tuckerton Creek that exceeded SRS year-round sampling criteria for *Approved* waters. These stations were 1813B, 1813C, 1813D, 1813E, 1813F, and 1813G, as shown in Figure 17 and Table 9.

All stations were in waters classified as *Special Restricted* with the exception of 1813E, which is located in *Prohibited* water. Although these stations exceeded the year-round criteria for *Approved* waters, none exceeded year-round criteria applicable to the classification of waters where they were located.

There are numerous stormwater outfalls within the Tuckerton Creek area. However, none of the stations that exceeded SRS year-round sampling criteria for *Approved* waters were specifically linked to rainfall correlations, as rainfall correlations were absent from this Sanitary Survey. There are a number of marinas, within this vicinity, which are capable of influencing coliform counts.

The highest year-round Geometric Mean for TC was 523.4 MPN/100 mL (station 1813G – located in *Special Restricted* waters), and the highest year-round estimated 90th percentile for TC was 2498.6 MPN/100 mL (1813F – *Special Restricted* waters). The criterion for *Special Restricted* waters suggests the Geometric Mean shall not exceed 700 MPN/100 mL and the Est. 90th Percentile should not be greater than 3300 MPN/100 mL. Figure 18 shows all sampling stations for BB4, and complete tabulated listings or water quality summaries for those stations are shown in Table 10.

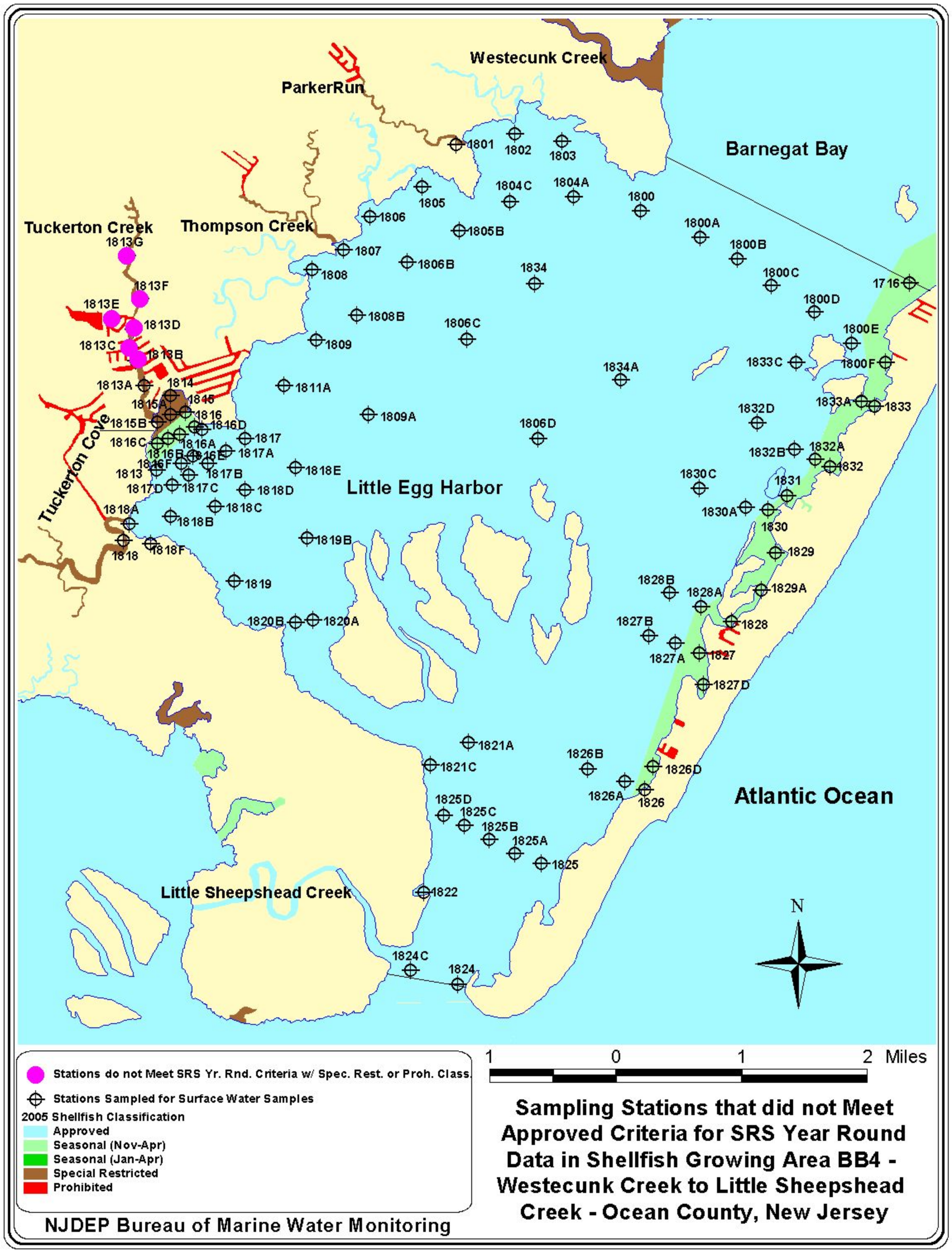

Figure 17: Sampling Stations that did not Meet Approved Criteria for SRS Year Round Data (w/in Special Restricted or Prohibited Classification) **- Shellfish Growing Area BB4**

TABLE 9: WATER QUALITY SUMMARY (TOTAL COLIFORM) FOR SAMPLING STATIONS THAT DID NOT MEET APPROVED CRITERIA FOR SRS YEAR ROUND DATA (W/IN SPECIAL RESTRICTED OR PROHIBITED CLASSIFICATION) **- SHELLFISH GROWING AREA BB4**

STATION	DEPTH	CLASSIFICATION	YEAR ROUND			SUMMER			WINTER		
			GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N
1813B	S	SR	121.3	547.8	39	159.7	659.7	24	78.1	357.2	15
1813C	S	SR	148.4	813.6	36	294.5	1259.9	21	56.8	189.5	15
1813D	S	SR	195.0	1256.0	35	377.5	1860.0	20	80.8	404.2	15
1813E	S	P	172.4	1345.0	39	315.3	1792.6	24	65.6	464.7	15
1813F	S	SR	399.0	2498.0	35	1042.6	2868.7	20	110.9	415.4	15
1813G	S	SR	523.4	1838.0	35	931.4	2752.1	20	242.7	465.6	15

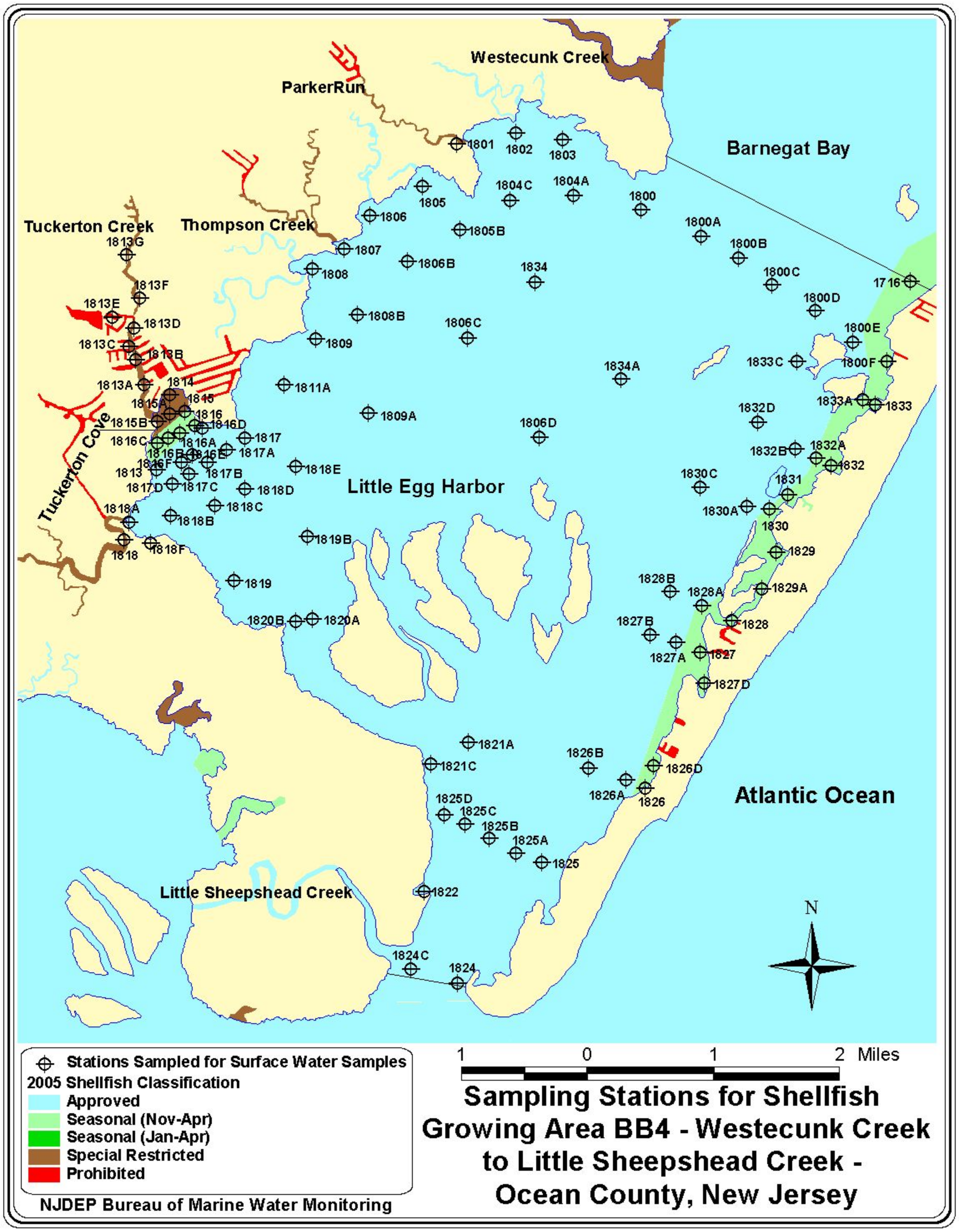

FIGURE 18: SAMPLING STATIONS - SHELLFISH GROWING AREA BB4

TABLE 10: WATER QUALITY SUMMARY (TOTAL COLIFORM) - SHELLFISH GROWING AREA BB4

STATION	DEPTH	CLASSIFICATION	YEAR ROUND			SUMMER			WINTER		
			GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N
1716	S	SNA	7.0	51.8	41	9.0	106.3	17	5.8	29.3	24
1800	S	A	4.0	9.1	37	3.5	6.5	17	4.4	11.6	20
1800A	S	A	3.7	6.7	41	3.3	4.3	17	4.1	8.4	24
1800B	S	A	3.2	4.4	41	3.3	4.7	17	3.2	4.2	24
1800C	S	A	3.6	7.1	41	3.7	7.4	17	3.5	7.0	24
1800D	S	A	3.7	7.5	41	3.4	5.6	17	4.0	8.9	24
1800E	S	A	4.9	19.4	41	5.4	30.8	17	4.6	13.4	24
1800F	S	SNA	10.1	83.4	41	15.0	161.8	17	7.6	49.4	24
1801	S	SR	4.9	16.1	39	5.7	21.1	24	4.0	9.7	15
1802	S	A	4.6	13.4	39	5.3	18.1	24	3.8	7.4	15
1803	S	A	4.1	8.7	39	4.5	10.6	24	3.5	6.0	15
1804A	S	A	4.4	12.2	39	4.7	12.1	24	4.0	12.5	15
1804C	S	A	3.5	5.4	39	3.4	5.2	24	3.5	5.9	15
1805	S	A	3.6	7.0	39	3.4	5.8	24	4.0	9.3	15
1805B	S	A	3.8	7.7	39	3.5	5.7	24	4.4	11.2	15
1806	S	A	3.7	6.7	39	3.5	6.4	24	3.9	7.2	15
1806B	S	A	4.4	10.5	39	4.1	9.0	24	5.0	13.5	15
1806C	S	A	3.3	4.7	39	3.3	4.7	24	3.3	4.7	15
1806D	S	A	3.3	4.3	37	3.1	3.4	17	3.4	4.8	20
1807	S	A	5.6	17.0	39	6.1	20.1	24	4.9	13.0	15
1808	S	A	4.5	12.7	39	4.3	11.2	24	4.9	15.7	15
1808B	S	A	4.5	14.4	39	3.8	7.9	24	6.0	29.7	15
1809	S	A	4.6	12.4	39	3.8	8.7	24	6.3	19.2	15
1809A	S	A	3.9	8.3	39	3.3	5.0	24	5.2	14.1	15
1811A	S	A	5.6	19.2	39	4.3	11.5	24	8.4	35.6	15
1813	S	A	5.2	15.8	39	5.8	19.3	24	4.4	11.2	15
1813A	S	SR	31.5	262.6	39	36.1	313.4	24	25.2	206.0	15
1813B	S	SR	121.3	547.8	39	159.7	659.7	24	78.1	357.2	15
1813C	S	SR	148.4	813.6	36	294.5	1259.9	21	56.8	189.5	15
1813D	S	SR	195.0	1,256.	35	377.5	1860.0	20	80.8	404.2	15
1813E	S	P	172.4	1,345.	39	315.3	1792.6	24	65.6	464.7	15
1813F	S	SR	399.0	2,498.	35	1,042.6	2868.7	20	110.9	415.4	15
1813G	S	SR	523.4	1,838.	35	931.4	2752.1	20	242.7	465.6	15
1814	S	SR	10.2	63.3	39	12.9	100.2	24	7.0	26.1	15
1815	S	SNA	7.7	32.2	39	10.5	53.4	24	4.7	9.6	15
1815A	S	SR	9.0	54.0	39	12.2	87.7	24	5.5	19.9	15
1815B	S	SR	7.8	44.5	39	11.1	74.6	24	4.4	14.2	15
1816	S	SNA	5.7	19.6	39	6.5	27.7	24	4.6	9.8	15
1816A	S	SNA	7.3	40.4	39	8.5	62.6	24	5.8	17.3	15
1816B	S	SNA	5.7	24.1	39	6.1	30.4	24	5.0	16.6	15
1816C	S	SNA	6.5	24.6	39	7.4	34.3	24	5.2	13.0	15
1816D	S	A	7.7	32.9	39	11.1	54.3	24	4.4	9.5	15
1816E	S	A	5.4	21.5	39	5.2	22.4	24	5.8	20.8	15
1816F	S	A	5.9	25.6	39	6.4	34.1	24	5.1	15.5	15

STATION	DEPTH	CLASSIFICATION	YEAR ROUND			SUMMER			WINTER		
			GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N
1817	S	A	5.3	19.3	39	4.0	10.4	24	8.3	39.9	15
1817A	S	A	5.0	15.9	39	4.7	13.5	24	5.5	20.8	15
1817B	S	A	5.0	20.5	39	4.5	17.2	24	5.8	27.7	15
1817C	S	A	5.7	17.3	39	5.8	16.8	24	5.7	18.9	15
1817D	S	A	5.2	14.1	39	5.8	17.7	24	4.2	9.1	15
1818	S	SR	8.9	38.8	39	11.7	52.2	24	5.8	21.0	15
1818A	S	A	6.0	20.8	39	7.9	32.3	24	3.9	7.3	15
1818B	S	A	4.2	11.8	39	4.1	12.2	24	4.3	11.7	15
1818C	S	A	3.7	7.3	39	3.8	8.7	24	3.5	5.0	15
1818D	S	A	5.0	17.0	39	4.2	14.0	24	6.8	22.0	15
1818E	S	A	4.4	15.2	39	3.5	6.4	24	6.5	37.8	15
1818F	S	A	5.5	18.1	39	7.1	27.3	24	3.7	6.9	15
1819	S	A	4.2	10.4	39	3.8	8.9	24	4.9	13.4	15
1819B	S	A	4.6	12.5	39	3.8	7.6	24	6.2	22.7	15
1820A	S	A	3.9	7.3	39	4.0	8.0	24	3.7	6.2	15
1820B	S	A	3.7	6.2	39	3.9	7.0	24	3.4	4.9	15
1821A	S	A	3.3	4.8	37	3.5	5.8	16	3.1	4.1	21
1821C	S	A	3.4	5.7	37	3.2	4.6	16	3.5	6.5	21
1822	S	A	3.7	6.4	34	4.4	9.2	14	3.2	4.4	20
1824	S	A	3.6	7.1	38	4.6	11.8	17	3.0	3.0	21
1824C	S	A	3.2	4.1	38	3.4	4.9	17	3.0	3.2	21
1825	S	A	3.3	5.0	38	3.7	6.6	17	3.0	3.2	21
1825A	S	A	3.3	4.4	38	3.3	4.4	17	3.2	4.4	21
1825B	S	A	4.5	14.7	9	5.8	32.0	4	3.7	7.1	5
1825D	S	A	3.4	5.4	36	3.1	3.5	15	3.5	6.4	21
1826	S	SNA	9.8	57.6	38	14.6	75.8	17	7.1	42.9	21
1826A	S	A	3.4	5.4	38	3.6	5.7	17	3.3	5.1	21
1826B	S	A	4.1	11.4	38	4.0	11.9	17	4.3	11.2	21
1826D	S	SNA	6.7	22.9	38	9.3	37.5	17	5.2	13.8	21
1827	S	SNA	5.6	16.7	38	7.6	26.6	17	4.4	10.1	21
1827A	S	A	3.2	4.3	38	3.3	4.7	17	3.2	4.1	21
1827B	S	A	3.4	5.5	38	3.7	6.9	17	3.2	4.3	21
1827D	S	SNA	6.9	28.7	38	10.2	55.2	17	5.1	14.3	21
1828	S	SNA	6.0	26.6	38	11.6	76.4	17	3.5	5.3	21
1828A	S	SNA	4.0	9.2	38	5.3	16.4	17	3.2	4.1	21
1828B	S	A	3.3	5.8	38	3.6	8.2	17	3.1	3.5	21
1829	S	SNA	10.6	72.8	38	23.1	196.0	17	5.6	20.6	21
1829A	S	SNA	5.8	22.2	38	9.3	50.1	17	3.9	8.1	21
1830	S	SNA	6.4	41.4	38	11.7	128.7	17	4.0	10.3	21
1830A	S	A	3.7	8.0	38	4.5	13.8	17	3.1	3.5	21
1830C	S	A	3.1	4.0	38	3.2	4.6	17	3.0	3.3	21
1831	S	SNA	7.3	59.7	38	14.2	238.2	17	4.2	9.8	21
1832	S	SNA	14.6	149.1	38	35.9	519.7	17	7.0	31.4	21
1832A	S	SNA	5.9	28.1	38	11.0	86.2	17	3.5	5.1	21
1832B	S	A	4.2	11.1	38	4.9	15.5	17	3.8	8.2	21
1832D	S	A	3.8	7.1	38	4.1	9.2	17	3.5	5.5	21

STATION	DEPTH	CLASSIFICATION	YEAR ROUND			SUMMER			WINTER		
			GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N	GEO. MEAN	EST. 90TH	N
1833	S	SNA	8.7	52.2	37	13.0	121.1	17	6.1	20.7	20
1833A	S	SNA	5.7	21.7	38	8.5	47.3	17	4.1	8.7	21
1833C	S	A	4.0	8.0	38	4.9	12.0	17	3.4	5.0	21
1834	S	A	3.1	3.3	39	3.0	3.2	24	3.1	3.4	15
1834A	S	A	3.7	6.7	37	3.7	5.8	17	3.7	7.6	20

RELATED STUDIES

WM&S/BMWM performs additional water quality studies related to the bacteriological monitoring program. Specifically, this area (BB4) has seven sampling stations (1800B, 1800D, 1818D, 1820A, 1826A, 1831, 1834A) that are part of the NJ Coastal Monitoring Network.

These stations are sampled on a quarterly basis for dissolved oxygen, salinity, Secchi depth, chlorophyll, and nutrients. There are approximately 250 of this network's sampling stations within the coastal waters of New Jersey. Twenty-four of those stations are located within the ocean waters off the New Jersey coast. The 226 remaining stations are spread throughout our back bay waters.

The results of water quality measurements from such stations are complied in a separate report. The station locations for BB4 are shown in Figures 19-20 and monitoring results for these stations are shown in Table 11.

As suggested, chlorophyll data are also collected. This provides the NJDEP the opportunity to maintain a quarterly picture of algal activity within State waters. This chlorophyll data also proves to be useful as adjunct information to the phytoplankton monitoring program.

As mentioned in the section on Marine Bio-toxins, data are also collected as part of the phytoplankton monitoring program, for which, WM&S/BMWM analyzes samples bi-weekly from May through August (Memorial Day through Labor Day). This is done in order to monitor for the presence of marine biotoxins in accordance with NSSP requirements.

There are 16 phytoplankton stations within the waters of New Jersey. Of those 16, four are located off the coast from the southerly portion of Sandy Hook down to Cape May. The other 12 phytoplankton stations are situated within New Jersey's back bay waters. Two of those stations, 1818D and 1800B, are located in shellfish growing area BB4.

Current research (refer to www.state.nj.us/dep/wms/bmw) suggests that populations of phytoplankton are sparse in BB4 with the exception of some larger blooms of brown tide, and toxic species are rarely noted although limited numbers are occasionally observed.

Phytoplankton stations are generally arranged so that samples for both are taken from matching locations. In this regard, data can be uniformly compared and analyzed.

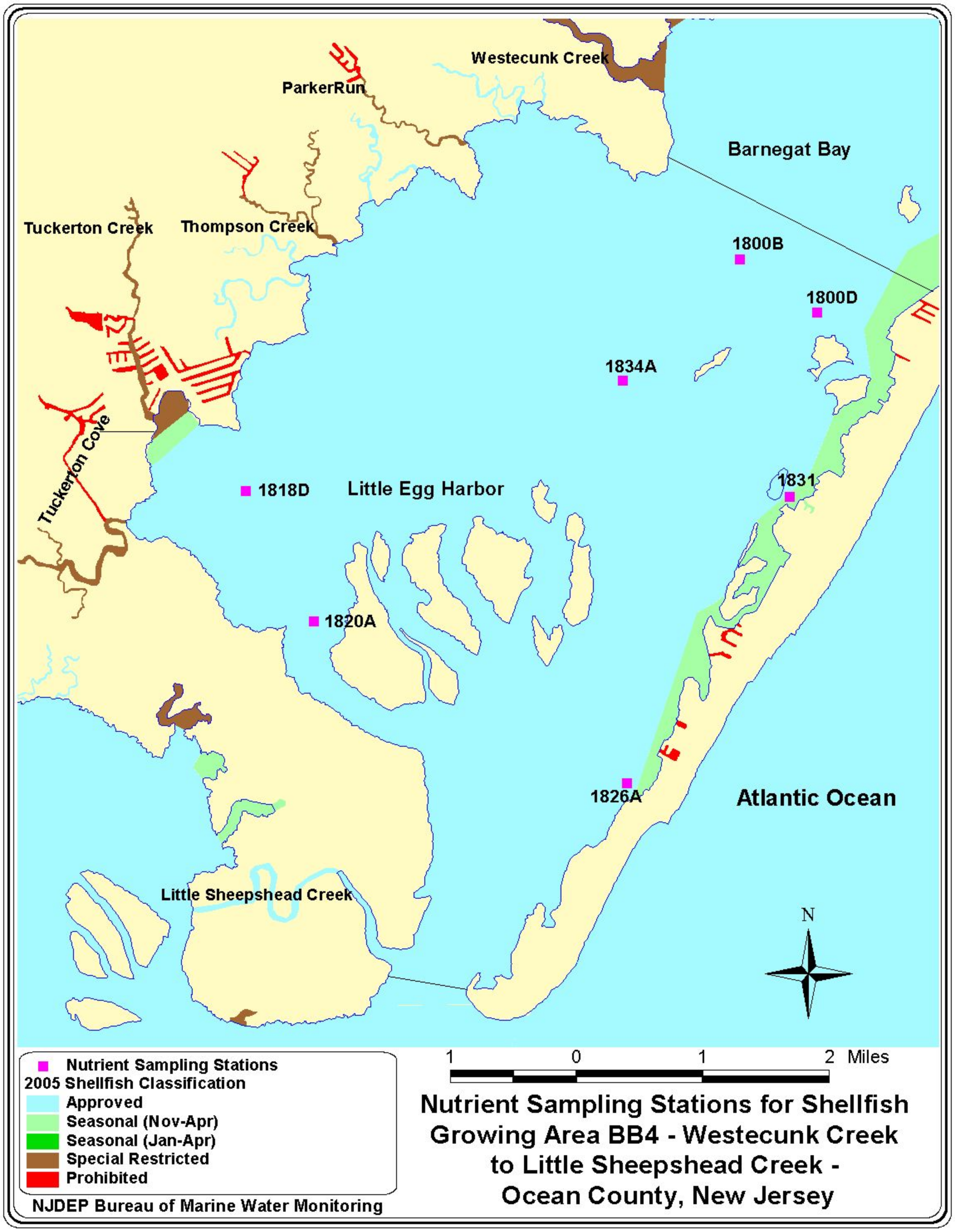

FIGURE 19: NUTRIENT SAMPLING STATIONS - SHELLFISH GROWING AREA BB4

FIGURE 20: NUTRIENT MONITORING STATION 1818D IS LOCATED JUST OUTSIDE TUCKERTON COVE IN LITTLE EGG HARBOR – SHELLFISH GROWING AREA BB4

TABLE 11: DATA SUMMARIES - NUTRIENT SAMPLING STATIONS - SHELLFISH GROWING AREA BB4

Station	Date	Temp (C)	Secchi Depth (feet)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	NH3 Ammonia (ug/L)	NO3 & NO2 or Nitrate & Nitrite (ug/L)	PO4 Ortho-phos-phate (ug/L)	TN Total Nitrogen (ug/L)	TP Total Phosphorus (ug/L)	Chl a (ug/L)
1800B	11/6/00	N	N	28.55	9.2	35.5	4.5 K	8.64	22.3	441.11	53.31	12.61
1800B	3/13/01	5.3	4	27.31	10.6	25.5	7.87	17.42	3.76	285.05	21.97	0.42 K
1800B	3/19/01	8.2	3	26.66	10.65	18.5	4.95	3.88 K	5.79	211.83	9.62	0.42 K
1800B	4/5/01	10.3	4	29.66	10.2	10.5	4.5 K	14.3	3.23	108.13	17.39	2.94
1800B	8/21/01	24.9	3	34.51	6	19.5	116.55	3.88 K	27.79	619.46	65.78	0.42 K
1800B	12/3/01	10.7	4.5	33.85	7.85	28.5	22.55	17.9	27.45	577.77	35.93	0.42 K
1800B	2/13/02	1.5	N	33.59	9.9	83.5	381.05	10.91	N	391.96 J	145.41	0.42 K
1800B	4/5/02	10.7	3	31.08	9.8	18.5	25.89	58.65	9.81	204.47	16.69	2.1
1800B	8/12/02	23.8	2.5	34.29	6.2	25.5	62.83 J	52.09	44.6	694.51	63.21	1.26
1800B	12/4/02	0.8	3.5	29.57	10.95	33	45.05 J	221.83	15.31	1296.69	60.46	3.36
1800B	8/13/03	24.4	4	31.69	6.2	69.5	53.57	10.17	61.63	216.08	98.65	2.1
1800B	3/3/04	5.1	4.5	27.44	10.6	11	17.16	3.45	32.08	267.88	42.49	6.31
1800D	4/5/01	10.7	3	29.88	9.95	22	4.5 K	11.05	3.81	92.41	9.87	1.68
1800D	4/5/02	10.6	3	31.75	8.05	29	9.41	59.41	6.45	183.25	7.47 K	2.1
1818D	11/6/00	N	N	30.88	8.9	32	4.5 K	8.64	17.84	319.23	42.93	4.63
1818D	4/5/01	9.8	4	30.66	10.45	14.5	4.5 K	7.8	4.39	21.66	5.17	1.37
1818D	8/21/01	24.2	2.5	34.62	6.8	19	142.95	4.7	22.62	532.78	65.55	0.42 K
1818D	12/3/01	11.4	4	34.26	10	24	22.55	21.47	28.83	366.21	30.34	0.42 K
1818D	2/15/02	2.8	2	33.96	10.05	34	52.28	3.88 K	14.53	340.98	30.2	3.78
1818D	4/5/02	11.2	3	30.89	8.9	25.5	55.19	26.74	9.81	154.68	20.25	3.36
1818D	9/13/02	20.3	2.5	32.12	6.15	27	104.44 J	87.12	58.45	992.66	117.42	3.78

Data Coding: J = Questionable Value, K = Less Than, N = Data not available

Station	Date	Temp (C)	Secchi Depth (feet)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	NH3 Ammonia (ug/L)	NO3 & NO2 or Nitrate & Nitrite (ug/L)	PO4 Ortho-phos-phate (ug/L)	TN Total Nitrogen (ug/L)	TP Total Phosphorus (ug/L)	Chl a (ug/L)
1818D	12/3/02	4	2	30.16	10.3	44.5	59.02 J	369.71	26.14	1640.65	95.28	0.42 K
1818D	8/13/03	24.3	5	31.62	7.4	26	47.67	9.37	44.52	189.99	79.36	2.94
1818D	3/3/04	6.3	4	28.51	10.6	10	24.29	0.31	28.52	276.68	34.99	6.31
1820A	11/6/00	N	N	31.25	8.8	24.5	5.37	21	18.96	248.67	37.17	1.68
1820A	6/27/01	26	2	31.09	8.75	37	52.24	17.91	36.49	464.29	99.54	3.78
1820A	8/21/01	23	3	34.62	5.8	43	182.55	3.88 K	26.5	411.81	68.7	3.36
1820A	12/3/01	11.8	4.5	34.26	9.7	28	29.16	26.09	29.49	369.38	33.13	0.84
1820A	2/15/02	3.2	3	33.87	10.3	45.5	54.06	3.88 K	17	350.89	45.87	4.2
1820A	6/12/02	19.9	N	32.78	6.7	35.5	125.05	20.05	29.7	328.49	67.69	3.78
1820A	9/13/02	19.9	N	32.38	6.4	64	115.53 J	89.89	60.31	775.31	387.99	5.05
1820A	12/3/02	2.4	1.5	N	9.8	1 K	31.63 J	261.81	25.66	1526.49	59	0.84
1820A	8/13/03	21	2	32.18	6.7	26	84.04	11.82	58.74	162.49	72.4	0.84
1826A	11/6/00	N	N	31.91	8.5	25.5	4.5 K	8.64	21.74	229.43	39.48	3.78
1826A	3/13/01	5	3.5	30.92	10.3	52.5	16.55	19.64	6.08	213.3	33.35	0.42 K
1826A	6/27/01	24.9	4	31.75	7.65	7	12.67	17.42	36.49	377.12	71.95	2.52
1826A	8/21/01	23.1	2.5	34.73	6.2	77.5	119.85	3.88 K	26.5	546.06	60.15	2.1
1826A	12/3/01	11.4	4	33.95	9.35	75.5	34.44	27.25	31.24	650.13	58.26	0.42 K
1826A	2/13/02	2	N	34.05	9.95	87.5	260.93	4.11	40.29	285.24	91.53	0.42 K
1826A	6/12/02	18.5	3.5	32.69	7.5	30.5	82.09	16.74	25.92	256.29	52.55	6.73
1826A	8/12/02	23.5	3.5	31.63	5.5	37	62.83 J	32.19	41.36	676.91	57	0.42 K
1826A	12/4/02	4.4	3	31.84	10.1	37.5	15.91 J	177.14	26.98	1556.84	50.52	0.84

Data Coding: J = Questionable Value, K = Less Than, N = Data not available

Station	Date	Temp (C)	Secchi Depth (feet)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	NH3 Ammonia (ug/L)	NO3 & NO2 or Nitrate & Nitrite (ug/L)	PO4 Ortho-phos-phate (ug/L)	TN Total Nitrogen (ug/L)	TP Total Phosphorus (ug/L)	Chl a (ug/L)
1826A	8/13/03	21.6	3	31.59	6.4	34	83.1	11.57	52.87	207.08	85.1	0.84
1826A	3/3/04	2.4	3.5	31.47	10.6	9	11.1	1.24	36.98	195.87	40.24	4.63
1831	11/6/00	N	N	30.13	8.85	31.5	4.5 K	27.17	21.18	338.48	45.24	7.57
1831	3/13/01	5	5	30.34	10.1	33	11.59	17.42	7.81	181.42	28.56	0.42 K
1831	6/27/01	25.7	1.5	31.31	8.05	17	43.44	23.04	42.72	402.47	97.57	N
1831	8/21/01	24.6	3	34.4	6.05	24.5	172.65	3.88 K	27.79	644.2	77.06	0.84
1831	12/3/01	11	4	33.85	9.1	39.5	23.87	24.16	25.02	397.25	45	0.84
1831	2/13/02	2	N	33.77	10.45	35.5	229.2	3.88 K	29.64	259.86	113.77	0.42 K
1831	6/11/02	20.3	2.5	32.96	7	30	79.14	26.72	30	377.61	79.41	8.41
1831	8/12/02	23.8	3	31.72	5.95	23	73.03 J	42.63	44.45	692.72	56.73	0.42 K
1831	12/4/02	0.4	3	29.91	11.7	33.5	32.62 J	213.03	12.09	1281.8	39.26	4.2
1831	8/13/03	23.5	4	31.86	6.1	28.5	80.74	10.77	52.93	222.12	90.71	2.1
1831	3/3/04	4.8	6	28.8	10.4	7	13.34	2.95	30.11	244.18	35.72	5.47
1834A	11/6/00	N	N	29.39	9.2	36	4.5 K	8.64	20.63	338.48	44.09	8.41
1834A	3/13/01	5	4.5	27.4	10.2	28	10.35	17.42	4.92	213.3	20.78	0.42 K
1834A	3/19/01	8.1	3	26.19	10.4	30.5	4.5 K	3.88 K	9.34	235.17	12.64	0.42 K
1834A	4/5/01	9.5	5	30.32	9.6	15.5	4.5 K	11.05	3.23	76.69	5.17	0.74
1834A	8/21/01	24.6	2.5	34.51	5.3	22	205.65	3.88 K	32.32	494.43	84.1	0.42 K
1834A	12/3/01	11.4	4	34.06	9.4	29	30.48	27.88	31.19	496.65	35.23	0.84
1834A	2/13/02	1.5	N	33.77	9.85	66.5	324.39	3.88 K	33.73	328.27 J	120.35	0.42 K
1834A	4/5/02	10.9	3.5	31.17	9.2	18.5	27.72	53.27	7.79	191.28	15.8	3.36

Data Coding: J = Questionable Value, K = Less Than, N = Data not available

Station	Date	Temp (C)	Secchi Depth (feet)	Salinity (PSU)	DO (mg/L)	TSS (mg/L)	NH3 Ammonia (ug/L)	NO3 & NO2 or Nitrate & Nitrite (ug/L)	PO4 Ortho-phos-phate (ug/L)	TN Total Nitrogen (ug/L)	TP Total Phosphorus (ug/L)	Chl a (ug/L)
1834A	8/12/02	23.8	2	33.46	6.2	44.5	73.03 J	46.8	41.84	743.38	58.17	0.42 K
1834A	12/4/02	4	3	32.72	10.5	52.5	33.24 J	193.99	15.84	1439.09	50.44	6.73
1834A	8/13/03	23.6	4	31.78	6.6	42.5	73.91	10.1	44.16	207.15	69.4	2.52
1834A	3/3/04	4.8	5.5	29.13	10.2	11	19.42	2.04 K	29.44	318.33	33.68	5.05

Data Coding: J = Questionable Value, K = Less Than, N = Data not available

INTERPRETATION AND DISCUSSION OF DATA

BACTERIOLOGICAL

Criteria for acceptability of shellfish growing water based on bacterial parameters is provided in the *National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish*. Each state adopts either the total coliform criteria or the fecal coliform criteria for growing water classifications. Application of either standard to different water bodies within the state is also allowed. In NJ, shellfish growing water classification of back bay waters is based on total coliform (TC) criteria.

BB4 is sampled with the 3 – tube decimal dilution test. This methodology is used for bacteriological fermentation, which provided the data for total coliform analysis via the SRS strategy (strategy chosen for analysis of this shellfish growing area due to the absence of direct outfalls). Tables 1 and 2 provide pertinent information on geometric mean and estimated 90th percentile criteria for classification.

The results of the water quality data collected from sampling in this shellfish growing area indicated that all but six stations were within SRS year-round criteria (total coliform) for *Approved* waters. The stations that exceeded NSSP *Approved* criteria were located in either *Special Restricted* or *Prohibited* waters.

Higher values for total coliform bacteria in the raw data listings are predominately associated with areas near lagoon or marina sections within BB4. As mentioned previously, these locations have buffers of *Seasonal*, *Special Restricted,* or *Prohibited* water classifications within their general confines or perimeters. These buffers provide sufficient delineation for waters where bacterial presence may be more prevalent.

Variability in the data was discussed in the sections on tidal and seasonal effects. This was evidenced by the t-statistic probability in these analyses being less than 0.05.

Tidal change within Shellfish Growing Area BB4 was noted to account for some of the variance for two stations. One of these stations was located in *Seasonal* (Nov. – April) waters and one was in *Approved* waters.

Where tidal variation occurred, one station showed a higher geometric mean for total coliform on the Ebb Tide and one had higher coliform counts on the Flood Tide. However, neither of these stations exceeded the criteria for classification, as geometric means for TC were never any higher than 8.2 MPN/100 mL and the estimated 90^{th} percentiles for these stations were not higher than 21.7 MPN/100 mL.

Twenty-eight of 95 stations showed a *Seasonal* component. One of these stations was located in *Prohibited* waters, five were in *Special Restricted* waters, eleven are in Seasonally classified waters (Nov. – April), and eleven stations were located in *Approved* waters. All but four of these stations showed higher geometric means and estimated 90^{th} percentiles during the summer.

Specific seasons are utilized as priorities for sampling (as required by the Model Ordinance for *Seasonally Approved* waters) in all of the assignments related to this growing area. These priorities can be aligned with the seasons and locations of stations where incidence of higher bacterial counts is likely, relative to influences such as marinas, lagoon communities, or wildlife. They can also be prioritized with the time of year that shellfishing is permitted in those locations. With BB4, sampling is prioritized within the winter season (Nov. – April), as that reflects the time of year that shellfishing is allowed within *Seasonal* growing waters.

CONCLUSIONS

BACTERIOLOGICAL EVALUATION

The following was concluded based on the water quality data for BB4 from October 3, 2000 through September 27, 2004. All but six of 95 stations within this 6 square mile area met SRS year-round criteria (total coliform) for *Approved* shellfish growing waters, on summary evaluation of 30 or more samples. The classification of waters where those six stations were located ranged from *Prohibited* to *Special Restricted,* and NSSP statistical parameters required for their respective classifications were met with regard to a year round review of 30 or more sampling events for those stations.

Water quality impacts from season and tide were present. However, the data for this report suggest that these influences, while present, were generally less impacting when reviewing geometric means and estimated 90th percentiles. This is likely due to dilution and mixing processes mentioned earlier in this report.

For the purpose of protecting public health, sampling strategy and classification for most back bay waters in New Jersey is primarily in response to indirect discharge from stormwater outfalls, or marinas and lagoons that exist within these waters. With BB4, these influences provide the primary reason for utilization of SRS Sampling Strategy along with the lack of direct discharges, as direct discharges require the use of APC Sampling strategy. Buffers of *Seasonal*, *Special Restricted*, or *Prohibited* classifications are used as protective zones in areas with the above influences.

RECOMMENDATIONS

It is recommended that the current classifications for Shellfish Growing Area BB4 remain in place. There are no upgrades or downgrades recommended at this time. Further, the sampling strategy (SRS) should continue and monitoring with regard to the current sampling schedules should proceed as presented in the Marine Water Sampling Assignments (2005-2006) guide.

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APPENDICES

Detailed Data Listing(s) from 10/03/00 to 09/27/04 for data pull 10/01/00 to 09/30/04