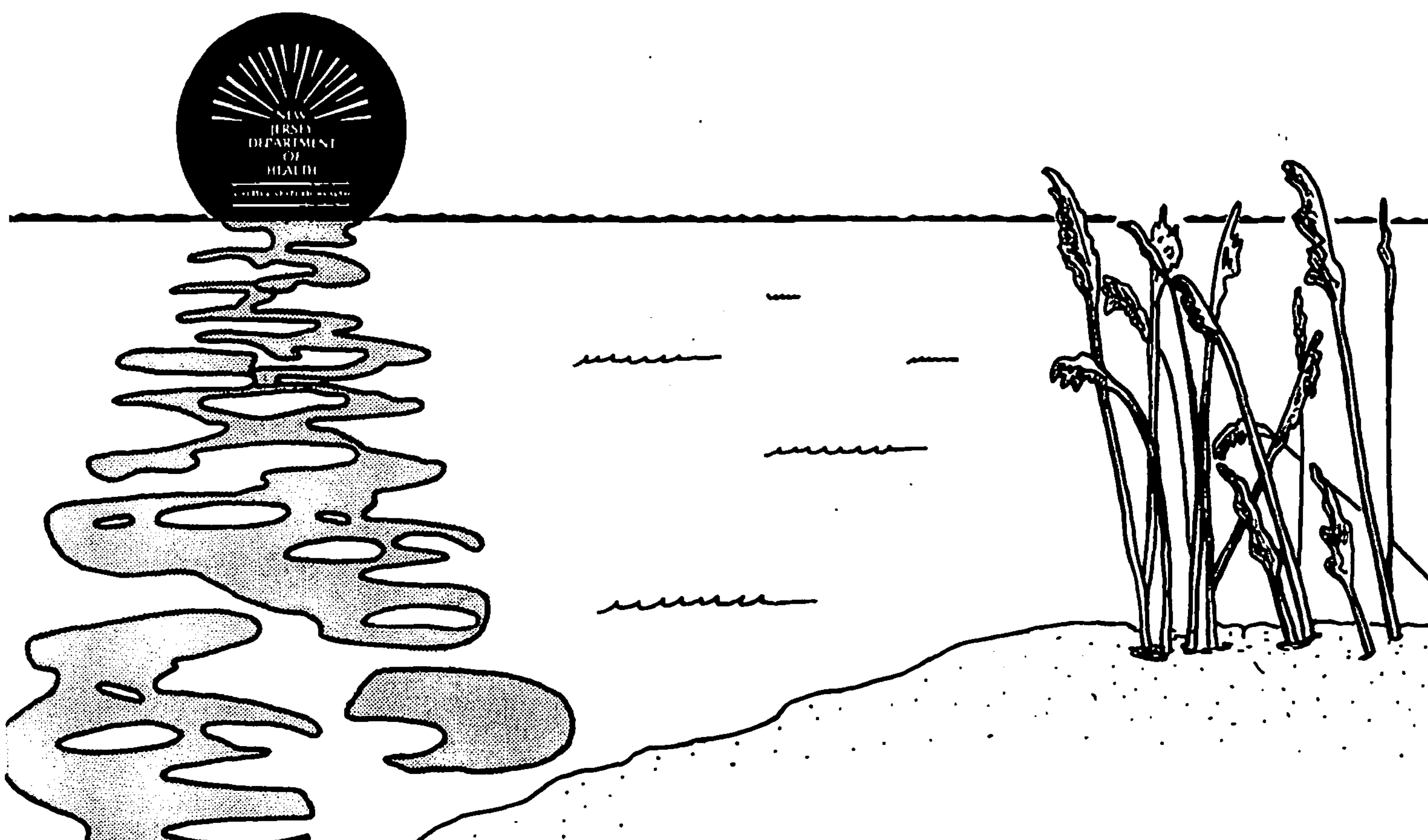
Progress Report

A STUDY OF THE RELATIONSHIP BETWEEN ILLNESSES AND OCEAN BEACH WATER QUALITY



Environmental Health Service
Division of Occupational and Environmental Health
New Jersey State Department of *Health*

March, 1988

PROGRESS REPORT

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Thomas H. Kean
Governor

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Commissioner
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EXECUTIVE SUMMARY

The New Jersey Department of Health (DOH) was commissioned in the Spring of 1987 by the Governor and the Legislature to determine if microbial contamination of the ocean resulting from human activities was leading to increased risk of infectious diseases. A particular concern was that the use of ocean outfall pipes for sewage disposal could lead to contamination of bathing beaches with subsequent exposure of swimmers to infectious agents. The Governor and the Legislature provided $1,000,000 for the first year of the study. Resource assistance for the study was provided by federal, state, county, municipal, and academic institutions.

Ideally health concerns of this nature could be addressed by determining illness rates in the population of concern. However, such a study is complex to design and implement, and can be very costly. There are no illnesses caused uniquely by sewage exposure, and the gastrointestinal illnesses following ingestion of sewage contaminated water can result from other sources of contamination at the beach such as unsanitary food, inadequate personal hygiene, and sources outside the beach environment. The illnesses are therefore present in the population unrelated to swimming or sewage exposure. As a result, in order to identify significant differences in illness rates attributable to ocean swimming the study must include a large number of people, estimated to be on the order of 20,000 individuals.

The selection, development, and implementation of the appropriate study design for a full epidemiological study required information on demographics of the populations visiting the beaches, their bathing habits, and water quality characteristics of several beaches. Toward this end, the DOH completed the preliminary phases of the study in the Summer and Fall of 1987 to investigate the methodology for beach and population selection, the interviewing process, and water quality analysis. Moreover, in cooperation with the New Jersey Department of Environmental Protection, the DOH also reviewed monitoring data from 1987 and previous years to estimate the health risk attributable to ocean water quality. The first year's activities were not designed to interview sufficient numbers of swimmers to achieve a valid statistical result.

Ocean water quality monitoring from the first summer indicated that coastal water was meeting existing state microbial water quality standards and that there was no evidence of major contamination by bacteria or viruses. An assessment of the risk to the swimming population based on the water quality data suggests that only slight if any excess illness rates above background would be expected.

Within the limitations of the methods, results of federal, state, and local water sampling suggest that the current sewage disposal strategies are not contributing a major microbial load to ocean water at the shore. On occasion higher levels of microbial contamination were detected offshore which may have resulted from episodic suboptimal chlorination. Sampling of water in the beach surf zone identified good water quality at most sites, although some beaches had periodic excursions of microbial levels. The probable origin of the contamination was onshore sources such as stormwater drainage, lakes, rivers, and inlets.

Methodological problems were identified during the initial interview experiences. Insufficient planning time and the use of two institutions to jointly manage the epidemiological data led to several delays. These problems will be resolved prior to this summer's activities.

As expected, infectious illnesses were readily detected among swimming and nonswimming beach visitors. Furthermore, the illness rates among both groups were elevated following the beach visits. However, because of the preliminary nature of the data collected in the Summer and Fall of 1987, no conclusion can be made regarding causal factors responsible for these elevated rates. It is important to note that there are multiple sources of infection transmission and noninfectious factors that exist as part of the overall beach environment in addition to sewage outfalls. Person to person transmission is a strong possibility as well as other factors such as personal hygiene, food contamination, heat stress, and sources outside the beach environment. These possible sources and factors will be carefully evaluated in the next phase of this study.

There are four major considerations in the design and implementation of the study planned for the Summer of 1988. The designed study should produce the necessary information with sufficient statistical power and be conducted within reasonable limits for effort and cost.

The first consideration was the availability of sufficient numbers of family units with children and their swimming status. On the basis of the available data, there seems to be sufficient populations at the beaches to enter the study as initially designed, which involved a follow-up of children from families visiting only ocean beaches during the weekend and with known swimming status.

The second consideration was to identify beaches that were visited by weekend-only swimmers. This is important as microbial water quality is evaluated on weekends in order to identify exposure. Furthermore, people who swim some place other than the beach under study may swim in water of poorer quality, hence biasing the results toward a higher illness rate in swimmers. The data indicated that New Jersey beachgoers interviewed this summer tent to swim at several places. Approximately sixty percent of the interviewed population swam at more than one place over the course of the week and therefore would be ineligible for follow-up.

The third consideration was to determine whether people are willing to be contacted about subsequent illnesses following a visit to the New Jersey shore. Approximately 75 percent of the people interviewed were willing to be recontacted. Optimally most epidemiological studies strive for 80 percent, but realistically settle for 60 to 70 percent follow-up.

The fourth and final consideration involved water quality assessment. The initial goals and study design were based on the assumption was that beaches could be categorized according to water quality in order to drive the study design. Since it was not possible to identify beaches with sufficiently different water quality and since overall the water quality was good, the study design was altered with the primary goal to investigate whether swimming at New Jersey coastal beaches led to a significant excess risk of infectious diseases among swimmers.

The tendency for swimming elsewhere and the generally good ocean water quality have major implications on the future conduct of the study in the Summer of 1988. The available options that were considered included:

1) Reject the study design due to the lack of available population size for statistical analysis,

2) Continue with the present study design but increase the population size to be interviewed to assure the minimum 20,000 figure suggested by the power calculation,

3) Modify the study design to a longitudinal format including an additional telephone call to establish baseline illness rates in the families, or

4) Calculate relative risks for both adults and children (compared to children only in the previous design). The repeated interviews of family units would let the individuals serve as their own control.

With input from the Science Advisory Group, modification of the original study design was undertaken based on the results of the initial study phases. The modified design will incorporate a combination of options 2 through 4 as a practical approach that was still consistent with the original goals of this initiative.

Apart from actual swimming related adverse health outcomes, which are predicted to be low, there is apparently an unrealistic perception among the general population of the risk and illness rates for beach visiting and ocean swimming. Without historical data it is difficult to derive conclusions. It appears, however, that local departments of health received considerably more illness reports this year than in previous years, although the water quality in 1987 was improved over previous years. It is quite possible that minor gastrointestinal, respiratory, and skin infectious were reported by the public because of heightened awareness while in other years these infections were not noted as significant or were attributed to food or travel causes. It was also observed that there was poor understanding, even on the part of some physicians, of plausible transmission and incubation periods for infectious diseases. For these reasons, there is a need to develop an outreach and risk communication program for physicians and state residents to specifically address the perception of ocean beach-related illnesses. The increase awareness of the science of waterborne illnesses should reduce unnecessary concern surrounding this issue and help focus attention on the issues being addressed by this study and on the programs designed to reduce sewage and solid waste output into the embayments and ocean beaches.

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1. INTRODUCTION

1.1 New Jersey Coast Line

The New Jersey shore areas are a unique environmental resource as well as a tourist attraction for both residents and visitors. Ocean water recreational activities are an important contributor to the quality of life in the State. Protection of New Jersey's shores is the responsibility of state and local government, industries, and citizens.

Four counties share the New Jersey coastline. The State's coastline is bounded on the north by Sandy Hook and on the south by Cape May City This region is included in the New York Bight. Northwest of Sandy Hook is the Raritan Bay, shared by New Jersey and New York, which receives outflow from the Raritan, Arthur Kill, and Hudson Rivers. Southwest of Cape May is the Delaware Bay, shared by New Jersey and Delaware, which receives outflow from the Delaware River.

The northernmost coastal county, Monmouth, has ten major lakes and inlets which feed into the ocean. The Manasquan River forms the southern border of the county. South from the Manasquan River the coast consists of barrier islands backed by a series of bays and harbors. The three remaining coastal counties, Ocean, Atlantic, and Cape May, include nine inlets through the barrier islands and two wildlife refuges in the bays.

1.2 Coastal Sewage Discharges

Most of the coastal communities in New Jersey rely on the ocean for disposal of human wastes. Sewage treatment plants in these communities utilize secondary treatment methods for the most part, which involves a microbial digestion step that converts organic material to sludge. A few plants still perform primary treatment, with physical settling of material. In either case the treatment produces a final effluent that is chlorinated prior to discharge through extended ocean outfall pipes.

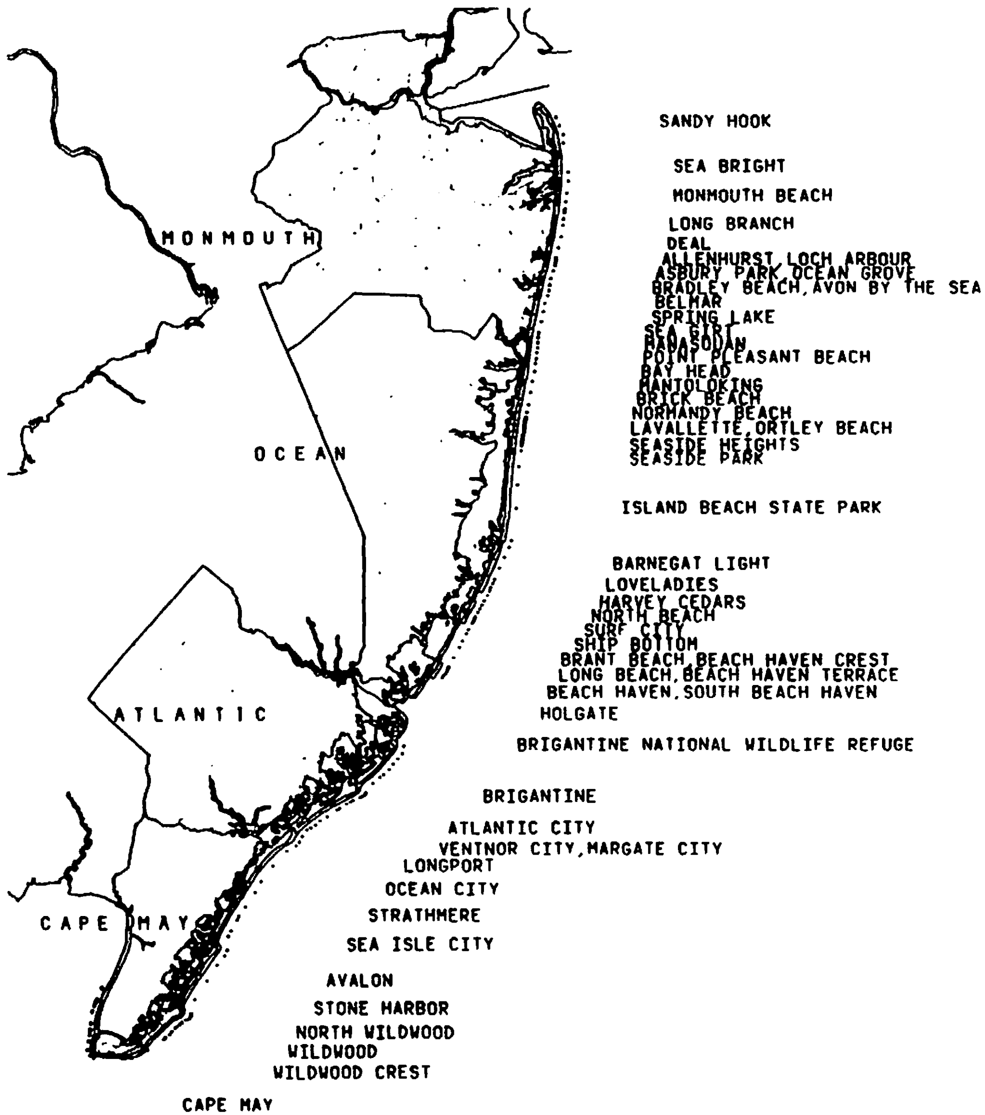
Other sources of microbial contamination of the ocean in addition to sewage treatment plants include intentional or accidental connections between sewers and stormwater pipe drainage. This can result in human wastes reaching coastal waters directly or through contamination of lakes, rivers, and estuary bays. Animal wastes including those from domestic pets, agricultural sources, or shore birds may contribute a bacterial load to the water directly or through sewered or unsewered storm runoff.

A major public health concern relating to the contamination of coastal and estuarine waters with wastewater effluents and sewage sludge is the risk of infections from pathogenic microorganisms in the discharges. The organisms are transmitted to man via swimming and other direct contact water activities as well as by the consumption of raw or partially cooked molluscan shellfish. Shellfish are present in the embayments and estuaries, and one of the several reasons for translocating the discharges from the embayments and estuaries to the coastal water is to decrease the risk of water related infectious disease via this route of transmission.

1.3 Control of Waterborne Diseases

Since the 1930's, the common wisdom has been that swimming in sewage contaminated marine waters carries with it an increased risk of infectious disease. This was confirmed by epidemiological studies conducted in the 1950's in fresh but not in marine waters (35). These studies were the basis for the development in the 1960's of a recreational water quality guideline based on the fecal coliform level, an indicator albeit somewhat imperfect of fecal contamination (NTAC 1968). The guideline was adopted

NEW JERSEY COASTLINE



1980 Physiographic MAP - NJDEP Mapscale 1:350000 12/87 KLK - NJDOH by the EPA in the 1970's. Subsequently, most of the states including New Jersey adopted the fecal coliform as the standard for judging the acceptability of freshwater bodies for recreational purposes.

Prospective epidemiological studies conducted by the EPA in the 1970's clearly showed that swimming in sewage contaminated marine as well as fresh waters carried with it an increased risk of a somewhat specific disease entity, acute gastroenteritis. The levels of enterococci but not of fecal coliforms in the water were best correlated to the risk of swimming related illness. An indepth discussion on the epidemiology of waterborne diseases is presented in the **Background** section of this report. More importantly, a mathematically expressible illness-indicator relationship was developed and this criterion along with a guideline developed from it were adopted by the EPA in 1978. This was done after consideration of what risk of illness might be considered acceptable at the federal level, that is, the risk and the corresponding enterococci limit beyond which intervention might be considered by the EPA. It was fully expected that the level of risk accepted by state and local regulatory agencies would be lower. Since, by design, all the epidemiological studies from which the enterococci criterion was developed were conducted at beaches which were acceptable by the existing fecal coliform guidelines, it is clear that the fecal coliform limits carry a measurable risk of swimming associated illness.

1.4 New Jersey Coastal and Beach Monitoring Programs

Current coastal monitoring programs conducted by various federal, state, county and local health and environmental agencies have focused on water quality issues in order to evaluate the efficacy of the State's wastewater disposal strategy and to monitor the coastal waters against possible adverse effects due to the onshore disposal of stormwater and the offshore disposal of wastewater effluents and sewage sludge. These programs include routine monitoring of marine beaches by the New Jersey State Department of Environmental Protection (DEP) to determine the acceptability for recreational use, routine offshore sampling by the United States Environmental Protection Agency (EPA) to examine the movement of wastewater effluents from ocean outfalls and dumped sewage toward the shores, and specific research studies of chemical and microbial contamination of ocean sediment and marine organisms.

Monitoring of marine beaches currently relies on a New Jersey standard for coliform level. The current New Jersey marine bathing beach regulation (N.J.A.C. 8:26-7.19) requires that fecal coliform counts not exceed 200 per 100 milliliters of water. This standard was incorporated in the 1985 DOH public bathing water regulations (N.J.A.C. 8:26-1 et seq).

1.5 Anecdotal Reports of Ocean-Related Illnesses

In the Fall of 1986, the New Jersey State Department of Health received anecdotal reports from Save Our Shores, a group of concerned physicians, which described various types of illnesses attributed by individuals to bathing in New Jersey marine beaches. In general, the described illnesses were common, mild, and self-limited. There was no requirement that illnesses of these types be reported to the New Jersey State DOH or any federal or state health agency for that matter except in the case of a possible epidemic outbreak. Because of the inadequacy of the exposure information, it was impossible to determine whether these anecdotal reports represented illnesses occurred as a consequence of swimming at marine beaches subject to excessive sewage contamination of the ocean water or even to swimming at the beaches per se.

Since the reported illnesses can also be transmitted by other routes such as food, direct contact, or aerosols, a controlled epidemiological investigation or at least data clearly demonstrating a common source outbreak would be required to establish an association between illness and swimming. However, even this would not necessarily provide a cause and effect relationship. In addition, some of the gastroenteritis and even some of the respiratory complaints may be swimming associated but not contamination related.

Because of the concern for public health and for the quality of the water at New Jersey marine beaches, the Governor and the Legislature commissioned the DOH, in cooperation with the DEP, to address specific questions related to ocean bathing water contamination and health outcomes utilizing a comprehensive epidemiological approach. To assure the study's scientific integrity, the DOH formulated a scientific advisory group consisting of members with expertise in epidemiology, infectious diseases, microbiology, oceanography, public health, and medicine. The members are affiliated with the DEP, the University of Medicine and Dentistry of New Jersey-Robert Wood Johnson School of Medicine (UMDNJ), the Jersey Shore Medical Center, the New Jersey Marine Sciences Consortium (NJMSC), the Stevens Institute of Technology, the Centers for Disease Control, and Save Our Shores.

This progress report serves to provide the scientific background for the study, to present the results of the preliminary field work conducted during the summer and fall, to discuss the implications of the results, and to present recommendations for further work deemed essential for the attainment of the study's goals.

2. THE DEFINITION AND LIMITATIONS OF EPIDEMIOLOGY

2.1 General Considerations

It is important to recognize from the outset of this report both the meaning of epidemiology and its limitations as a science. Broadly defined, epidemiology is the study of the distribution and determinants of diseases and injuries in human populations. Associations are sought between exposures to potential disease causing factors and the related health outcomes in large groups of people. Epidemiology is the primary approach by which health scientists have been able to characterize disease according to the routes (e.g. drinking water, person to person contact, shellfish, swimming) by which infectious agents are transmitted to man and, therefore, the steps that have to be taken to prevent or at least minimize the spread of the diseases.

The identification of sources and routes of transmission can be difficult if there are multiple routes of transmission and multiple potential sources for a given illness. Identifying the source is virtually impossible from the report of a single case of the illness. This is true of most of the gastrointestinal and respiratory diseases. For example, even though an individual may perceive that he or she contracted infectious hepatitis or acute gastroenteritis from swimming, it is equally plausible that infection occurred elsewhere at the beach from nonswimming activities such as eating contaminated food, inadequate personal hygiene, or having contact with other people.

Because of the uncertainties noted above, in studies such as the one in question there is a need for a control or a comparison population which is not exposed to the agent in question. If the demonstration of a relationship of disease to a given source is desired, exposure to other sources via the same route should be kept minimal in both populations.

Once the proper exposed and unexposed groups are identified, the illness rates for the two groups are compared statistically in order to determine if there is an association between disease and a particular route of transmission or source of the agent. Even this association should not be interpreted as a causal relationship. Epidemiologists usually apply formal rigorous criteria for judging a causal association between exposure and disease. The criteria are as follows (20, 26):

1. Strength of the Association: The relative risk or the ratio of diseases rates in the exposed and unexposed populations is established. The larger the ratio, the greater the likelihood that the factor is causally related to the outcome.
2. Dose-Response Relationship: The likelihood of a causal relationship is strengthened if there is an indication that the frequency or incidence of the disease increases with increasing levels of exposure.
3. Consistency of the Association: The more often the association appears in different studies utilizing different study populations and methods, the more likely that the association is causal.
4. Temporal Association: Exposure must occur before the onset of the disease and must allow for induction, incubation, and latency periods.
5. Biological Plausibility: Causal association is further strengthened if the association is supportable by existing

scientific knowledge about the disease and agent in terms of physiology, biochemistry, pathology, kinetics, and history, among other factors. An explanation for the association which may conflict with the current scientific knowledge should be evaluated with care.

These criteria should be kept in mind when designing a study which examines a hypothesized relationship between a disease and an agent. For these reasons, careful consideration must be given to the history of the issue under investigation and to the purpose of the investigation. Failure to do so may result in the design and implementation of a costly epidemiological study that is fatally flawed from the outset and which will provided meaningless information which may be erroneously interpreted by the public and government agencies.

2.2 Application To Studies of Swimming-related Illnesses

The problems with design are particularly complex for epidemiologic studies of environmental exposures and resultant health outcomes. In general, such studies lack a specific agent of exposure, include individuals with a broad range of exposure doses or multiple exposures, involve exposures that are difficult to identify and quantify, and investigate illnesses with multiple possible causes.

For example, if swimming occurs in sewage contaminated water the swimmers will ingest varying amounts of different microbial agents. They may also ingest similar infectious agents from contaminated food and drinking water. Quantification of the various exposures for each individual is essentially impossible, as is explaining the source of infection for a certain individual. A given case of gastroenteritis could be due to food poisoning, drinking water contamination, swimming water contamination, or contact with an ill family member or stranger at the beach. In addition, gastroenteritis is often experienced as a result of generalized community epidemics unrelated to swimming.

The requirements for the design of an epidemiological study become even more exacting if the study is to be the basis for standard development for an environmental contaminant such as infectious agents in bathing water. This necessitates establishing a dose-response relationship in which higher doses lead to higher frequency or greater severity of illness. Study requirements should be even more stringent if the route of transmission carries with it a risk of illness not associated with the exposure, for example illness which is swimming associated but not contamination related. This necessitates including a control environment that has the route of transmission but not the contaminant, in this situation a swimming beach which is virtually devoid of the contaminant.

In order to establish a causal association between swimming in contaminated water and illness it would be important to establish the following:

1. Strength of the Association: There is an elevated relative risk for illness among swimmers in contaminated water as compared to swimmers in uncontaminated water or to nonswimmers, with all other exposures such as travel, hygiene, food, and drinking water held constant.

2. Dose-Response Relationship: The association between swimming in contaminated water and illness shows a consistent relationship between degree of contamination and frequency of illness in the swimming population.

3. Consistency of the Association: The association between swimming in contaminated water and subsequent illness is identified from multiple studies.

4. Temporal Association: Illnesses occur in previously healthy individuals after an incubation period appropriate for the exposure or agent of interest, which for infectious gastroenteritis is on the order of one to three days,

5. Biological Plausibility: Identified illnesses are plausibly contracted from the postulated source of exposure. Sewage carries large loads of intestinal organisms but few eye, ear, or throat organisms; the latter group would be expected from oral or nasal secretions expelled during coughing or spitting. Gastroenteritis but not ear or upper respiratory infections would be expected after swimming in sewage contaminated water.

3. BACKGROUND

Ingestion of water contaminated with human pathogens is a recognized pathway for the transmission of infectious diseases. If the source of the contamination is sewage then the specific diseases of concern, in particular the nature and frequency of intestinal infection, reflect the underlying health status of the population. Chlorination of drinking water supplies have reduced or eliminated previously common waterborne epidemics in this country such as typhoid fever and salmonellosis. At present, due to the generally good health status of the population, sewage from the population in this country is expected to carry the causative organisms for less severe illnesses such as viral gastroenteritis. As travellers out of the country may discover, sewage contaminated water from other populations may still carry noticeable infectious risk.

3.1 Sources of Microbial Contamination

There are a large number of natural and man-made sources of water drainage along the coast which have the potential for contaminating the coastal ocean waters with fecal material of either human or animal origin. These include sewage treatment plants, sewage pipe breaks, sewer stormwater connections, stormwater drainage, marinas, outflow from natural bodies of water or bays, and direct contamination of water from water craft or by wildlife.

3.2 The Epidemiology of Swimming Related Diseases

Illness outcomes of concern following swimming are rarely specific in either presentation or in diagnosis. One group of swimming associated illnesses is caused by organisms present on the swimmer and will occur regardless of water quality. These illnesses are primarily the result of the breakdown of normal skin and membrane barriers, particularly in the upper respiratory tract and the skin. A commonly experienced example is "swimmer's ear", an external ear infection resulting from immersion and generally caused by organisms resident in the outer ear canal (14).

A second group of illnesses result from microbial agents present in the water. Such illnesses may be due to indigenous aquatic organisms or to organisms introduced into the water from human and animal wastes (14). The former include pneumonia following near drowning (causative organisms include *Pseudomonas*, *Aeromonas*, and *Legionella* species), *Aeromonas* and *Vibrio* infections of wounds, primary amoebic meningoencephalitis, and schistosome dermatitis. Individuals with altered immune status due to conditions such as alcoholism, diabetes, leukemia, or aplastic anemia may be particularly susceptible to infections due to indigenous organisms.

Infections due to microorganisms introduced to water following sewage contamination are well known to health professionals. These are primarily gastrointestinal illnesses which may be caused by a variety of viral and bacterial pathogens. Water borne illnesses such as typhoid fever and cholera are no longer public health concerns in developed nations due to improved sanitation. Episodes of severe viral diseases such as hepatitis contracted from contaminated shellfish consumption are also greatly controlled. In addition to these specific severe illnesses, other agents and in particular viruses have been implicated in water borne epidemics of mild gastroenteritis.

The route of exposure for gastroenteritis is through oral contact with fecally contaminated substances. As a result exposure to such infectious agents can occur through numerous routes of transmission besides being acquired during swimming. It is well known that outbreaks of gastroenteritis can occur due to contaminated food or drinking water. Transmission of gastrointestinal illnesses from direct contact of one person with another, for example hand-to-hand contact, is also possible. There is a constant risk of these infectious because enteric diseases are endemic in communities throughout the year (28).

Several studies have demonstrated a link between water quality and illness. Swimming exposure was strongly associated with an epidemic of gastroenteritis in a lake in Michigan and there was serologic evidence that the Norwalk virus was the causative agent (1, 24). There was also a low rate of respiratory symptoms in the affected individuals. Coxsackie A16, a virus known to occur in sewage and estuaries, was identified as the probable causative agent in a cluster of gastrointestinal illness after lake swimming (12). A recently completed study in England showed that swimming in sewage contaminated marine water carried a measurable risk of illness, specifically acute gastroenteritis (5).

One of the more extensive studies conducted for the EPA found that gastrointestinal but not respiratory, eye and ear infections were associated with swimming water quality as measured by a series of microbial indicators (enterococci, E. coli, Klebsiella, Enterobacter-Citrobacter, total coliforms, C. perfringens, P. aeruginosa). The gastrointestinal symptoms were characteristic of virally induced illnesses, being of acute onset (24-48 hours) with short durations (24-72 hours) and consisting of diarrhea, vomiting, nausea, stomach ache, and fever (6, 9). The EPA study identified the closest association between enterococci as the indicator organism for water quality and the development of swimming-related illness.

In addition to fecal-oral transmission there have been episodes where infectious diseases have been passed from one swimmer to another, either by direct contact or through the water. Enteroviruses have been identified in swimming pool water in the absence of fecal coliforms and in water specimens meeting recommended chlorination levels. The source of the viruses was considered to be the swimmers, with shedding through nasopharyngeal secretions and fecal material (22).

Visiting beaches as opposed to pools was found to carry an increased risk of respiratory viral-like illnesses in children in one study (10). The primary etiologic agents were considered to be enteroviruses transmitted between individuals through the water rather than by direct person-to-person transmission. An adenovirus outbreak characterized by sore throat, fever, headache, and loss of appetite was associated with a private swimming pool where there was a period of defective chlorination, although the possibility of person-to-person transmission rather than waterborne transmission was not definitively eliminated (27).

Several research studies have shown that children have a higher risk than adults of developing illness following swimming (10). This increased risk may be due to a combination of children having experienced fewer infections and therefore having developed fewer type-specific antibodies and also to the tendency for children to ingest relatively larger doses of ocean water when swimming. Young children would therefore represent a a subpopulation of swimmers having a higher susceptibility to infectious agents in the environment than would adults.

The results of a recent epidemiological study (R. Calderon, personal communication) confirm an assumption which many investigators have held for some time based on the etiology of swimming and shellfish disease outbreaks. The assumption is that the risk of water borne illness is considerably greater from water contaminated with human fecal wastes, primarily sewage, than from water contaminated by animal wastes as might occur with "pure" stormwater runoff or direct contamination from aquatic animals and birds.

3.3 Potential Indicator Organisms for Human Sewage

It is difficult to specifically demonstrate whether current wastewater handling and water quality monitoring methods are preventing excess illness after ocean water contact. The difficulty relates in part to problems with defining relevant human illness and in part to limited techniques for evaluating the microbial contamination of water.

Detecting sewage contamination of water presents technical problems. It would be necessary to quantify a large variety of microorganisms, requiring different and in some cases lengthy assay techniques, in order to characterize the disease-causing potential of a water sample to the best ability of existing laboratory techniques. In general the pathogenic organisms of interest, particularly viral agents, at present are either difficult or impossible to culture from environmental samples.

These same technical problems were considered when current water quality monitoring methods were established. Historically it was noted that certain bacteria, while not responsible for disease, were usually present in feces and sewage along with pathogens that cause human disease. These indicators were more readily cultured in the laboratory and could be used as an indication that sewage contamination of water had occurred. Assays are therefore conducted to detect indicator organisms which although not in themselves disease causing are considered to predict the presence of sewage and its pathogens.

Evaluating water quality through measurement of indicator organisms remains the state of the art. The current water quality test used on a national basis with an internationally recognized standard is the fecal coliform concentration, a measure of the number of lactose fermenting coliform bacteria in 100 milliliters of water. The standard is set at 200 colony forming units (CFU) per 100 milliliters of water.

An additional indicator that has been suggested is the level of enterococci, which are a subgroup of fecal streptococci. These fecal bacteria are more specific than fecal coliforms for human wastes and are more resistant to chlorination than fecal coliforms. In addition epidemiological studies suggest that there is better correlation between water enterococci levels and human illness than exists for coliforms (7). There is no standard based on enterococci. The current water quality recommendation is set at 35 CFU/100 ml.

Bacterial assays may not reflect the presence of viruses, which have environmental survival patterns different that those of bacteria. Viruses may be more persistent in water than bacteria, and in some cases more resistant to chlorination. Assays for viruses in environmental samples have only recently been under development. Such assays are generally experimental, requiring the filtration of large volumes of water, and so do not lend themselves to routine water quality monitoring.

Through studies using human volunteers the Norwalk virus has been shown to have some survival at the level of disinfection present in sewage after routine treatment with chlorination, making it a disease-causing organism of concern. The virus cannot assayed environmentally, so that clinical identification is dependent primarily on serologic assays. A bacteriophage was proposed as an indicator for the Norwalk virus.

Bacteriophages are viruses that infect bacteria rather than humans. The f2 male specific bacteriophage occurs in sewage and septic tanks. Its host is E. coli, a common fecal bacterium. The bacteriophage survives chlorination in a pattern similar to those of the Norwalk-type agents capable of causing gastroenteritis in humans, and can therefore be used as an experimental indicator to detect contamination by chlorinated sewage.

The use of indicator organisms rather than pathogenic organisms as a measure of water quality is complicated by the lack of an organism specific for human fecal material. The bacterial species used as indicators also occur in the intestines of other warm blooded animals. Animal wastes can transmit illness but are generally felt to be less significant in pathogenic potential, so that the indicators but not the disease causing organisms are present. An analysis of gull droppings found that fecal coliforms were the majority of the coliforms present. Fecal streptococci were on occasion present in numbers similar to the fecal coliform. There were lesser numbers of C. perfringens with no Salmonella identified (18). It should be noted that animal feces can carry human pathogens. Leptospirosis and giardiasis have occurred as infections in humans after ingestion of water contaminated by wastes of domestic or wild animals.

3.4 The State of Indicator Organism Systems

A consensus among public health scientists as to the best indicator organism or organisms for judging the quality and acceptability of fresh and marine recreational waters is not evident. This lack of consensus has persisted since the 1930s. Three main opinions as to what should be done about the indicator systems emerge. These are:

1. Microbiological quality of fresh and marine waters, including swimming pools, is best measured by using bacteria that indicate fecal contamination, such as coliform or fecal coliform bacteria or enterococci,
2. The risk of infection is associated more with microorganisms derived from the skin, mouth, and upper respiratory tract of bathers rather than fecal contamination so that water quality sampling should address these organisms, and
3. Microbiological standards with any indicator group of bacteria are virtually impossible to construct and are meaningless measures upon which to base public health decisions such as closing beaches.

From these diverse opinions it is seen that the current fecal coliform bacteria used by EPA and adopted by several states including New Jersey to judge the quality of marine beaches may be judged by some public health scientists as inadequate. This opinion would be true if the public health goal is the prevention of total illness associated with swimming in water contaminated with microorganisms derived from fecal wastes, the mouth, nose, and skin areas of bathers, rather than the more defined goal of preventing gastrointestinal illness due to sewage contamination only.

It is quite obvious that the selection of the adequate indicator systems is unlikely to be resolved with relative ease. However, because of the existence of voluminous information on the fecal coliform indicator system, the fecal coliform standard has been favored by states, the EPA, the World Health Organization, and foreign countries, as the indicator of choice for judging the quality of recreational waters.

In recognition of the need to improve the scientific basis for making public health decisions regarding the safety of recreational waters the EPA recently promulgated an enterococci guidance of 35 CFU/100 ml for marine water (6). For fresh waters, the guidance is based on enterococci (20 CFU/100 ml) and E. Coli (77 CFU/100 ml). These guidance values are intended to augment and not to replace the current fecal coliform standard for bathing beaches.

3.5 New Jersey State Recreational Bathing Regulation

In 1985, the New Jersey State Department of Health promulgated new microbiological standards (N.J.A.C. 8:26-1 et seq.) for bathing waters based on the EPA recreational waters standards. There are two acceptable bacteriologic methods for evaluating water quality at bathing beaches (Table 1).

In 1985, the State Department Environmental Protection, under the authority of the County Environmental Health Act (N.J.S.A. 27:3A-21 et seq) initiated the Cooperative Coastal Monitoring Program with county health departments for the general analysis of coastal water quality. The enterococci assay was added to the battery of tests in an effort to obtain more information on the utility of using the enterococci as the indicator organisms of choice.

3.6 Beach Pollution Transport Dynamics

The impact of microbial contamination at a bathing beach, regardless of source, will be influenced by how long the contamination persists. One factor determining the persistence is the rate of water recirculation in the swimming area. As a general rule, swimmers in the ocean are mostly found in the surf zone between the shoreline and the breakers. If the density of swimmers in this zone is high and if the rate at which the

TABLE 1.

New Jersey Water Quality Standards for Bathing Beaches

Organism/Method	Swimming/wading pools	Hot tubes/spas	Bathing beaches
	colony counts per milliliter		
Fecal Coliform Method			
Membrane filtration	--	--	200/100 ml
MPN Procedures (E.C. and A1 media)	--	--	200/100 ml

water within this zone exchanges with the water seaward of it is low, then there is a potential for the swimmers themselves to become a source of contamination to each other. One step toward understanding this possibility is to develop a capability to predict the renewal rate of the surf zone waters. Previous studies of this renewal rate appear to be confined to straight, uninterrupted beaches. These results show that there is not a continuous ebb and flow of ocean water at the beach. The water in the surf zone returns seaward only in rip currents which occur at alongshore distances of from one to eight surf zone widths.

The circulation in the surf zone is driven predominantly by the momentum provided by the impinging waves with secondary influence from the wind. The magnitude of the average alongshore current in the surf zone depends directly on the wave energy and on to what extent the direction of approach of the waves deviates from a line perpendicular to the shoreline.

In contrast to a straight uninterrupted beach, the shoreline of northern New Jersey has numerous jetties and bulkheads which have been constructed in an attempt to control the alongshore drift of sand. Since these structures cross the surf zone they must affect circulation and exchange processes there. Field work was necessary to extend presently available theoretical and experimental results for straight uninterrupted beaches to those more typical of the northern New Jersey coastline.

3.7 Epidemiological and Water Quality Research Needs

The long range programs being carried out by the DEP to improve ocean water quality do not insure that all sources of fecal contamination, or even human fecal contamination, are being removed from embayments, estuaries, rivers, lakes, and stormwater drains with outlets to the New Jersey coast. However, there are programs in place to locate and eliminate such sources. These programs and the recent monitoring data argue against recent degradation in water quality but not against the need for some epidemiological studies.

Further epidemiological studies should be designed to answer two other specific questions. The first one, noted earlier, was to determine if swimming in waters subject to stormwater runoff which contains relatively large number of enterococci and fecal coliforms of presumed animal origin carries with it a measurable risk of contamination associated illness. Phrasing the second question requires some additional background information.

The epidemiological studies from which the enterococcus marine recreational water quality criterion was developed were all conducted at beaches potentially contaminated by significant inputs of raw, undisinfected sewage. It has recently been shown that the Norwalk virus, the most frequently identified etiologic agent in waterborne outbreaks of acute gastroenteritis (21) is very resistant to the effects of chlorination unless a free chlorine residual is attained. Free chlorine residuals are not achieved in the chlorination of primary or secondary treated wastewater effluents. A certain bacteriophage, the f2 male specific bacteriophage, was found to have levels in sewage only slightly decreased during wastewater treatment as generally practiced although the enterococci and fecal coliform densities in the effluents were reduced to very low or undetectable levels. Since the Norwalk viruses cannot be propagated or quantified in water samples, the phage is its best available simulant, at least with regard to chlorination.

All municipal wastewater effluents discharged through ocean outfalls or into embayments in New Jersey are chlorinated. Clearly, the dependency on chlorination to reduce the coliform and enterococci indicator levels in the effluents so that they will not adversely affect the water quality at nearby recreational and shellfish resources is greatest with estuarine and embayment discharges and discharges from relatively short ocean outfalls. Release of effluents through longer outfall pipes increases dilution and reduces the impact on water quality. Thus, the second question which needed to be addressed epidemiologically was the propriety of disposal strategies which depended on secondary treatment followed by chlorination to safely discharge wastewater effluents through relatively short outfalls. The corollary to this question was to determine the validity of coliform or even enterococci levels as indicators of the risk of swimming associated illness in situations where the contamination derived from chlorinated wastewater effluents.

Both these questions required the ability to distinguish meaningfully between beaches with various water quality through the use of one or a combination of indicator organisms. An initial study design with attendant goals and objectives was developed that incorporated assessment of the epidemiological and water monitoring methodologies.

4. GOALS AND OBJECTIVES OF THE OCEAN HEALTH STUDY

4.1 Goals

The focus of the Ocean Health Study is to investigate the occurrence of unusual increases in illness rates among ocean bathers as compared to nonbathers. The primary goals of the original study design were:

1. To investigate epidemiologically whether the discharge of chlorinated municipal wastewater effluents from sewage treatment plant ocean outfalls carried with it a risk of swimming associated illness beyond that predicted from the enterococcus levels in the bathing water,
2. To evaluate the utility and effectiveness of other sewage indicators to predict the rate of illness following contact with swimming water containing chlorinated sewage,
3. To evaluate the effectiveness of chlorination in reducing sewage microorganism levels prior to effluent release into the ocean, and
4. To determine whether stormwater runoff containing high levels of the enterococcus and fecal coliform indicators but no human fecal input carries with it a commensurate risk of swimming associated illness when discharged into coastal waters.

4.2 Objectives

1. To assess the feasibility for using existing methodology in an epidemiologic study of ocean water quality,
2. To determine the incidence of gastrointestinal and respiratory illnesses following swimming exposure to ocean water containing chlorinated sewage discharged under current disposal practices,

3. To determine the incidence of infectious illnesses following swimming exposure to ocean water of varying quality as determined by microbial assays,
4. To determine the water quality index best correlating with illness incidence following exposure to ocean water containing chlorinated sewage,
5. To characterize the quality of water at beaches and the oceanographic patterns along the New Jersey coast, including recirculation and exchange patterns, and
6. To inventory sources of microbial contamination along the New Jersey shores.

5. COMPONENTS OF PROPOSED HEALTH STUDY DESIGN

In order to appreciate the impact coastal sewage discharge may have on illness rate, it was decided to combine health outcome information with exposure data reflecting water quality. There are multiple other sources of microbial contamination of the water and of nonwater related infectious disease transmission, and it is vital to link exposure to illness. If information describing the sources of contamination are also obtained, the public and responsible government agencies are then able to properly identify the major areas of concern and develop the appropriate short-term and long-term programs to minimize exposure to sewage in order to prevent excess waterborne illnesses and to protect the marine environment. On the basis of this premise, the following issues were identified as essential for consideration to assess the minimum components to meet the goals of the study.

5.1 Case Definition

When an association is postulated between an exposure and a disease outcome, it is essential to define the disease in as specific a way as possible. Such a case definition must permit distinction between individuals becoming ill due to the exposure of concern and individuals with similar illnesses that have causes unrelated to the exposure of concern. Typically a case definition includes a description of the clinical features and if appropriate the route of exposure and incubation period for the illness.

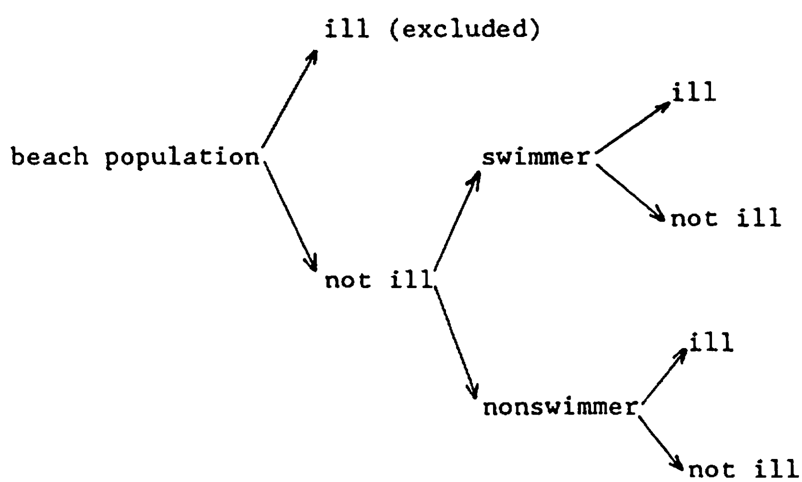
When available, trained medical observations and/or specific laboratory tests provide the most specific case definitions. People have various thresholds for the perception of the presence and severity of illness, so personal reports of illness provide a less reliable diagnosis and are more difficult to incorporate into a case definition. When relying on self reported illness, the case definition used should be as specific as possible and should reflect observations and symptoms understandable by lay individuals.

5.2 Study Design

Epidemiological methods make use of several different approaches. A surveillance system can be used to detect changes in disease patterns. Such systems depend on health professionals for reports and so are most useful for rare or severe illness. The reporting rate of mild infectious illnesses to any component of the health care system is low, so that records at governmental agencies or medical offices would considerably underestimate the true incidence of these illnesses in the community. A study involving closer investigation of illness in populations was expected to provide the most accurate information about health status to address the health issues raised by this study.

For more specific information regarding causation and illness rates epidemiological studies can be conducted. There were two study designs considered for the project. A case-control study compares individuals with a specific disease and individuals without the disease to determine if occurrence of illness correlates with any definable exposures or factors. This design was considered, but a satisfactory case definition could not be established that would successfully distinguish between illness due to swimming in contaminated water and illness due to other sources encountered at the beach.

A cohort study identifies a group of individuals with and without a specific exposure status and determines the illness outcome for the two exposure subgroups. In this study the beach population would be interviewed. Those ill would be excluded from the study. Those not ill would have their swimming status determined. A subsequent follow-up would determine the illness rates for both swimmers and nonswimmers. This can be represented as follows:



The cohort study offers the advantage of providing a measure of disease frequency in the population, since illness rates can be established.

5.3 Selected Health Endpoints

Illness resulting from sewage contamination of water was the primary concern which prompted the study, although other potential sources of microbial contamination of beaches are known. Consequently the health effects of concern were those expected to result from swimming exposure to fecal organisms. Generally such illnesses are expected to be generally mild and self limiting. Gastroenteritis is the syndrome best correlated with degree of sewage contamination of swimming water. This syndrome is manifested by fever, nausea, vomiting, and diarrhea. Gastroenteritis is more reliably described and reported in the absence of physician diagnosis than are respiratory and ear infections. However, in an effort to understand the epidemiology of illnesses related to the entire beach environment other conditions such as respiratory, eye, ear, nose, and skin illnesses were also considered in the survey.

All these illnesses can be caused by multiple bacterial and viral agents. The final outcome, such as gastroenteritis, presents the same clinical symptoms regardless of the specific causal agent or of the source of the exposure. In contrast to laboratory conditions where an experimental animal is infected under controlled methods, direct experimentation or even measurements cannot be done in human populations. Epidemiological studies attempt to unravel various causative factors in order to develop an association to explain the occurrence of disease, but must include the complexity of human behaviors.

5.4 Population at Risk

Selection of the target population is necessary to identify a group of individuals who will be exposed to the agent of concern. The target population should be susceptible to the illness, include both exposed and unexposed individuals, and have few confounding exposures which could produce the same illness due to another exposure.

Being present at the beach was necessary to be part of the population at risk. As previously discussed (see **Epidemiological Studies**) children are expected to have greater susceptibility of children to infections. The most prominent confounding factor would be swimming in another location with additional risk of exposure to infectious agents. The study population of greatest interest consisted of children visiting the shore only during the weekends when water quality testing was being conducted, and who had no other swimming exposures before or after the study weekend.

5.5 Exposure Status and Assessment

There are two components to the determination of an individual's exposure status. Firstly, the precise nature of the agents of exposure should be identified. If possible this should include quantitative assessment of the agent. Secondly, it must be determined if the individual was actually exposed to the agent in question. If the agent is present but does not enter or affect the body in some way, there is no hazard.

In terms of agents of exposure the concerns relating to the ocean were microbial contamination and the possibility that swimmers were exposed to infectious agents. Assessment of water quality was evaluated by microbial tests of water at the beach using both available standards and experimental indicator organisms. Such assays were of necessity limited by the availability and practicality of laboratory methods.

An individual's exposure status for gastrointestinal illnesses relates to the ingestion of water. Since even an adult has difficulty estimating the amount of water ingested while swimming and the simple presence or lack of ingestion may not be known for a child, swimming status was defined by getting the head wet. This can be determined by interviews with a knowledgeable individual who would also be available for follow-up information on health outcome.

5.6 Sample Size Considerations

The conclusions drawn from a study can be greatly effected by the size of the study population. For example, it is important to rule out with assurance the possibility that an effect was not missed if the results appear to be negative. The ability to statistically rule out this difference is based on the study's "power". Power can be broadly defined as the ability to detect and accurately estimate changes in frequency or mean value. A study's power should be considered at the onset of the project because the outcome of the sample size calculation may influence the precise nature of the study design and would provide a realistic assessment to the meaning of the results. The factors influencing the study's power are:

1. The availability and number of people likely to have been exposed or unexposed to the agent of interest,
2. The variability of the selected health endpoint,
3. The magnitude of the selected health endpoint,
4. The significance level accepted as confirmation of an association, and
5. The study's design and statistical analyses employed.

The choice of sample size in an epidemiological study is determined by efforts to reduce two different errors. A Type I error occurs when the results indicate that a difference exists when in actuality there is no difference. This kind of error rarely occurs because a small probability of alpha is chosen. The Type I error is more familiarly called the significance level and is indicated by the alpha level. A Type II error occurs when a study fails to detect a difference that actually exists and is indicated by the beta level (17).

A sample size, for example the number of interviews to be conducted, represents a balance between scientific needs to maximize the validity of the results and practical limitations such as the cost of conducting the study. The choice of sample size includes other considerations such as risk difference and background illness rates. A decision is made about what difference is considered worth detecting when comparing the exposed and unexposed groups, or the difference in risk between the two groups for acquiring illness. This risk difference is chosen depending on such factors as the severity of illness and potential long-term consequences of the illness.

Background rates of gastrointestinal illness have been estimated to occur at a rate of two episodes per person per year (28). In this study the rate of gastrointestinal illness among nonswimmers, which is not zero, would be compared to the rate of the same illness in swimmers. It was decided to look for an increase of 1.5 to 2 times the illness rate (50% to 100% increase) in swimmers as opposed to nonswimmers.

Sample size calculations are done to determine the appropriate sample size for the study design. Choice of alpha and beta, risk difference, and estimated background illness rates enter into power calculations. The end result are values of suggested population sizes which would be necessary to observe a difference (predesignated in size, i.e, 30%, 50%, 100%) with a selected probability (80%, 90%, 95%) at a preselected significance level (5%). For example, assuming a one case per thousand background rate of gastrointestinal illness rate in nonswimmers, interviews with approximately 10,000 individuals would be required in each exposure group (nonswimmers, swimmers) in order to detect a 50% difference in gastrointestinal illness rates between the swimming and nonswimming population at the 5% significance level with reasonable confidence at 90% probability (Table 2).

Smaller increases and higher rates of background illness require a larger sample size. As the Table indicates, if background illness rates

TABLE 2

Calculations for Total Sample Size

Background Illness rate (cases per 1000)	Swimming-Associated Percent Increase in Illness Risk		
	30%	50%	100%
20	99,600	37,780	10,640
10	54,426	21,548	6,602
5	31,482	13,302	4,550

alpha = 0.05
beta = 0.9

are 20/100 and an increased swimming associated risk of 6/1000 is expected, a total sample size of almost 1000,000 individuals would have to be interviewed in order to statistically differentiate the illness risks of swimmers and nonswimmers.

5.7 Schedule

Due to the complexity and large scale of the study, a multiphase schedule was developed. Six phases were identified:

- Phase I - Methods development and field testing of the questionnaire, initial beach selection, surveying of populations at beaches for demographic characteristics, evaluation of the technique for telephone recontacts for population and beach selections, and the establishment of laboratory assays for monitoring water quality at beaches.
- Phase II - Pilot testing of the questionnaires and beach sampling protocols reflecting changes in methodology based on Phase I work and involving 100% follow-up of interviewed families.
- Phase III - Review of data collected during Phases I and II and preparation of progress report.
- Phase IV - Development of final data collection methods.
- Phase V - Full scale epidemiological study in the Summer of 1988.
- Phase VI - Review of data collected during Phase V and final report preparation.

6. METHODS

6.1 Epidemiology

6.1.1 Case Definition

Gastroenteritis was selected as the infectious illness of primary interest for analysis, although illnesses of the eye, ear, nose, skin, and respiratory tract were also surveyed to obtain a better overview of the epidemiology of illnesses related to the general beach environment. For the purposes of the epidemiological study a case of gastroenteritis was defined as an individual meeting all the following criteria:

1. Was present on the beach and interviewed during a study weekend,
2. Had known swimming exposure status,
3. Had no additional swimming exposure the week prior to or subsequent to the study weekend, and
4. Reported credible gastrointestinal illness within five days of being on the beach.

Swimming exposure status was dichotomized as swimmer or nonswimmer based on whether or not the individual's head got wet at least once. The definition of highly credible gastrointestinal illnesses (HCGI) was adopted from an EPA study (6). An episode of HCGI was considered to be an individual reporting one of four conditions:

1. Vomiting,
2. Diarrhea with fever,
3. Diarrhea disabling enough for the individual to stay at home or seek medical advice, or
4. Stomach ache or nausea with fever.

Individuals meeting all requirements of the case definition were considered to be ill with HCGI.

6.1.2 Demographic Characteristics of Study Participants

One of the major focuses of Phase I was to determine the demographic characteristics of the population visiting various beaches. This evaluation included the estimation of the number of families that, once entered into the study, would become ineligible for the study due to reasons such as later swimming in other sites, unwillingness to participate with a telephone survey, or inaccessibility by telephone. Another important demographic aspect that required evaluation was the size of the population under the age of 10 years visiting the beach. If this age group is to be the focus of the study, a sufficient sample size must be available at various beaches.

6.1.3 Interview Process

A two step interview process was selected for the preliminary study phases. Study participants were recruited from New Jersey coastal beaches on summer weekends. The first interview was conducted at the beach. Family units with at least one child under 10 years of age were approached by a trained interviewer and voluntarily entered into the study. A signed consent form (Appendix 1) was obtained as the first step in the interview. For each family member present in the household including those not at the beach, the interviewer recorded age, gender, illness episodes in the previous week, swimming exposures in the previous week, and swimming status at the beach. Arrangements were made for a telephone contact on the following Thursday and Friday.

The second interview was conducted by telephone. For each family member present in the household including those not at the beach, the interviewer established illness episodes experienced in the week following the beach visit and swimming exposures in the week following the beach visit, and reestablished swimming status at the beach.

Phases I and II had similar design formats. The questionnaire form was altered for Phase II. (See Appendix 2 for Phase I beach and telephone questionnaires and Appendix 3 for Phase II beach and telephone questionnaires). The target sample size in Phase I was 1500 and in Phase II was 1000 interviews. Telephone contacts were attempted with 5% of the families interviewed during Phase I of Phase I and with 100% of the families during the two weekends of Phase II interviewing.

6.1.4 Interviewers

Interviewers were hired by UMDNJ and were students in graduate or professional programs. They received a total of 6 hours training which included interviewing training, familiarization with the Phase I and Phase II questionnaires, review of recording and coding systems for the questionnaire, and instruction for conducting follow-up telephone interviews.

A T-shirt with a university logo and an identification badge were worn by interviewers on the beaches. The interviewer selected prospective respondents based on the appearance of a family group with children. Logs were kept of the number of individuals who were approached for an interview but were ineligible, declined to participate, or could not understand the language(s) known by the interviewer.

All interviewers were debriefed the Tuesday following the beach interviews for comments and suggestions. There were modifications in the survey questions and in coding schemes as a result of the information obtained from the interviewers. In addition, interviewers bilingual in

Spanish and English were assigned to specific beaches based on the previous interviewing experiences.

Supervisors from UMDNJ were assigned to one or two beaches and were at the shore during the study period. Communications between the interviewers and the supervisors remained a problem throughout the study due to the limited number of supervisors available during the study.

6.1.5 Quality Control and Quality Assurance

Completed questionnaire forms were coded for computer entry by the beach and telephone interviewers. These forms were then reviewed for completeness and accuracy by UMDNJ coordinators. Photocopies of the forms were then sent to the consultant for data entry, review and analysis.

6.1.6 Data Analysis

Coded questionnaire data were entered into a personal computer using the data entry portion of the statistical package STATPAC (Wolnick Associates, 1982). After error checking and partial duplication of data entry as a quality control measure, the data were analyzed using PC SAS (SAS Institute, 1986) and SYSTAT (Wilkinson, 1987).

Limited statistical methods were applicable because of the small numbers of interviews planned for Phases I and II. The initial analysis examined demographic characteristics (i.e.,age) for each beach and current illness rates reported during the beach interview. The second analysis examined the follow-up information obtained by telephone interview. Of main importance was whether people went swimming again after their weekend visit to the beach. Frequency distributions of each illness symptom, age groups and other swimming exposures for the study population were calculated.

The primary goal of the two phases of data collection was to test the data collection method and obtain basic demographic information on selected beaches. Although rate estimates were derived for illness in the various groups, these were not considered to represent estimates of the actual illness rates because of the small numbers of individuals studied. For this reason, tests of statistical significance were not performed.

6.1.7 Illness Reports

There were two sources of anecdotal illness reports received during the study. Consent forms given during beach interviews provided a telephone contact number at the UMDNJ for the family to report illnesses occurring after the follow-up interview or for a family not interviewed by telephone. These calls were compiled by UMDNJ personnel.

The DOH received sporadic reports of illness that were in some fashion related to ocean contact. These reports came from individuals and from local or county department of health. The information was compiled for the summer by the DOH. The formal case definition could not be applied to the reports but illnesses were considered to be potentially ocean related if the following conditions were met:

1. Illness followed ocean swimming,

2. Either gastrointestinal or skin symptoms were reported,

3. If present, the skin symptoms did not accompany a viral respiratory illness, and

4. Other information did not clearly exclude the report as ocean swimming related.

Respiratory illnesses including colds, sore throats and ear infections were not considered to result from inherent water quality. These infections could result from the effects of swimming on normal body barriers or could be contracted from other ill individuals at the beach whether through physical contact or through water transmission.

6.2 Water Quality

6.2.1 Sources of Microbial Contamination

Although sewage treatment plants (STPs) were the initial concern, other potential sources of microbial contamination of coastal ocean water were known or suspected. The general categories of these sources were identified and when possible the sources were further characterized by microbial monitoring.

6.2.1.1 Sewage Treatment Plants

The effectiveness of chlorination was investigated by assaying pre and post-chlorination samples for the selected microbial indicators. Samples were collected on three occasions from nine coastal STPs: Northeast Monmouth, Long Branch, Deal, Ocean Township, Asbury Park, Neptune, South Monmouth, Ocean County North, and Ocean County Central.

Trained DEP personnel collected sampled at the STPs in sterile polypropylene bottles. Thiosulfate was added to the bottle prior to collecting the post-chlorination sample. Bottles were transported on ice to the State Department of Health Public Health and Environmental Laboratories. There was immediate analysis for coliforms and enterococci. Samples were batched and forwarded to the University of Rhode Island to analyze for C. perfringens spores and the f2 male specific bacteriophage. Geometric mean indicator levels were calculated from the assay results. Where the assay results were at the sensitivity level of the assay, the limit value was used in the calculation of the geometric mean.

6.2.1.2 Coastal Sources

Information from the DEP and county agencies was compiled to identify the major potential sources of microbial contamination other than STPs. These sources, primarily natural outflows and stormwater drains, as well as the STPs were mapped using the DEP Geographic Information System (GIS). In addition, intensive sampling was done along short segments of the coast to investigate water quality at selected lakes and inlets with outflow to the ocean. Additional sampling was planned for fall and spring periods to further characterize the water quality of lakes and inlets as well as to study STP outfalls.

6.2.2 Routine Monitoring Data

Historical water sampling data, primarily from 1985 and 1986, were compiled from the DEP and the EPA. During the swimming season from mid May through mid September measurements of ambient bacterial levels in the bathing zone water are routinely carried out by county or municipal agencies one day each week and reported to the DEP. Analysis is done by either the modified A1 procedure of the most probable number technique or the membrane filtration technique.

In addition, from mid May through October the EPA monitors ocean water quality along several collection networks in the New York Bight. One of these networks runs from Sandy Hook south to Cape May. A helicopter collects ocean water samples once a week at approximately 40 sites along the New Jersey coast for coliform and enterococci bacterial assays. Samples are collected with a Kemmerer sampler just off shore at a depth of 1 meter. Analysis is done by the mTec method.

The compiled sampling data were plotted on GIS to provide a pictorial presentation of the geographic distribution of the monitoring data which could be compared to the known contamination sources. Mapping was based on the 156 beach sampling sites from the DEP cooperative coastal monitoring program including seven sites in Cape May on the Delaware Bay. The nearest DEP station was assigned to each EPA station for mapping purposes.

6.2.3 Study Sites

Initial selection of beaches for Phase I of the study was based on available marine beach water quality data from DEP cooperative coastal monitoring program (31) and on beach usage patterns reflecting numbers and demographics as described by municipal and county agencies (local health officers, personal communications). It was not possible to include in the study more subtle variables expected to influence the choice of beaches for families. These factors include travel distance, beach fees, and varying quality of sanitary, recreational and concession facilities at the beaches which depend on whether the beaches are under federal, state, municipal, or private jurisdictions.

Beach access was granted to DOH personnel and consultants following a discussion of the study protocol with the town mayor and/or administrator and county or local health officer for each site. The townships with jurisdiction over the selected beaches provided a contact person for further assistance. Information from Phase I regarding both the demographics of beach visitors from the questionnaires and the water quality characteristics obtained from microbial assays determined beach selection for Phase II.

6.2.4 Selected Indicator Organisms

All samples collected for the DOH study were assayed for fecal coliforms, E. coli, enterococci, and for the f2 male specific bacteriophage. In addition to these indicator systems two additional microorganisms were selected for analysis.

C. perfringens is a normal component of human feces. Clostridial spores are more resistant to environmental stresses including chlorination than are vegetative bacteria and are assumed to survive chlorination without organism death. They persist in the environment so that resuspension of bottom sediments into the water column can release the spores. The spores therefore act as a more conservative tracer and provide evidence of sewage contamination over longer periods.

An experimental assay for Staphylococcus aureus was used in the study to attempt to quantify the impact of bathers on water quality in a localized area. If bathers shed fecal material, the four selected indicator organisms will be present in the swimming area. The tests for the indicators could not distinguish if sewage or if bathers were the source of the organisms. S. aureus is a skin bacterium expected to be in present in negligible quantities in sewage. High levels of the bacterium would be suggestive of high bather density with the possibility of water contamination by the bathers. Initial efforts to isolate the organism from water were unsuccessful and the assay was discontinued.

6.2.5 Sampling and Analytical Methods

Sampling was conducted in two parts, weekends and weekdays. During the routine EPA network collections on weekdays, study samples were collected from beyond the surf zone by helicopter for C. perfringens and phage assays. The EPA conducted coliform and enterococci assays on the weekday samples. On several days the EPA agreed to add special sampling stations in lakes and inlets along the northern part of the coast. During the weekends when interviewing was scheduled, water sampling was done at the study beaches during an incoming tide. Surf zone samples were collected in the bathing sections of the beach. At some beaches samples were also collected in sections of the beach off limits for recreational use or in sections of the beach restricted to surfing and therefore with greatly reduced use. One fresh water lake was sampled for the equivalent of a surf zone sample.

Sample collections were conducted in the beach surf zone by trained DOH personnel and beyond the surf zone by the EPA helicopter. Beach collections were done at chest height below the water surface. Beyond the surf zone samples were collected at approximately the same time by EPA personnel using a Kemmerer sampler. The collections were done in sterile polypropylene bottles and transported within six hours to the DOH laboratory. Bottles destined for C. perfringens or phage assays were frozen. These samples were shipped on dry ice to the appropriate laboratory the following week.

For the weekend samples bacterial assays were done in duplicate by the DOH laboratory. Two volumes, 10 cc and 30 cc, were filtered on Micropore filters. The coliform assays were done on mTec medium with urease confirmation. The enterococci assays were done on mE medium with esculin-iron agar confirmation. All C. perfringens and bacteriophage analysis was done by consultant work. Clostridial spores were assayed by the mCP method. The bacteriophage was assayed by a plaqueing procedure with an E. coli host strain susceptible to the f2 male specific phage; few if any somatic phage are counted by this method (V. Cabelli, personal communication). Bacteria were reported in colony forming units (CFU) per 100 ml and phage were reported as plaque forming units (PFU) per 100 ml. For each site, geometric means of the microbial counts were calculated.

6.3 Beach Pollution Transport Dynamics

Oceanography work addressed the wind, current, and temperature characteristics along the shore. Factors of ocean dynamics have an important impact on the transport and survival of the microbial indicators released into the ocean.

The surf zone field work was conducted along a 425 meter segment of beach between two jetties at Bradley Beach, New Jersey. The use of this beach gave data that would coincide with the test site for the epidemiological survey trials. A directional wave sensor was installed just seaward of the surf zone at the site in order to determine the appropriate wave parameters forcing the surf zone circulation. Currents were monitored continuously with both the directional wave sensor and an ENDECO model 174 recording current meter installed on a mooring 100 meters offshore from the wave sensor. Currents in the surf zone were measured with Mansch-McBirney electromagnetic current meters which were installed in the ocean only for short-duration observational periods. Wind was monitored continuously with an anemometer installed at a fishing pier north of the beach.

The transport and exchange processes within the surf zone at the Bradley Beach site were observed by injecting Rhodamine WT dye at selected points. The dye was followed both visually and by repeated fluoremetric measurement of dye concentration within the surf zone. The temporal pattern of dispersion was identified.

6.4 Consultants

The services of the University of Medicine and Dentistry - Robert Wood Johnson School of Medicine were retained to hire, train, and debrief the interviewers, to assist in the development of the pretrial and trial questionnaires, and to collect and process the interview data for shipment to Yale University for data analysis. Work was conducted by Audrey Gotsch, Dr.P.H. and Louise Weidner, Ph.D.

Rebecca Calderon, Ph.D., of Yale University was retained to develop the pretrial and trial questionnaires, to design the epidemiological component of the study, to assist in the selection of the indicator organisms, to analyze the interview data, and for the interpretation of the overall epidemiological data.

Victor Cabelli, Ph.D., of the University of Rhode Island was retained to assist in the development of the study design and interview questionnaire, to design the sampling framework, to conduct analytical methods for the selected microbiological indicator organisms, to conduct field testing of the analytic methods, and for the interpretation of the overall data.

Richard Hires, Ph.D. of the Stevens Institute of Technology and the staff of the New Jersey Marine Sciences Consortium were retained to develop and conduct the component of the study addressing the relationship between the wind, ocean current, ocean temperature, and ocean salinity with water circulation patterns at the beach, considering also the transport of sewage materials discharged into the ocean and possible impact on the beaches.

7. RESULTS

7.1 Epidemiology

7.1.1 Phase I Interviews

7.1.1.1 Beach Interviews

Early in the study it was recognized that some of the beaches originally selected were inappropriate for the study due to demographic considerations. Rejected beaches either lacked sufficient number of children or had beach use patterns resulting in families at the beach only for the weekend. In addition, other appropriate sites not initially slated for the study were investigated and and beaches were added to the study as identified.

A total of 13 beaches were investigated during the summer with interviews and/or water quality testing in the bathing area (Table 3). Nine beaches had both interviews and water quality testing done. Eleven beaches had interviewing done during Phase I and 10 during Phase II.

Based on a sampling of 2220 contacts there was an overall 73% participation in the beach interview process. For specific beaches this ranged from 39% to 88%. Among those not interviewed there were approximately equal numbers of contacts refusing to participate, contacts ineligible because not a family, and contacted families ineligible because of plans to stay more than one weekend. Of those interviewed, 54% were willing to cooperate with a telephone recontact.

A total of 1510 interviews were conducted on three weekends: July 11-12, July 18-19, and August 8-9. Information was collected on 6087 individuals. The beaches at which the interviews were conducted and the number of people covered by the interviews are summarized in Table 4.

TABLE 3

Beaches Investigated, Ocean Health Study 1987

Beach	Interviews	Water Quality Testing
Asbury Park	x	x
Atsion	x	x
Belmar	x	x
Bradley Beach	x	x
Brick		x
Cheesequake	x	
Island Beach State Park	x	x
Keansburg	x	
Long Branch	x	x
Manasquan		x
Sandy Hook	x	x
Seaside Heights	x	x
Spring Lake	x	x

Children under 10 years of age composed 25% (N=1522) of the individuals and had a swimming rate of approximately 60% (N=913). Beaches varied in the proportion of families present as well as in the proportion who had other than English as the primary language.

7.1.1.2 Telephone Follow-up Interviews

There were 99 families that were recontacted by telephone Wednesday through Friday following their visit to the beach. These follow-up interviews represented 410 individuals. The age and swimming status of the beach interview and telephone follow-up are summarized in Table 5. Of these individuals, 69% were swimmers as defined by getting the head wet and 34% had been swimming since the target weekend. Children under 10 years of age composed 29% (N=119) of the individuals and had a swimming rate of approximately 69% (N=82).

7.1.1.3 Crude Illness Rates for Study Participants

The individuals interviewed at the beach were asked if they had any gastrointestinal symptoms currently or 24 hours prior to coming to the beach. The results of those questions are summarized in Table 6 which describes the crude rates of illness (swimmers and nonswimmers) for the individuals combining all beaches.

The follow-up group was asked about illness that occurred after the trip to the beach. Although the numbers are very small, the percentages for each symptom is summarized in Table 7. The overall rate is given as well as the rate for the two exposure groups (swimmer and nonswimmers). The illness rates after swimming include those with persisting illness from the week before swimming. Crude rates for all illnesses were calculated to be 2.2%. Because the number of individuals recontacted was

TABLE 4

Number of Individuals Covered By Interviews At Beaches By Weekend In Phase I

Beach	Weekend July 11-12	July 18-19	August 8-9	
Island Beach	411	410	458	
Seaside Heights	428	406	0	
Spring Lake S	318	397	0	
Bradley	391	409	438	
Long Branch	388	379	0	
Asbury Park	0	0	403	
Spring Lake N	0	0	406	
Sandy Hook	0	0	445	
TOTAL				6087

TABLE 5

Summary Of Swimming Status By Age For Phase I

	Beach Interviews	
Group	Swimmer	Non-Swimmer
<10 years	15%	10%
10-60 years	44%	29%
>60 years	<1%	1%
Total (N=6087)	60%	40%

	Telephone Follow-Ups	
Group	Swimmer	Non-Swimmer
<10 years	20%	9%
10-60 years	43%	26%
>60 years	<1%	<1%
Total (n=410)	64%	36%

TABLE 6

Illness Rates From Phase I Survey At Beach (N=6087)

Symptom	Overall(%)	Swimmers(%)	Non-Swimmers(%)
Cramping	0.6	0.5	0.4
Nausea	0.5	0.3	0.4
Vomiting	0.3	0.1	0.2
Diarrhea	0.6	0.6	0.5

TABLE 7

Illness Rates By Swimming Status In Phase I Telephone Follow-up (N=410)

Symptom	Overall(%)	Swimmers(%)	Non-Swimmers(%)
Cramping	2.4	2.9	1.6
Nausea	1.7	1.1	3.1
Vomiting	1.2	1.45	0.8
Diarrhea	3.2	2.9	3.2
Eyes	0.5	0.4	0.8
Ears	1.7	1.1	3.1
Skin	1.7	2.2	0.8

small, a few individuals with or without illness could significantly influence the rates. Since Phases I and II were to focus on methods development and instrument testing, the data in Table 7 were not subjected to statistical analysis.

7.1.2 Phase II Interviews

7.1.2.1 Beach Interviews

The Phase II interviews were conducted at 10 beaches on two weekends; August 22-23 and August 29-30. A total of 879 interviews were conducted resulting in information on 3579 individuals. The number of individuals interviewed by beaches per weekend are summarized in Table 8. Island Beach State Park was canvassed heavily as it was identified as a possible study beach. Children under 10 years of age comprised 30% (N=1073) of the total interviewed, of whom 43% (N=461) were swimmers.

7.1.2.2 Telephone Follow-up Interviews

There were 351 telephone recontacts representing follow-up information on 1460 individuals. The age and swimming status of the beach interview and telephone follow-ups are summarized in Table 9. The population interviewed on the beach was slightly different in swimming status as compared with the subpopulation that was subsequently recontacted. The largest change occurred in the group consisting of individuals less than 10 years of age. This group comprised 35% (N=511) of the population interviewed in the telephone follow-up and had a 31% (N=161) swimming rate. Information on this group is crucial to the planning of the study for two reasons. The first reason previously mentioned is that this group is most sensitive to changes in water quality and therefore most apt to develop infectious illnesses. The second reason is that previous studies have had a problem with either the

TABLE 8

Number Of People Interviewed In Phase II At Beaches By Weekend

Beach	Weekend August 22-23	 August 29-30
Island Beach State Park	882	692
Spring Lake South	91	0
Bradley Beach	418	379
Asbury Park	97	0
Spring Lake North	289	0
Sandy Hook	418	5
Cheesequake	0	125
Wharton	0	36
Keansburg	0	35
Belmar	0	130
TOTAL		3597

TABLE 9

Summary Of Swimming Status By Age For Phase II Interviews

Group	Beach Interviews Swimmer	Non-Swimmer
<10 years	13%	17%
10-60 years	25%	42%
>60 years	<1%	3%
Total (N=3597)	38%	62%
	Telephone Follow-Ups	
<10 years	11%	24%
10-60 years	25%	37%
>60 years	<1%	2%
Total (N=1460)	37%	63%

number of swimmers or nonswimmers in this age group not being sufficiently large for statistical calculations.

The other criterion important for study consideration is separating out people who swim in other bodies of water either the week before or in the week after the initial beach interview. This could be a serious problem as people swim multiple places other than their weekend visit to the shore (Table 10). In Phase I approximately 60 percent of all individuals would be excluded from the study. In the Phase II study that number dropped to 50 percent.

7.1.2.3 Crude Illness Rates for Study Participants

As in Phase I, people were asked about existing gastrointestinal symptoms during the beach interview. The list of symptoms was also expanded to include some respiratory illnesses. These are summarized in Table 11. The list was further expanded in the telephone interview and the results of the symptoms reported after the beach visit are in Table 12. No tests of statistical significance were performed due to the small numbers and methodology development purpose of Phases I and II.

7.1.3 Important Interview Logistical and Management Issues Identified During the Combined Interviews

During the two preliminary phases of the study there were some problems identified with the data collection method. Due to the rapid start-up schedule, the personnel for interviewing were hired on short notice and were able to commit for varying periods of time. This necessitated recruiting new workers throughout the summer. Sufficient supervisory personnel were not available for logging and checking questionnaires, resulting in a delay in transmission of the forms for data entering at a separate institution. There was further delay due to poor

TABLE 10

Number of People Who Swim Only At Beach or Swim At Additional Places And Percent of Subjects Not Eligible Due to Swimming At Other Than New Jersey Beaches

	Beach Only	Swim Additional	% Not Eligible
Phase I (N=412)	159	253	61
Swimmer	82	162	66
Nonswimmer	77	91	64
Phase II (N=1372)	690	682	50
Swimmer	256	347	57
Nonswimmer	434	335	43

TABLE 11

Illness Rates From Phase II Interviews (N=3579)

Symptom	Overall(%)	Swimmers(%)	Non-Swimmers(%)
Stomachache	2.9	3.6	2.5
Nausea	1.3	1.6	1.2
Vomiting	0.6	0.8	0.5
Diarrhea	1.7	1.8	1.6
Fever (100^{o})	1.0	0.8	1.1
Cough	5.0	4.4	4.9
Sore Throat	3.8	3.2	4.2
Runny Nose	5.3	4.7	5.7

TABLE 12

Illness Rates From Phase II Followup (N=1460)

Symptom	Overall(%)	Swimmers(%)	Non-swimmers(%)
Stomach Ache	2.9	4.4	1.8
Nausea	2.5	2.9	2.0
Vomiting	1.4	1.45	1.2
Diarrhea	3.2	3.9	2.4
Cough	2.0	1.8	2.0
Sore Throat	4.1	5.3	3.1
Runny Nose	5.6	6.3	5.0
Eyes	1.1	1.1	1.1
Ears	1.1	1.1	1.1
Skin	1.6	1.9	1.3
Cold	1.8	1.0	2.4

legibility of photocopied materials. It was therefore difficult to give timely feedback to interviewers for coding errors, which including missing or miscoded items. Some identification codes on beach interviews could not be matched with identification codes on follow-up interviews. During questionnaire revision the beach and telephone interview questions were not entirely compatible.

Several factors led to inability to acquire interviews on the beaches. Language barriers were encountered more frequently than had been expected. Available interviewers bilingual in English and Spanish were scheduled on beaches as needed, although a standardized Spanish translation of the questionnaire was not available. The required signature on the consent form resulted in a large number of refusals, with a strong bias for male interviewers to receive refusal. Interviewers commented that those families willing to participate were interested in the study and were willing to cooperate.

7.1.4 Illness Reports

The UMDNJ received calls from a number of interviewed families reporting illness. There were 21 individuals with gastrointestinal illnesses, 3 with skin complaints, 19 reports of respiratory illnesses, and 6 with other complaints. Although in general the incubation periods were not available, one report was of illness occurring six days after the beach visit. In another episode an entire family reported illnesses, although none of the members had been in the water. Similarly, two children considered by their physician to have acquired illness due to swimming had not been in the water.

Through telephone calls and information relayed from local and county health departments there were 62 reports to the DOH of 89 individuals with illnesses possibly related to ocean swimming. Only 23 reports were of consistent gastrointestinal and skin complaints with a total of 34 ill individuals. Of these, there were 14 cases of gastrointestinal illnesses, 14 skin infections, and 6 individuals with both illnesses. The calls included 27 reports of 42 individuals with respiratory illnesses.

There were indications that illness episodes not related to the ocean were reported as such to the DOH. In three reports not counted, the individuals were in contact with neighbors who had the same syndromes but did not travel to the beach. An additional two reports were of gastrointestinal illness occurring in individuals who did not enter the water at all. Two of the cases of skin infection were by description oral herpetic lesions, considerably more likely to be contracted through person-to-person contact or representing recurring infection. In addition, incubation periods were sometimes considerably out of reasonable range for the exposure to have taken place at the beach. Respiratory or gastrointestinal viral infections occurring several weeks or even months after the beach visit are expected to be totally unrelated to the swimming episode but were reported as swimming related.

Calls to health departments tended to cluster after news stories such as garbage slicks reaching the shore. There were also clusters of calls after localized sewage spills, for example reporting illness in Cape May after an episode of contaminated water in Monmouth County. This supports the theory that the beach visiting population had greater sensitivity to mild symptoms that would have been unnoticed or unreported in previous years. The resulting bias in reporting makes comparison with previous surveillance unreliable.

7.2 Water Quality

Phase I activities involved identification of sources of microbial contamination along the coast, review of water quality testing data, and water sampling at selected beaches.

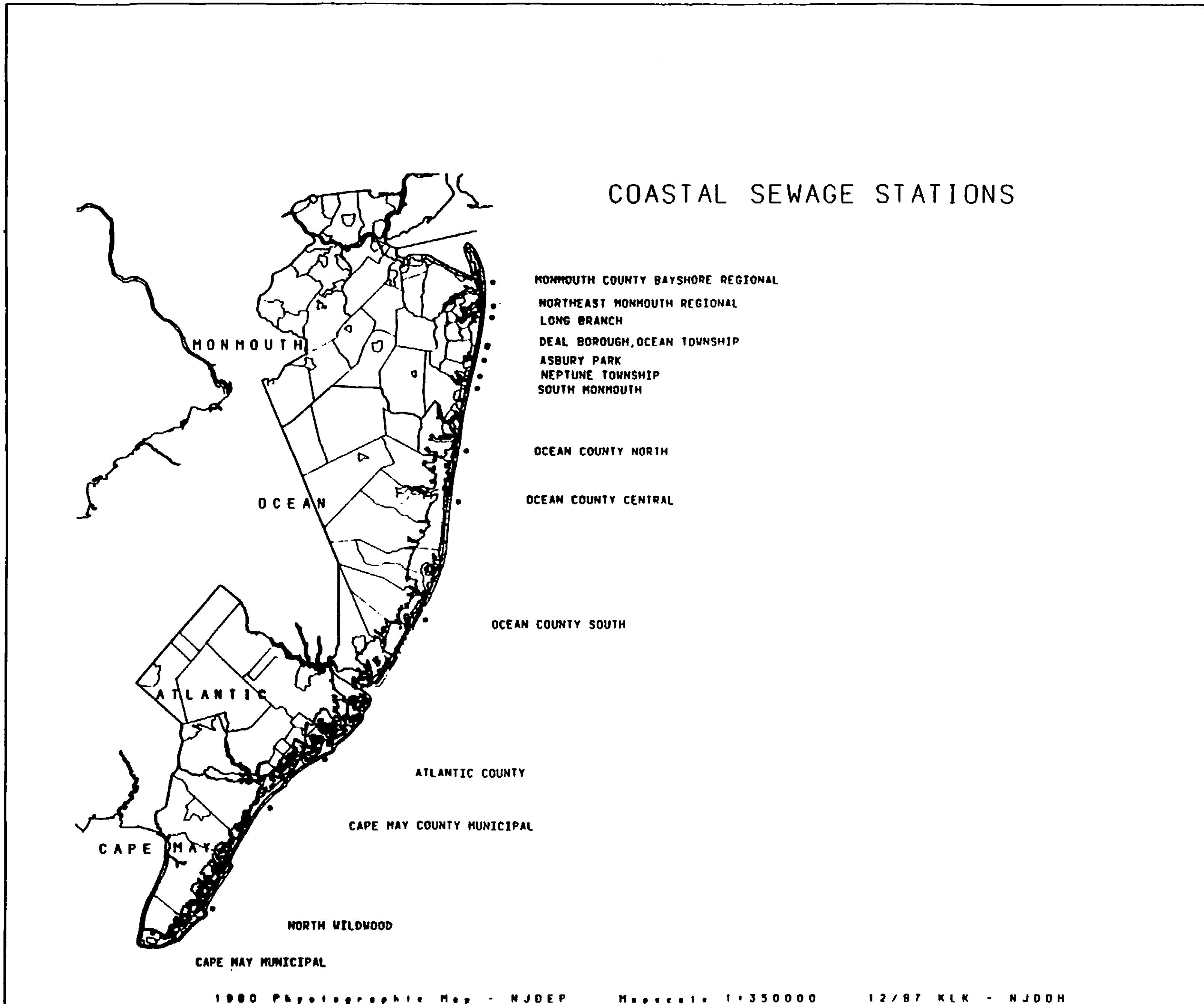
7.2.1 Sources of Beach Microbial Contamination

7.2.1.1 Sewage Treatment Plants (STPs)

The DEP has for some time been engaged in a program to eliminate municipal wastewater effluents from the rivers, embayments, and estuaries by discharging into coastal waters through relatively long ocean outfalls. The rationale for this program is obvious. The open ocean is better able to assimilate these discharges that are embayments and coastal areas. Equally important, in the event of a breakdown in treatment and/or disinfection at the plant there are minimized risks of affecting the quality of the bathing water discharged offshore due to physical and biological decay of the agents during their transport from the long outfall toward the beach.

Ocean outfalls have been used for many years in the coastal area from Sandy Hook south to Cape May (Figure 1). The effluents from some of the older facilities still are limited to primary treatment of sewage with discharge through relatively short outfalls (Table 13). Because of this, a long-range program has been underway to improve sewage disposal methods along the coast.

The first aspect of the program addressed short outfalls in the southern coastal region. The municipal wastewater discharges which exit to the coast through the Great Egg Harbor Inlet were transferred to a long ocean outfall in 1982. Those which pass out through the Townsend Inlet are now discharged through a long ocean outfall which went on line in



COASTAL SEWAGE STATIONS
MONMOUTH
OCEAN
ATLANTIC
CAPE MAY
MONMOUTH COUNTY BAYSHORE REGIONAL
NORTHEAST MONMOUTH REGIONAL
LONG BRANCH
DEAL BOROUGH,OCEAN TOWNSHIP
ASBURY PARK
NEPTUNE TOWNSHIP
SOUTH MONMOUTH
OCEAN COUNTY NORTH
OCEAN COUNTY CENTRAL
OCEAN COUNTY SOUTH
ATLANTIC COUNTY
CAPE MAY COUNTY MUNICIPAL
NORTH WILDWOOD
CAPE MAY MUNICIPAL
1980 Physiographic Map - NJDEP Mapscale 1:350000 12/87 KLK - NJDOH

Figure 1

TABLE 13

Coastal Sewage Treatment Plants

Site	Outfall length	Diffuser length	Type	(dry) mgd
1. Monmouth Co Bayshore Regional Outfall Authority	4000'		2nd	15.
2. Northeast Monmouth Regional Sewerage Authority	980'	1500'	2nd	7.5
3. Long Branch Sewerage Authority	1927'	280'	2nd	4.5
4. Deal Borough	1000'		1st	0.8
5. Ocean Township	1800'	235'	2nd	4.5
6. Asbury Park (current)	1000'		1st	3.4
planned July 1988	1500'	400'	2nd	
7. Neptune Township Sewerage Authority	5000'	1000'	2nd	5.5
8. South Monmouth Regional Sewerage Authority	5000'	1000'	adv 2nd	6.0
9. Ocean County Utilities Authority Northern	5000'	1464'	2nd	13.
10. Ocean County Utilities Authority Central	7000'		2nd	18.
11. Ocean County Utilities Authority Southern	4520'	1480'	2nd	7.
12. Atlantic County Utilities Authority	7710'	1000'	2nd	30.
13. Cape May County Municipal Utilities Authority	6081'	510'	2nd	6.
14. North Wildwood	10'		1st	2.8
planned July 1988	5000'	530'	2nd	
15. Cape May Municipal Utilities Authority	500'		2nd	2.2

Source: New Jersey State Department of Environmental Protection, 1987.

August, 1987, and an outfall at North Wildwood which should be functional during the Summer of 1988 to receive the municipal wastewater effluents which could have reached the coastal beaches via the Hereford Inlet. The second aspect of this long range program has been to upgrade existing sewage treatments facilities and to lengthen the outfall pipes as required. This has been done for two sewage treatment facilities in the northern part of the state, Neptune Township and South Monmouth. The upgrading of a third northern facility, Asbury Park, should be completed in 1988 as well.

7.2.1.2 Inlets and Embayments

There are 18 lakes and inlets feeding into the New Jersey coastal waters from Sandy Hook to Cape May (Figure 2). Microbial contamination of these fresh water sources due to land-based sources, wildlife refuges, and marinas has the potential for impacting on local ocean water quality.

The lakes occur in the northern counties and drain watersheds that are populated. Domestic and wild animals provide possible sources of microbial contamination. In addition, previous water monitoring by Monmouth County suggests that stormwater drainage into these lakes may on occasion be contaminated by sewage pipe breaks (Monmouth County Department of Health, personal communication).

The inlets occur in the southern counties and drain embayments that lie between the mainland and the barrier islands. The embayments receive water from land runoff and rivers. Previous water monitoring by several counties indicates that many areas along the bays have elevated coliform levels in the water.

These lakes and inlets are the sites for approximately 450 marinas along the coast. The DEP estimates that over 100,000 recreational boats are used in New Jersey each summer. There are minimal resources to monitor the fecal discharge from these boats. Larger boats with holding tanks for toilets have only about ten pumpout facilities available along the entire coast to empty their tanks.

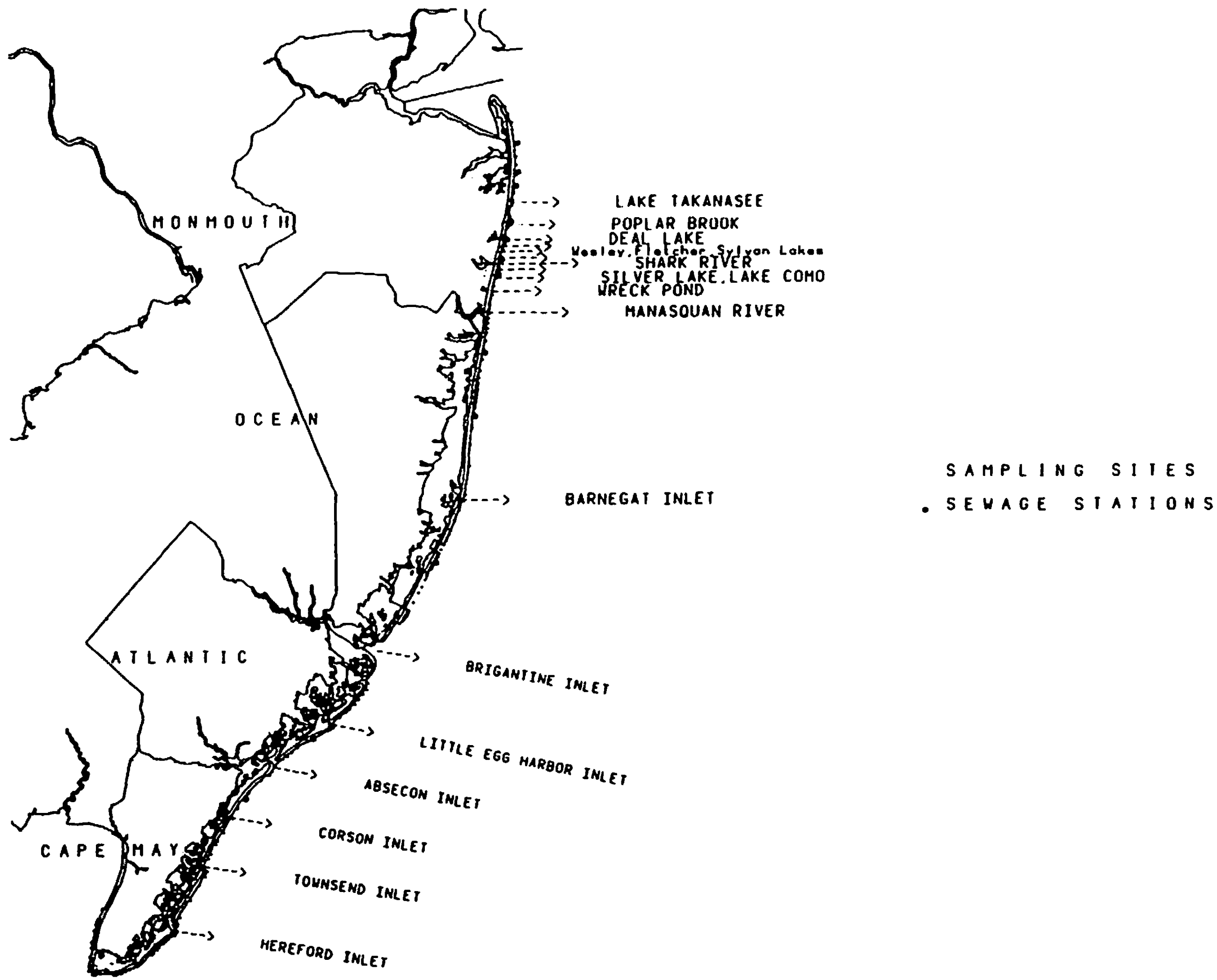
7.2.1.3 Stormwater Drainage

There are over 100 storm pipes discharging along the coastline from Sandy Hook to Cape May, including heavy concentrations in urban regions such as Atlantic City and in Cape May County (Figure 3). The DEP Coastal Monitoring Program identified stormwater runoff as a probable source of microbial contamination of swimming beaches, noting increases in indicator levels at multiple beaches after heavy rainfall. Fecal wastes of domestic pets and wild animals will be carried by storm water drainage into pipes or as runoff. Flow between sewers and storm drains may occur and the DEP has a program to eliminated such cross-connections. In some cases this represents accidental connections of the systems while in other cases it results from breaks in old pipes laid side by side.

7.2.1.4 Raritan Bay and New York Bight

The Raritan Bay and New York Bight have been studied by several federal and state agencies. Water quality was assessed in the New York Bight by the United States Environmental Protection Agency (37). Sampling was done 5 or 6 days a week for six months in 1986 at 140 stations in the New York Bight. Water samples were tested for the two bacterial indicators. There were only two occasions when fecal coliform densities exceeded 50 CFU/100 ml and on no occasions did the enterococci densities exceed 35 CFU/100 ml. Blooms of red and green algae were present at times

RIVERS, LAKES AND INLETS WITH OCEAN OUTLETS



1980 Physiographic Map - NJDEP   Mapscale 1:350000   12/87 KLK - NJDOH

Figure 2

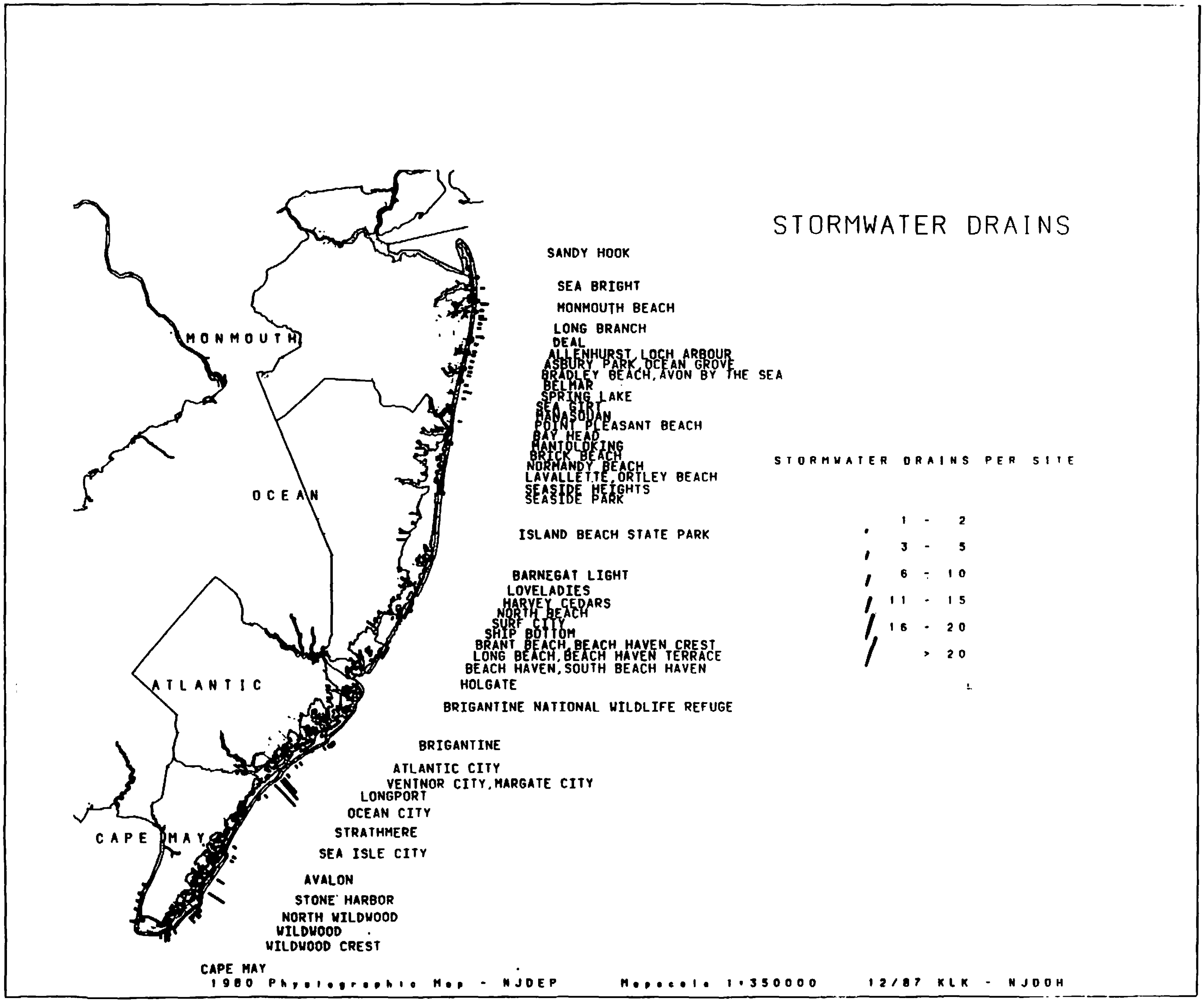

STORMWATER DRAINS
MONMOUTH
OCEAN
ATLANTIC
CAPE MAY
SANDY HOOK
SEA BRIGHT
MONMOUTH BEACH
LONG BRANCH
DEAL
ALLENHURST, LOCH ARBOUR
ASBURY PARK, OCEAN GROVE
BRADLEY BEACH, AVON BY THE SEA
BELMAR
SPRING LAKE
SEA GIRT
MANASQUAN
POINT PLEASANT BEACH
BAY HEAD
MANTOLOKING
BRICK BEACH
NORMANDY BEACH
LAVALLETTE, ORTLEY BEACH
SEASIDE HEIGHTS
SEASIDE PARK
ISLAND BEACH STATE PARK
BARNEGAT LIGHT
LOVELADIES
HARVEY CEDARS
NORTH BEACH
SURF CITY
SHIP BOTTOM
BRANT BEACH, BEACH HAVEN CREST
LONG BEACH, BEACH HAVEN TERRACE
BEACH HAVEN, SOUTH BEACH HAVEN
HOLGATE
BRIGANTINE NATIONAL WILDLIFE REFUGE
BRIGANTINE
ATLANTIC CITY
VENTNOR CITY, MARGATE CITY
LONGPORT
OCEAN CITY
STRATHMERE
SEA ISLE CITY
AVALON
STONE HARBOR
NORTH WILDWOOD
WILDWOOD
WILDWOOD CREST
CAPE MAY
STORMWATER DRAINS PER SITE
1 - 2
3 - 5
6 - 10
11 - 15
16 - 20
> 20
1980 Physiographic Map - NJDEP
Mapscale 1:350000
12/87 KLK - NJDOH

Figure 3

along many of the coastal beaches. Such blooms cause discoloration of the water and in the case of red algae can result in toxin release.

7.2.1.5 Wildlife Refuges

There are two major wildlife refuges along the shore in the embayment areas with wild animal populations which can impact on coast water quality through outflow of fecally contaminated water (Figure 2). The Barnegat National Wildlife Refuge is located west of Long Beach Island in Little Egg Harbor and may drain north through the Barnegat inlet or south through the Little Egg Inlet. The larger Brigantine National Wildlife Refuge is located at the Little Egg Inlet, and may drain through the Absecon inlet as well.

Additional small-scale sources of wildlife contamination of ocean waters are likely. It has been observed that large colonies of shore birds are present under piers along the coast. Monitoring results from sampling sites directly adjacent to these piers suggests that the fecal deposits from the birds may contribute significantly to the contamination of water on a local basis as evidenced by elevations in coliform counts.

7.2.1.6 Episodic Events

The summer of 1987 was marked by a number of incidents along the New Jersey coast of environmental and sometimes of communicable disease concern. These included sewage spills at Deal and Atlantic City which resulted in beach closings due to potential infectious risk, garbage and hospital trash washing on shore at north-central beaches and presenting risk of trauma, floating logs presenting risk of trauma, and the deaths of dolphins as part of a large phenomenon extending along much of the upper and mid Atlantic coast. No scientific connection was suspected between dolphin and human illnesses.

These episodic events tended to interfere with the scheduled weekends for conducting beach interviews, since beach usage patterns were expected to be nonrepresentative. Adverse weather conditions during two weekends in August further interfered with the health study.

7.2.1.7 Other Public Health Issues

Multiple possible routes of infectious diseases transmission were observed at the beaches. In addition other exposures may have occurred before or after the beach trip, such as through neighborhood illness or swimming pools. Many of the beach exposures are not unique to the coasts, but are encountered by most travellers and vacationers. An episode of illness may therefore have been contracted during a trip to the beach, but may be entirely unrelated to water quality or even to swimming activity.

Infectious illnesses due to fecal organisms can be transmitted through improper hand washing. It was noted during the study that of public restrooms at ten beaches, less than half had any soap. Food as a vehicle for gastroenteritis is also possible during hot summer days due to improper temperature control of purchased or home-prepared items.

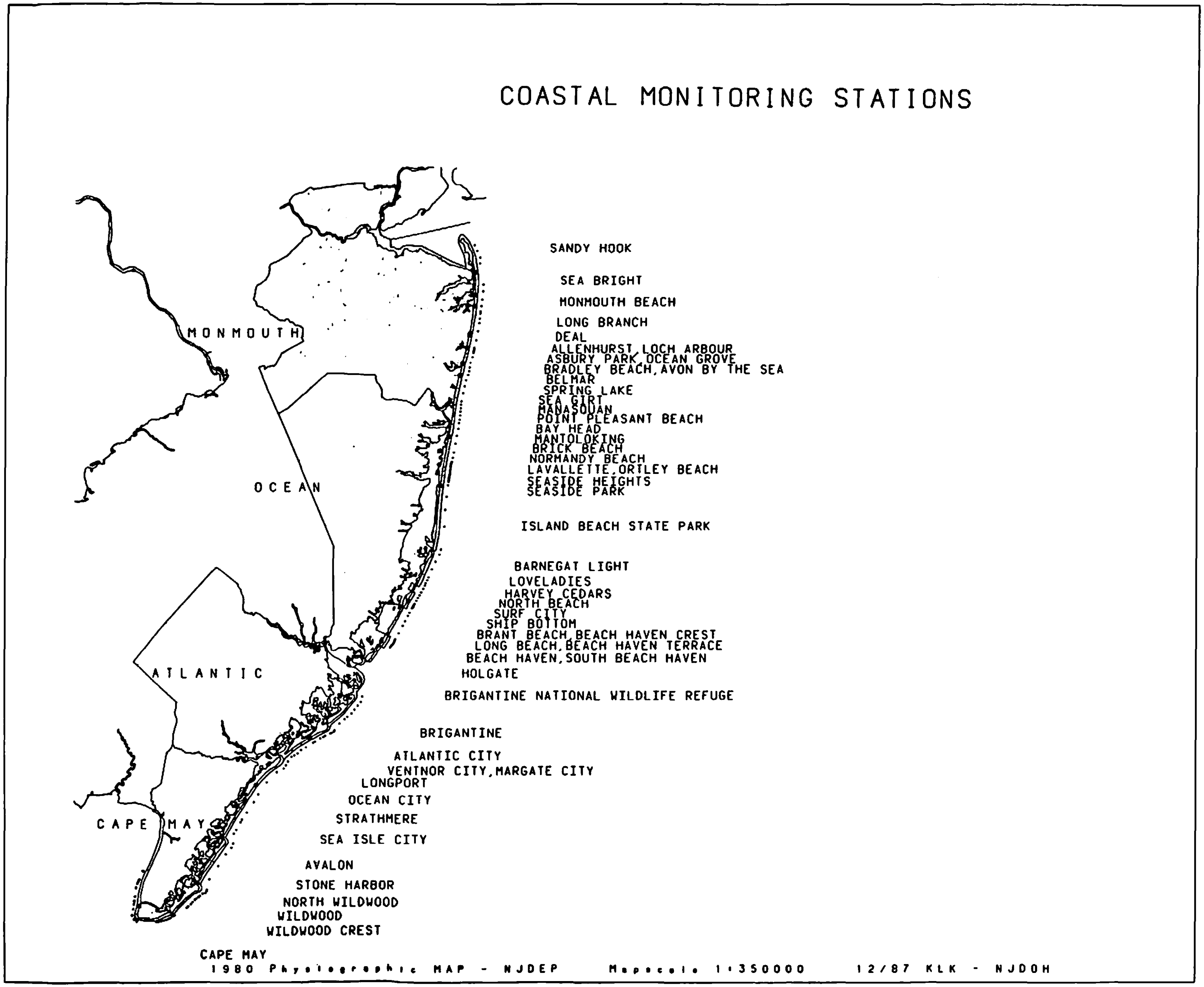
The most prominent infectious disease concerns are person-to-person and object-to-person transmission. The boardwalk and beach environment bring children in close contact with large crowds under warm and damp conditions experienced in few other situations. The crowded conditions at some beaches could facilitate transfer of infectious agents either by direct skin contact or through local contamination of the water, particularly if ill individuals were present at the beach; the beach interviews reported that individuals with infectious disease symptoms were coming to the shore. Children in diapers were seen in the bathing areas, a potential source of significant local fecal contamination of water.

7.2.2 Microbiology

7.2.2.1 DEP Coastal Cooperative Monitoring Program

There were existing water quality data from the extensive DEP monitoring system already in operation. In the DEP cooperative study there were 120 coastal monitoring sites in 1985 and 147 coastal monitoring sites in 1986 from Sandy Hook to Cape May City (Figure 4, Appendix 4) (31). Data from the the two years were analyzed in several different ways based on the primary contact criterion (PCC) of 200 coliforms per 100 milliliters for Surface Water Quality Standards (SWQS): frequency of samples above the PCC, geometric mean, median, and maximum value.

According to the DEP report the PCC was exceeded by 156 samples in 1985 and 102 samples in 1986. Approximately 75% or these were after rainfall of at least 0.01 inches. The SWQS was exceeded by 13 stations in 1985 and 2 stations in 1986. The frequency above standard indicated that there were clusters in the Asbury Park, Wildwood, and Cape May Lower Ferry areas (Figures 5, 6). In 1986 Wildwood was much less prominent in excursions above standard. Maximum values showed numerous excursions in both years, suggesting that on rare occasions there was an increased bacterial load in the water at multiple sites (Figures 7, 8). Maps of median values (Figures 9, 10) and geometric mean (Figures 11, 12) highlight similar areas in Monmouth, Atlantic, and Cape May counties. Again stormwater drainage is the likely cause of these elevated levels. In general there was improvement from 1985 to 1986, occurring particularly in areas targeted by the DEP for programs. These improvements are noticeable in the Asbury Park and North Wildwood coastal stretches. In 1985 and 1986 there were no beach closings attributable to operation problems of coastal waste water treatment facilities in 1985 and 1986.


COASTAL MONITORING STATIONS
MONMOUTH
OCEAN
ATLANTIC
CAPE MAY
SANDY HOOK
SEA BRIGHT
MONMOUTH BEACH
LONG BRANCH
DEAL
ALLENHURST, LOCH ARBOUR
ASBURY PARK, OCEAN GROVE
BRADLEY BEACH, AVON BY THE SEA
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NORTH BEACH
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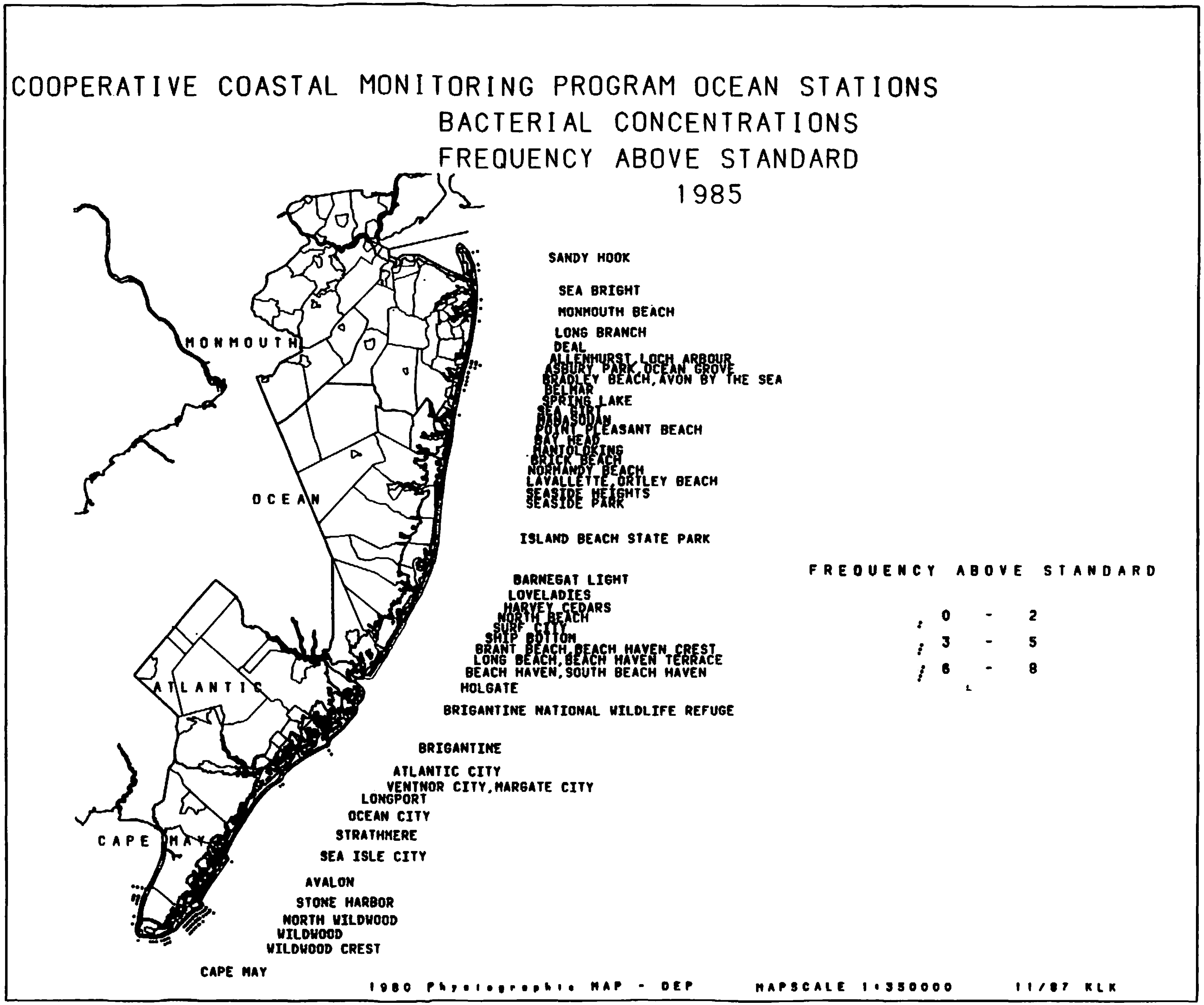
HOLGATE
BRIGANTINE NATIONAL WILDLIFE REFUGE
BRIGANTINE
ATLANTIC CITY
VENTNOR CITY, MARGATE CITY
LONGPORT
OCEAN CITY
STRATHMERE
SEA ISLE CITY
AVALON
STONE HARBOR
NORTH WILDWOOD
WILDWOOD
WILDWOOD CREST
CAPE MAY
1980 Physiographic MAP - NJDEP
Mapscale 1:350000
12/87 KLK - NJDOH

Figure 4


COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
FREQUENCY ABOVE STANDARD
1985
MONMOUTH
OCEAN
ATLANTIC
CAPE MAY
SANDY HOOK
SEA BRIGHT
MONMOUTH BEACH
LONG BRANCH
DEAL
ALLENHURST,LOCH ARBOUR
ASBURY PARK,OCEAN GROVE
BRADLEY BEACH,AVON BY THE SEA
BELMAR
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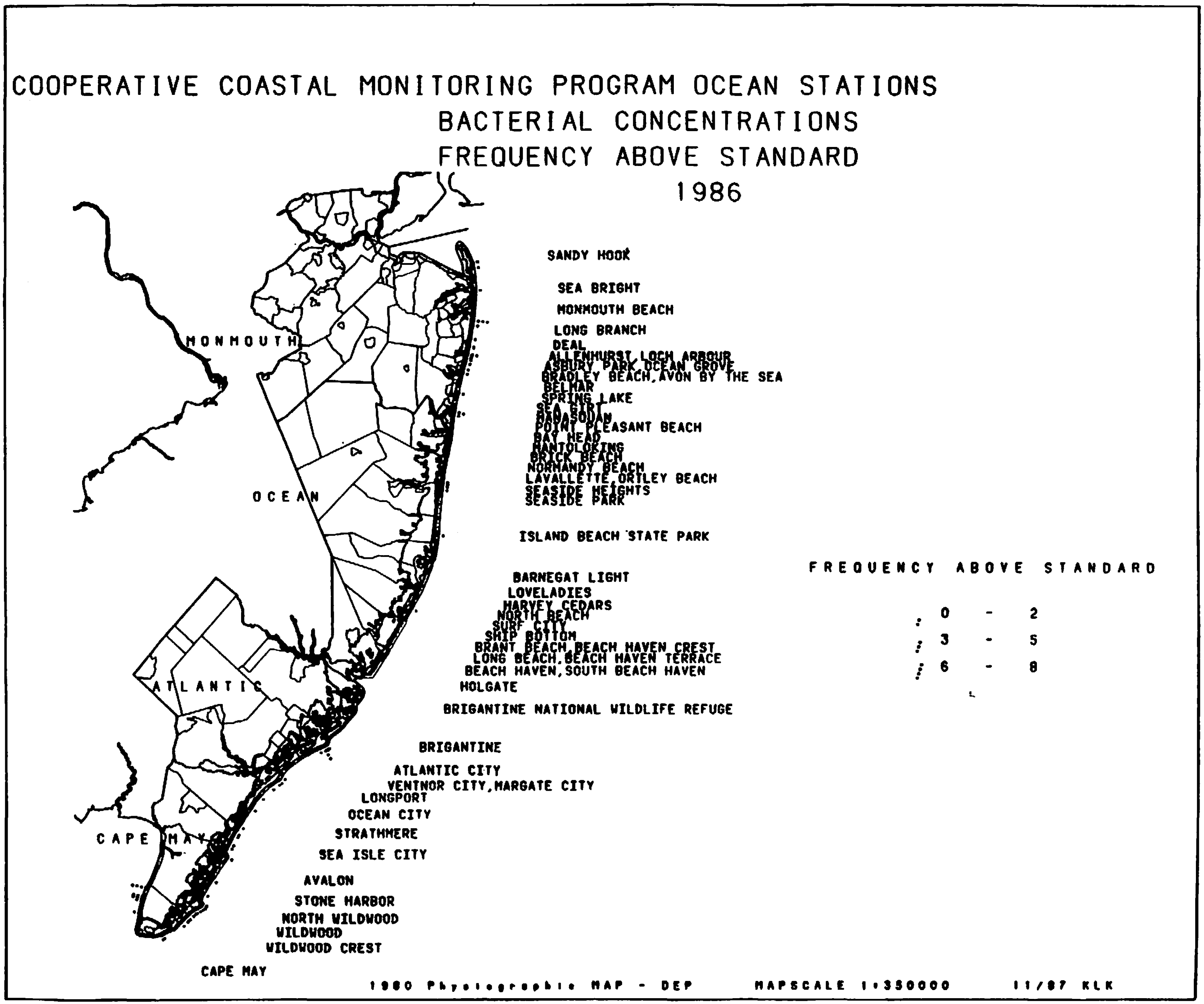
BEACH HAVEN,SOUTH BEACH HAVEN
HOLGATE
BRIGANTINE NATIONAL WILDLIFE REFUGE
BRIGANTINE
ATLANTIC CITY
VENTNOR CITY,MARGATE CITY
LONGPORT
OCEAN CITY
STRATHMERE
SEA ISLE CITY
AVALON
STONE HARBOR
NORTH WILDWOOD
WILDWOOD
WILDWOOD CREST
CAPE MAY
FREQUENCY ABOVE STANDARD
0 - 2
3 - 5
6 - 8
1980 Physiographic MAP - DEP
MAPSCALE 1:350000
11/87 KLK

Figure 5


COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
FREQUENCY ABOVE STANDARD
1986
MONMOUTH
OCEAN
ATLANTIC
CAPE MAY
SANDY HOOK
SEA BRIGHT
MONMOUTH BEACH
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ISLAND BEACH STATE PARK
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NORTH BEACH
SURF CITY
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BRANT BEACH,BEACH HAVEN CREST
LONG BEACH,BEACH HAVEN TERRACE
BEACH HAVEN,SOUTH BEACH HAVEN
HOLGATE
BRIGANTINE NATIONAL WILDLIFE REFUGE
BRIGANTINE
ATLANTIC CITY
VENTNOR CITY,MARGATE CITY
LONGPORT
OCEAN CITY
STRATHMERE
SEA ISLE CITY
AVALON
STONE HARBOR
NORTH WILDWOOD
WILDWOOD
WILDWOOD CREST
CAPE MAY
FREQUENCY ABOVE STANDARD
0 - 2
3 - 5
6 - 8
1980 Physiographic MAP - DEP
MAPSCALE 1:350000
11/87 KLK

Figure 6

COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
1985 MAXIMUM VALUE

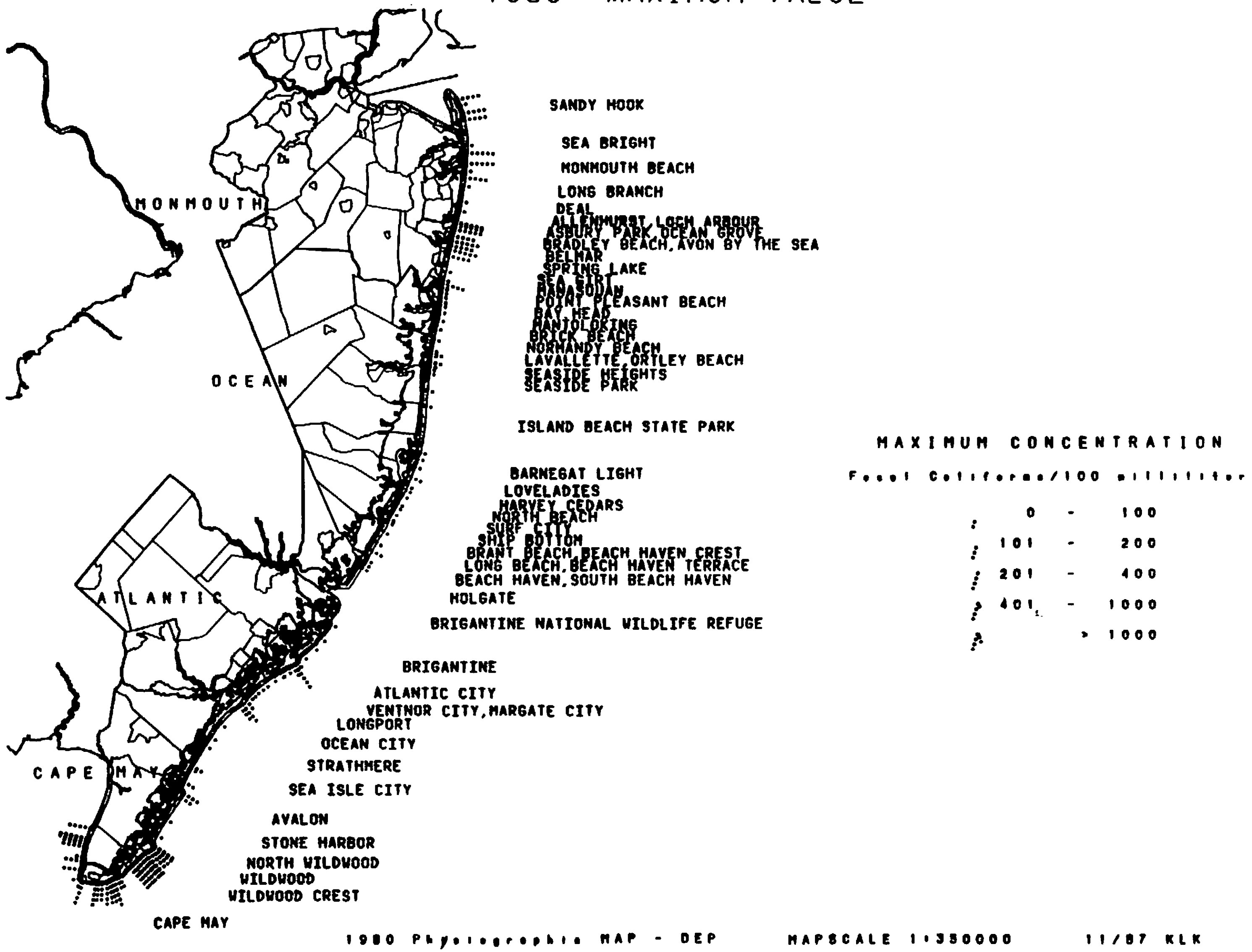

Figure 7

COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
1986 MAXIMUM VALUE

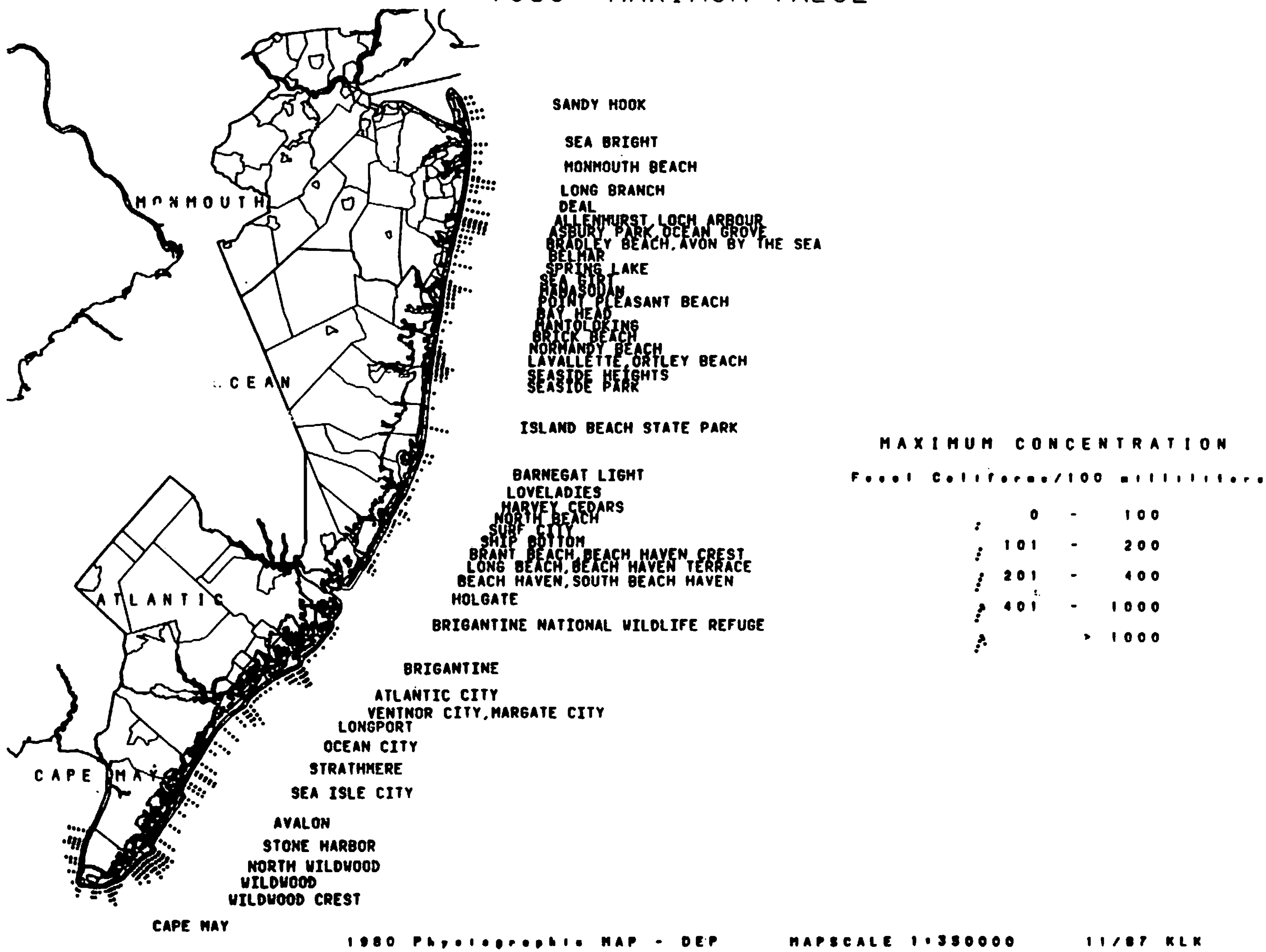

Figure 8

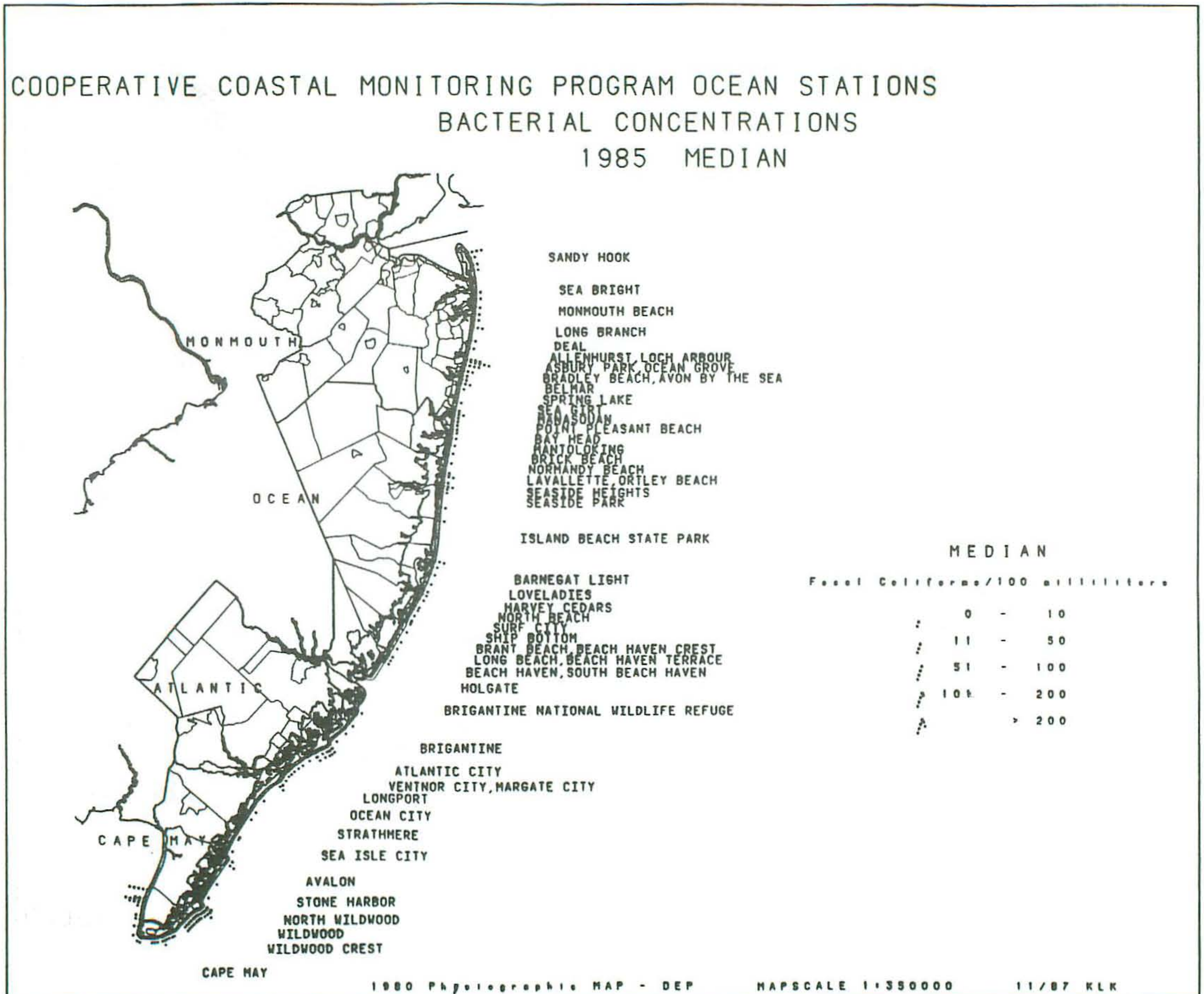
COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
1985 MEDIAN
MONMOUTH
OCEAN
ATLANTIC
CAPE MAY
SANDY HOOK
SEA BRIGHT
MONMOUTH BEACH
LONG BRANCH
DEAL
ALLENHURST,LOCH ARBOUR
ASBURY PARK,OCEAN GROVE
BRADLEY BEACH,AVON BY THE SEA
BELMAR
SPRING LAKE
SEA GIRT
MANASQUAN
POINT PLEASANT BEACH
BAY HEAD
MANTOLOKING
BRICK BEACH
NORMANDY BEACH
LAVALLETTE,ORTLEY BEACH
SEASIDE HEIGHTS
SEASIDE PARK
ISLAND BEACH STATE PARK
BARNEGAT LIGHT
LOVELADIES
HARVEY CEDARS
NORTH BEACH
SURF CITY
SHIP BOTTOM
BRANT BEACH,BEACH HAVEN CREST
LONG BEACH,BEACH HAVEN TERRACE
BEACH HAVEN,SOUTH BEACH HAVEN
HOLGATE
BRIGANTINE NATIONAL WILDLIFE REFUGE
BRIGANTINE
ATLANTIC CITY
VENTNOR CITY,MARGATE CITY
LONGPORT
OCEAN CITY
STRATHMERE
SEA ISLE CITY
AVALON
STONE HARBOR
NORTH WILDWOOD
WILDWOOD
WILDWOOD CREST
CAPE MAY
MEDIAN
0 - 10
11 - 50
51 - 100
101 - 200
> 200
MAP - DEP
MAPSCALE 1:350000
11/87 KLK

Figure 9

COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
1986 MEDIAN

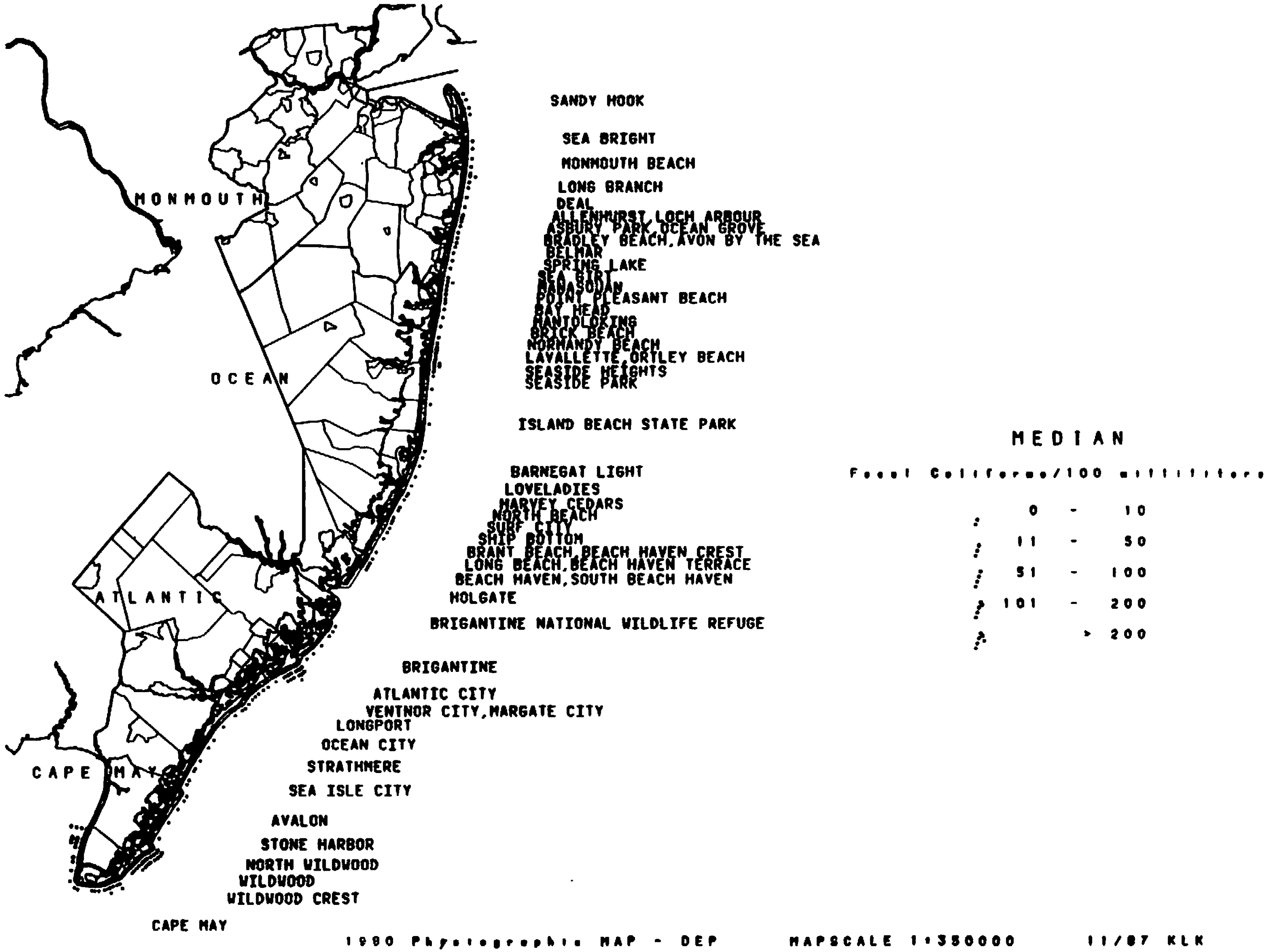

Figure 10

COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
1985 GEOMETRIC MEAN

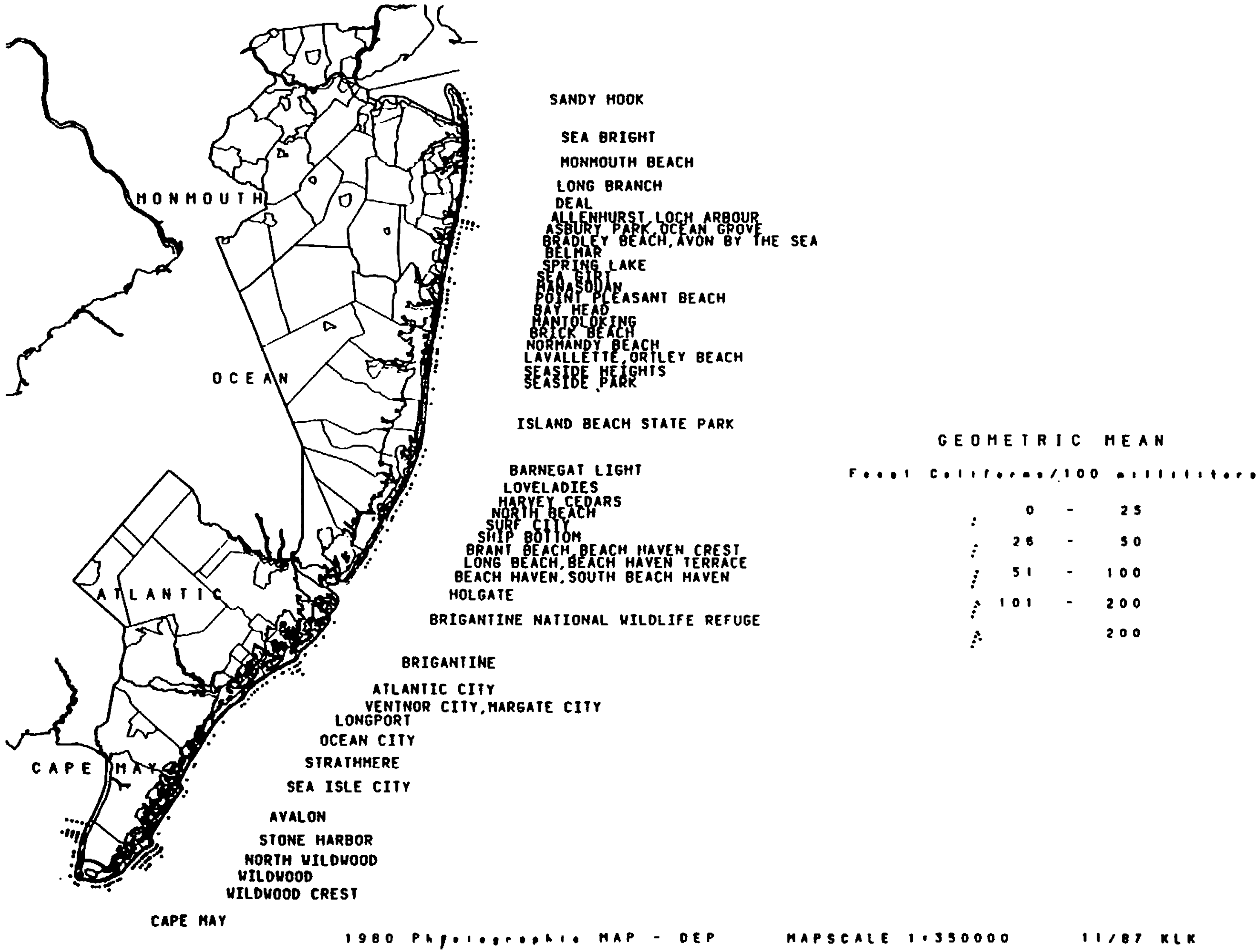

Figure 11

COOPERATIVE COASTAL MONITORING PROGRAM OCEAN STATIONS
BACTERIAL CONCENTRATIONS
1986 GEOMETRIC MEAN

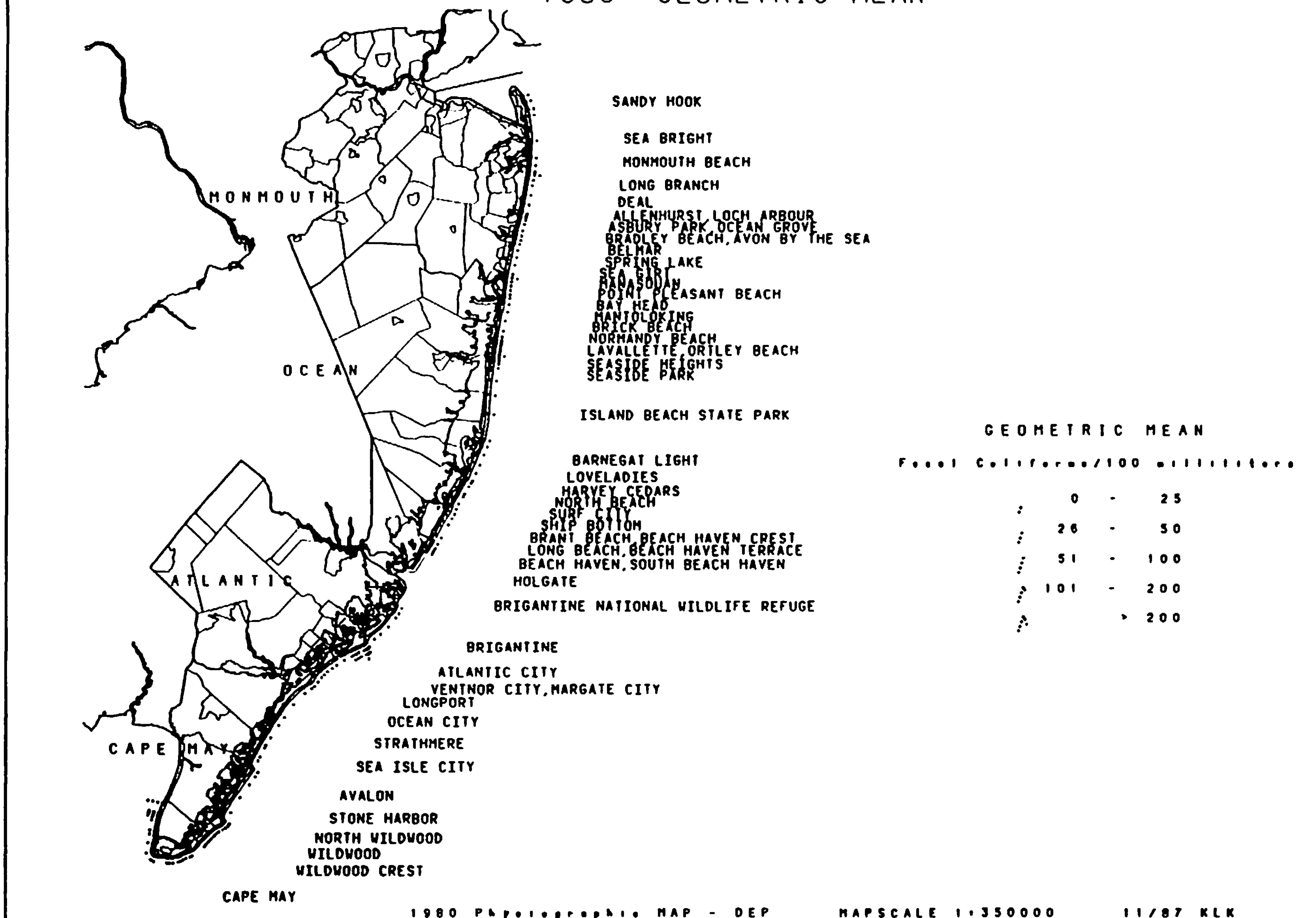

Figure 12

Overall the coastal monitoring data as presented in Figures 5 to 12 for 1985 and 1986 indicate clusters of areas along the coast of New Jersey with occasional contamination problems. These include regions of Monmouth County, Atlantic County, and Cape May County. The DEP considered that the excesses were due to multiple factors including STP malfunctions at Wildwood, illegal cross-connections of sewage and stormwater systems, contaminated bay waters, marinas, and discharge from urban stormwater pipes. Compared with Figure 3, the problem areas coincide with the clustering of storm water drains along the shoreline. The DEP analysis of the 1985 and 1986 monitoring data showed a correlation between increased bacterial contamination of ocean water and increased rainfall, suggesting that stormwater discharge is a major contributor to episodic decreases in water quality.

7.2.2.2 EPA Offshore Monitoring Program

Of the 465 EPA samples of offshore ocean water tested in 1986 all were within the federal PCC for fecal coliforms (Table 14). Two sites had samples above 50 CFU/100 ml. The two highest geometric means of 3.2 and 3.1 occurred at those two sites. All samples met the EPA criteria for enterococci level.

These offshore samples were collected between the STP outfall pipes and the beach surf zone. Since offshore water does not show microbial contamination would be expected if the STP outfalls were the source of microbial contamination, the findings lend credence to the theory that the elevated indicator levels measured at the beaches reflect contamination sources on the shore that impact on beach water quality, not the shoreward flow of sewage.

Algal blooms of Nannochloris atomus occurred in 1986 along much of the coast. This organism is not among the phytoplankton species responsible for either "red" or "green" tides of previous years. A red tide of Katodinium rotundatum was present off the coast of northern Monmouth County. A probable diatom bloom in late May was also reported.

In 1987 the EPA again conducted weekly sampling of water from beyond the surf zone, reflecting incoming water quality potentially impacted by sewage outfall pipes but without major impact from stormwater, lakes, bays, or bathers. The geometric mean levels of indicator organisms in the water samples collected during the sampling tours on the EPA network are given in Table 15. Also included are mean C. perfringens spore levels obtained from a similar monitoring effort in 1980-1981. Three stations were added to the network, JC-20, JC-25, and JC-26 (Shark River Inlet) in order to better understand the indicator levels in relation to possible sources of fecal contamination.

It can be seen from the comparison of the C. perfringens spore levels in 1987 to those in 1980-1981 that in 1987 the mean levels were consistently lower. Based on C. perfringens levels there was not degradation in the water quality attributable to offshore sources or even to the more likely onshore sources such as rivers and embayments since 1981. Results may reflect year to year variability in the levels.

Clearly, the water quality at none of the stations was in violation of either the EPA coliform guideline (a mean of 200 CFU/100 ml) or the enterococci recommendation (a mean of 35 CFU/100 ml). Even when the individual values are examined, there was only one day (8/5/87) at one station (JC-21) when the guideline for mean values was exceeded. From the

TABLE 14

Indicator Levels as Geometric Means for 1986 EPA Network Sites

EPA station	Maximum Value fecal coliform/100 ml	Geometric Mean* fecal coliform/100 ml
J 1A	7	1.0
J 2	3	1.2
J 3	4	1.4
J 5	7	1.3
J 8	2	1.1
J 11	15	1.8
J 14	8	1.5
J 21	15	1.6
J 24	2	1.1
J 27	10	1.3
J 30	10	1.0
J 33	8	1.2
J 37	3	1.1
J 41	1	1.0
J 44	0	1.0
J 47A	0	1.0
J 49	4	1.3
J 53	12	2.4
J 55	2	1.1
J 57	6	1.2
J 59	0	1.1
J 61	4	1.4
J 63	0	1.1
J 65	2	1.1
J 67	3	1.1
J 69	3	1.1
J 73	5	1.5
J 75	51	3.1
J 77	6	1.5
J 79	6	1.3
J 81	2	1.1
J 83	16	1.7
J 85	6	2.4
J 87	5	1.4
J 89	18	2.0
J 91	4	1.4
J 93	100	3.2
J 95	3	1.2
J 97	10	2.0
J 99	4	1.4

* geometric means were calculated using the natural log

Source: EPA New York Bight Water Quality Summer 1986

TABLE 15

Geometric Mean Indicator Levels In Surface Water Samples Collected From Just Beyond The Surf Zone During Six Sampling Tours In 1987 Of The USEPA New Jersey Coastal Sampling Network[a].

	GM Indicator Level Per 100 ml Water					
	C. Perfringens		F Phage[b]	Enterococci	Coliform	
Sampling station	1980-81	1987	1987	1987	1987	Possible Source of Fecal Contamination[c]
IA	36.7	9.5	<0.56[2]	<1.0	<1.0	Raritan lower NY Bays
2	28.7	6.0	<0.5[1]	~1.4[d]	<1.0	
3	18.3	2.7	<0.5[1]	<2.5[e]	~1.1	
5	16.8	2.0	<0.5	~1.3	<1.0	
8	17.2[f]	2.6	<0.5	<1.6	<1.0	Monmouth Cnty STP
11	55.6[g]	2.6	<0.5	~1.0	<1.0	Nrtheast Monmth STP
14	20.1	3.2	<0.5[1]	<u>1.5</u>	<1.5	Long Branch STP
20		2.6	<0.5[1]	<1.1	<1.0	
21	26.0	8.9	1.2[4]	9.5[h]	4.8[h]	Asbury Park STP
24	13.8	6.7	1.7[3]	2.2	3.7	
25		3.0	1.0[1]	<1.0	<1.7	
26		4.2	~1.4[4]	5.1	13.8	Shark River
27	7.8	3.6	~1.4[4]	4.3	6.7	
30	<u>11.2</u>[i]	2.5	<0.57[2]	~1.3	~2.3	
33	11.1	2.1	<0.67[2]	~1.3	<1.2	
37	6.3	~1.1	<0.5	<1.8	~2.1	Manasquan Inlet
41	6.9	~1.9	<0.56[2]	<1.7	~1.7	Manasquan Inlet
44	5.4	~1.4	<0.5	<1.1	<1.4	
47A	3.8	~1.7	<0.5[1]	<1.0	<1.0	
49	4.4	~0.81	~0.5[4]	<1.1	<1.2	Source of phage?
53	5.2	<0.97	<0.5	<2.2	<1.7	
55	5.5	<1.3	<0.5	~1.3	<1.8	
57	4.9	~1.0	<0.56[1]	<1.1	<1.0	
59	1.7	<0.82	<0.52[2]	<1.6	<1.9	Barnegat Inlet
61	5.3	~1.3	<0.5	<1.5	<1.8	Barnegat Inlet
63	3.7	~1.1	<0.5	<1.0	<1.0	
65	3.4	~0.91	<0.5	<1.1	<1.5	
67	2.7	~1.1	<0.5	<1.2	<1.0	
69	2.0	~0.74	<0.5	<1.5	<1.0	
73	2.4	1.0	<0.5[1]	<1.2	~4.1	Wildlife Refuge?
75	3.5	~1.5	<0.5	~1.5	1.0	Absecon Inlet
77	3.8	~3.1	<0.5	~1.5	~1.6	Storm drains, Atlantic Cnty STP

TABLE 15 (continued)

Geometric Mean Indicator Levels In Surface Water Samples Collected From Just Beyond The Surf Zone During Six Sampling Tours In 1987 Of The USEPA New Jersey Coastal Sampling Network[a].

Sampling Station	C. Perfringens 1980-81	C. Perfringens 1987	F. Phage[b] 1987	Enterococci 1987	Coliform 1987	Possible Source Of Fecal Contamination[c]
	GM Indicator Level Per 100 ml Water					
79	2.0	2.3	<0.5[1]	<1.1	<1.4	
81	3.5	2.9	<0.5[1]	~1.6	~1.3	Gt. Egg Harbor Inlet
83	1.5	<0.71	<0.5	<1.0	<1.2	
85	1.7	1.7	<0.5	~2.1	~1.7	Corson Inlet
87	1.5	<0.8	<0.5	<1.0	<1.0	
89	2.2	1.1	<0.5	~1.4	~1.7	Townsend Inlet
91	2.1	<0.5	<0.5	<1.0	~1.5	
93	2.8	~0.59	<0.5[1]	~2.2	3.9	
95	1.7	~1.4	0.63[1]	<1.1	<1.5	
97	1.3	0.63	<0.5[1]	<1.4	~1.4	
99	1.4	~0.91	<0.5[1]	~1.4	<1.3	

a Sampling Dates: 7/15, 7/29, 8/5, 8/12, 8/19, 8/25

b Superscript numerical values indicate number of samples from which F phage were recovered.

c Assumes that in general, movement of contamination is from north to south long the coast

d Approximation because of indeterminate values below the sensitivity of the assay. Sensitivity limits: C. perfringens and F male-specific bacteriophages, 0.5 or PFU/ 100 ml; enterococci and fecal coliforms 1 CFU/100 ml. Values less than limit set at the limits in calculating geometric means.

e Values for at least half the samples less than sensitivity of assay.

f Values underscored are suggestive of an indicator input because they are appreciably higher than that for station immediately to their north. Possible source indicated in appropriate column.

g Break in outfall during 1980-81; repaired by 1987.

h Primarily due to high values on 8/5/87; suggestive of suboptimal disinfection at Asbury park STP on that date.

i Difference between 1980-81 and 1987 probably due to lengthening of outfall.

comparison of the indicator levels at this station relative to those at the stations to its north and south (Table 16) it would appear that there was suboptimal disinfection at the Asbury Park STP since there were high levels of all four indicators at stations JC-21. The Asbury Park outfall is one of the shortest ones along the coast. As seen from the mean levels of the C. perfringens spores and viruses, the effluents from the outfall generally reaches the shoreline in detectable quantities (Tables 15 and 16). Depending on meteorologic and hydrographic conditions, the Asbury Park discharge may affect the area as far south as Bradley Beach (station JC-24 on 8/12/87, Table 16). Sewage contaminated water emerging form the Shark River Inlet was perceived as another possible source of the indicator levels found at station JC-24 and hence Bradley Beach. It can be seen from the 7/29 data (Table 16) that this can occur, but that in general the contamination from the inlet is carried to the south (8/12 and 8/19, Tables 15 and 16).

The decreasing C. perfringens levels from station JC-1A through JC-5 both in 1980-1981 and 1987 clearly show a source of fecal contamination to the north. The absence of coliforms and the low levels of both enterococci and phage indicate a distant source. The comparison of the C. perfringens spore levels for station JC-5 and JC-8 both in 1980-1981 and 1987 suggests that the effluents from the Monmouth County STP physically reaches the surf zone.

Abnormally high levels of C. perfringens spores and at times the other indicators were found in the samples collected from test station JC-11 in 1980-1981. This appears to result from a break in the outfall for the Northeast Monmouth STP. The break was repaired and a long diffusér was added subsequent to that time.

TABLE 16

Unusually High Indicator Levels Observed During The 1987 USEPA Sampling Tours Of Beyond the Surf Stations And Suspected Sources.

Date	Station	Indicator Level Per 100 ml Water				Possible Source
		C. Perf	F Phage	Enterococci	Coliforms	of Contamination
7/15	JC-21	27.0	0.5	9	2	Sewage, Asbury Park STP
7/29[a]	JC-21	3.0	ND	1	3	
	JC-24	4.5	2.0	2	18	Sewage, Shark River
	JC-26	23.5	10.5	10	79	Sewage, Shark River
	JC-59[d]	< 0.5	< 0.5	17	53	Wild animals,stormwater
	JC-73[d]	1.0	< 0.5	1	17	Wild animals,stormwater
8/5	JC- 3	4.5	< 0.5	44	1	
	JC-21	93.0	15.0	620	216	Sewage, Asbury Park STP
	JC-27	1.5	< 0.5	11	9	
	JC-37	3.5	< 0.5	15	5	
	JC-53	0.5	< 0.5	14	12	
	JC-61	< 0.5	< 0.5	5	5	
8/12[b]	JC-21	6.5	1.5	3	5	
	JC-24	35.5	4.0	18	75	Sewage, Asbury Park STP
	JC-26	18.5	4.0	14	50	or Fletcher Lake
	JC-27	14.5	3.5	6	31	
	JC-30	10.0	ND	2	24	
	JC-33	8.5	1.0	1	3	
8/19	JC-21	1.0	<0.5	2	< 1	
	JC-24	ND	ND	1	2	Sewage, Shark River
	JC-25	3.0	2.0	< 1	3	Sewage, Shark River
	JC-26	4.0	<0.5	12	25	Sewage, Shark River
	JC-27	5.5	2.0	6	9	Sewage, Shark River
	JC-30	5.0	0.5	1	1	Sewage, Shark River
	JC-33	2.5	1.5	1	1	?
	JC-77	10.0	<0.5	< 1	12	Stormwater
8/25	JC-21	10.0	0.5	22	2	

a Levels at nearby station shown to indicate movements of contaminated water
b About 1.0 in. rain fall on 7/27
c About 2.5 in. rainfall on 8/10
d Stations near inlets to embayments

TABLE 17

Mean Percent Reductions In The Indicator Levels Following Chlorination Of Effluents At Sewage Treatments Plants Which Discharge Through Ocean Outfalls

Sewage Treatment Plant	Treat Type	Med Flow	Outfall (Km)	Cl_2 Resid (mg/L)	Percent Reduction Following Chlorination			
					C Perf	F Phage	Enterococci	Coliforms
Northeast Monmouth	Sec.	7.5	0.76	4.3 ± 4.9	63.9	56.6	~99.89[f]	~99.997
Long Branch	Sec.	3.4	0.67	1.7 ± 1.0	76.7	~91.8	>99.94[g]	~99.998
Deal	Pri.	0.8	0.31[e]	3.2 ± 1.3	>99.95	~99.8	>99.996	>99.9990
Ocean Township	Sec.	4.4	0.62	3.2 ± 1.7	96.7	41.9	>99.9994	>99.99992
Asbury Park	Pri.	3.4	0.31[e]	3.0 ± 0.9	90.0	79.5	>99.9990	~99.99990
Neptune	Sec.	5.5[d]	1.82	4.0 ± 0.4	99.8	99.7	~99.94	99.990
South Monmouth	Sec.	6.0[d]	1.82	1.7 ± 0.2	88.4	85.4	~99.4	~99.93
Ocean County North	Sec.	11.0	1.97	1.4 ± 0.6	84.0	60.5	>99.995	99.9993
Ocean County Central	Sec.	19.0	2.13[e]	4.0 ± 1.0	98.4	48.0	>99.98	>99.997

a Pri. - Primary; Sec. - Secondary; Advanced secondary at South Monmouth STP
b Total chlorine residual
c Geometric mean for three samples, 8/3, 8/18, 8/24, in 1987
d Two day detention time following chlorination
e No diffuser; other lengths include the diffuser
f Approximation because of an indeterminate value, usually below sensitivity in that for the post chlorinated efficient
g Indeterminate values for at least two samples

The effects of the repair of the break in the Northeast Monmouth STP outfall and the lengthening of the Southeast Monmouth STP outfall appear to be reflected in the comparison of the indicator levels (JC-8 to JC-11 and JC-27 to JC-30, respectively) in 1987 to those in 1980-1981. It appears that the effluents from the Long Branch STP outfall reach the surf zone from the comparison of the spore, phage, and enterococci data at JC-14 to those at JC-11 for 1987.

Differences were obtained in the C. perfringens, enterococci and fecal coliform levels at the station just south as compared to those just north of most of the inlets to the embayments in the southern part of the state. The levels themselves were low and the differences were small. It would appear nevertheless that fecally contaminated water passing out through the inlets was discernible. Since these are onshore sources, their impact on the water quality at the beaches can only be assessed from the collection of samples within the inlets and from the surf zone at the nearby beaches.

7.2.2.3 Sewage Treatment Plants

Comparison of the STP pre and post-chlorination microbial assays indicated that in general the plants are functioning as intended. Chlorination resulted in the bacterial concentrations decreasing several orders of magnitude, in some cases up to a millionfold (Tables 17, 18). Clearly, C. perfringens because of its spores and the F phage are markedly more resistant to the effects of chlorination than the other two indicators. Primary or secondary treatment followed by chlorination as practiced at all the plants reduces the levels of the fecal coliforms and enterococci to such an extent that these indicator organisms should not be detectable at the surf zone with one possible exception. The Asbury Park

STP discharges 3.4 mgd from an outfall only 0.31 km in length. Thus, the issue to be resolved epidemiologically is the adequacy of the enterococci and coliform indicators to predict the risk of viral gastroenteritis from chlorinated effluents in which the bacterial levels but not those of the viral simulants are markedly reduced.

The data suggest some die-off of the Norwalk virus simulants during transport from the outfall to the surf zone. If the levels of the phage in sewage are appreciably less than those of the gastroenteritis viruses or if the viral agents do not die off during transport as do the phages, then there can be a measurable and possibly important risk of swimming-associated gastroenteritis at beaches whose water contains few, if any, of the f2 phages.

A risk of swimming associated illness at beaches potentially affected by ocean outfall may also derive from another factor. Suboptimal disinfection at an STP that discharges from an outfall which is short enough relative to its flow may present such a risk. In certain situations all indicators, and presumably the pathogens, reach the shore in sufficient numbers to be detected. Three such suspected occurrences were identified in the course of the examination of the STP effluents, and as noted earlier a fourth one was suspected from the monitoring study on the EPA network. The reductions obtained in the indicator levels following chlorination and the measured post-chlorination indicator levels are given in Table 19. The presumed lapse in disinfection at the Asbury Park STP clearly had a major impact on the levels of all four indicators at station JC-21 (Table 16). This need not have been also true to the other instances of suspected suboptimal disinfection since they occurred at STPs whose outfalls were somewhat longer. In particular, the Northeast

TABLE 18

Mean Indicator Levels In The Postchlorinated Effluents.

Sewage Treatment[a] Plant	Indicator Level/100 ml After Chlorination[b]			
	C. Perfringens	F Phage	Enterococci	Coliforms
Northeast Monmouth	2.5^{3}	1.2^{4}	$\sim 1.5^{1}$	$\sim 1.1^{2}$
Long Branch	3.2^{3}	1.6^{3}	$<1.7^{0}$	$\sim 1.3^{0}$
Deal Township	1.0^{1}	3.7^{2}	$<1.7^{0}$	$<6.5^{0}$
Ocean Township	1.1^{3}	2.7^{4}	$<1.4^{0}$	$<1.4^{0}$
Asbury Park	4.2^{3}	1.6^{4}	$<1.4^{0}$	$\sim 3.8^{0}$
Neptune	3.0^{1}	9.6^{1}	$\sim 2.6^{0}$	6.0^{1}
South Monmouth	4.8^{2}	3.0^{3}	1.9^{1}	3.2^{1}
Ocean County, North	6.2^{2}	3.1^{3}	$<1.4^{0}$	$\sim 6.3^{0}$
Ocean County, Central	1.3^{2}	4.4^{3}	$<3.5^{0}$	$<3.8^{1}$

a See Table 17 for STP characteristics
b Numerical superscripts denote factors of ten

Monmouth and the Ocean Central plants engineer into their chlorination processes extended detention time periods which prolong the contact between sewage and chlorine prior to discharge through the outfall. Immediate post chlorination samples such as those tested do not reflect the degree of disinfection of the sewage such is achieved by the time of release into the ocean.

7.2.2.4 Sampling at Selected Beaches

The results of microbial monitoring are given in Table 20. As noted in the **Methods** section, water samples were collected from both the shoreline and just beyond the surf zone in order to determine the extent to which onshore sources of the indicators, and possibly pathogens, might confound the interpretation of the data. Of special concern was fecal contamination of the water from the bathers themselves since the consequent health effects are neither predictable nor correctable.

The results of the water quality monitoring permitted preliminary characterization of the beaches for study purposes. The discussion of specific beaches follows.

7.2.2.4.1 Island Beach State Park

Measurable levels of enterococci, fecal coliforms, C. perfringens or phage generally were not found in the water samples collected from just beyond the surf zone (BSZ), suggesting that in general physical delay through dilution and sedimentation of the outfall effluents during transport to the shore is sufficient to make the effluents undetectable by the usual means. In all probability measurable levels of the spores could be found in bottom sediments due to their occasional transport to the shore in very low numbers and the protracted survival in the bottom sediments. The C. perfringens and f2 phage levels in the shoreline (WSZ)

TABLE 19

Percent Reduction In The Indicator Levels Following Chlorination In Suspected Instance Of Suboptimal Disinfection Of Sewage Treatment Plant effluents

Sewage Treatment Plant	Date Sampled	Percent Reduction Following Chlorination (level/100 ml in postchlorinated effluent)			
		C. Perfringens	F Phage	Enterococci	FC
Northeast Monmouth	8/18	0.0[L] (5.9[3])	40.8 (1.7[4])	<95.6[L] (>1.7[3])	<98.7[L] (>4.7[4])
South Monmouth	8/3	56.6[L] (8.7[2])	85.0 (2.7[3])	<91.1[L] (1.5[2])	<98.9[L] (5.4[1])
Ocean County, Central	8/18	89.8 (6.3[2])	48.7 (4.6[3])	99.6 (2.3[1])	<99.7[L] (>5.9[3])
Ocean County, Central	8/24		0.0[L] (1.0[4])		
Ocean Township	8/24		0.0 (4.2[4])		
Lower SD for all		57.1	7.5	99.7	99.96
samples		96.4	91.0	>99.98	>99.998
Upper SD for all samples		99.7	99.2		

See Tables 17 and 18 for footnotes.

TABLE 20

Geometric Mean Indicator Levels In Water Samples Collected At Beaches Tentatively Selected For Epidemiologic Studies

Beach	Days Sampled[a]	Sampling Site[b]	N[c]	Mean Indicator Level per 100 ml[d,e] (Standard Deviation) C Perf	F Phage	Enterococci	Coliforms
Island Beach State Park	1-9	WSZ	25-27	<0.67	<0.5[2]	~2.1*** (0.8-5.6)	~3.4*** (1.4-7.8)
		BSZ	14-15	<1.1	<0.5[4]	<0.63	< 0.73
	8,9	WSZ	6	10.0** (3.6-28)			
		BSZ	4	<0.71			
Seaside Heights	1-4	WSZ	12	1.3 (0.8-2.4)	<0.58[4]	10.9 (6.1-19)	19.0* (3.7-97)
		BSZ	6	<0.77	<0.69[4]	7.1 (2.8-18)	2.7 (0.4-20)
Brick Township	5,6	WSZ	6	1.3 (0.5-3.3)	<0.5	2.0 (0.6-6.5)	5.4** (2.8-10)
		BSZ	4	1.5 (0.4-5.3)	<0.5	~0.71 (0.7-1.1)	1.0
Spring Lake	1-4	WSZ	12	2.6 (0.9-7.7)	~0.56[6]	6.1 (2.0-18)	2.2 (0.8-6.1)
		BSZ	6	1.0 (0.6-1.7)	~0.56[4]	4.3 (1.3-15)	<0.5
Belmar	9	WSZ	2	6.9	~0.71[1]	11.2*	31.0*
		BSZ	2	3.4	<0.5	<0.5	5.1
Bradley Beach	1-9	WSZ	26-27	4.6* (1.3-16)	1.1[3] (0.4-3.2)	3.9 (1.0-16)	4.1* (1.0-17)
		BSZ	15-16	1.9 (0.7-5.7)	0.81[8] (0.3-2.0)	1.7 (0.5-6.5)	1.5 (0.5-4.5)

TABLE 20 (continued)

Geometric Mean Indicator Levels In Water Samples Collected At Beaches Tentatively Selected For Epidemiologic Studies

Beach	Days Sampled[a]	Sampling Site[B]	N[c]	Mean Indicator Level per 100 ml[d,e] (Standard Deviation) C Perf	F Phage	Enterococci	Coliforms
Asbury Park	5-9	WSZ	13-14	17.2[**] (7.0-42)	~0.95[8] (0.4-2.3)	4.1 (0.9-19)	24.1[**] (6.7-86)
		BSZ	8-9	5.8 (2.4-14)	2.3[5] (0.5-11)	2.1 (2.1-9.5)	3.5 (0.7-17)
Long Branch	1-4	WSZ	11-12	7.8[***] (3.6-17)	~0.65[6] (0.4-1.0)	10.0 (3.1-32)	3.1 (0.6-17)
		BSZ	5-6	<0.69	~0.67[3] (0.4-1.1)	3.2 (0.9-11)	<0.63
Sandy Hook, Main Beach	9	WSZ	2	6.0	<0.5	<0.5	1.2
		BSZ	2	1.3	<0.5	~0.71	~0.71

a Days: 1, 7/11; 2, 7/12; 3, 7/17; 4, 7/18; 5, 8/1; 6, 8/2; 7, 8/22; 8, 8/23; 9, 8/30

b WSZ: Within the surf zone, samples collected from shoreline by foot
BSZ: Beyond surf zone, samples collected just beyond surf zone by helicopter

c Number of samples.

d Numerical superscript is number of samples from which phage were recovered

e ~ approximate value; < less than sensitivity of assay

*, **, ***: Indicator levels in WSZ and BSZ samples significantly different a P<0.05, 0.01 and 0.001, respectively

samples also were generally below the sensitivity limits of the respective assay with one notable exception. On the eighth and ninth study days the levels of C. perfringens spores in the water samples collected within the surf zone were appreciably and significantly higher than those found during the other sampling days. This was presumably due to resuspension of the spores in bottom sediments because of surf activity. This in turn is the basis for the statement that very low levels of pollution from the outfall occasionally reaches the shoreline. The enterococci and fecal coliform levels in the surf zone samples were very low but significantly higher than those in the off shore samples. Since there are no other sources for the organisms in the area, it is probable that the microorganisms derive from the bathers themselves. Although the effects of the bathers themselves on the fecal indicator levels in the water was clearly shown, its magnitude was small; and, because of this, the beach is considered acceptable as a control beach for the conduct of epidemiological studies as regards the quality of the water.

7.2.2.4.2 Seaside Heights

As seen from the C. perfringens and f2 phage levels in both the BSZ and WSZ samples, the situation of this beach relative to the offshore ocean outfall to its north (Ocean County, North) is similar to that of the Island Beach State Park, in that insignificant levels of pollution reach the shore line. There are, however, appreciable onshore sources of the indicators which may come from the bathers themselves, birds as reported by DEP personnel, or stormwater. Moreover, the contamination is widespread enough to extend beyond the surf zone. Because of this, Seaside Heights was not considered a good control beach.

7.2.2.4.3 Brick Township

This beach is considered an acceptable control beach insofar as water quality is concerned for the same reasons given for Island Beach State Park.

7.2.2.4.4 Spring Lake

The ocean outfall which could affect the water quality at the beach is the one for the South Monmouth STP. There is no evidence that appreciable levels of pollution reach the shore line as seen from the indicator levels in the BSZ samples as compared to those in the samples collected within the surf zone. The mean spore level in the shore line samples was slightly higher than those in the tentative control beaches, suggesting that intermittent contamination from the outfall has reached the shore more frequently. There appears to be more onshore pollution than that at Island Beach State Park or Brick Township, but less than that at Seaside Heights. Some of the onshore contamination could derive from Wreck Pond. This is an acceptable control beach with the proviso that some of the days may have to be segregated in the analysis of the epidemiological data.

7.2.2.4.5 Belmar

This beach could only be surveyed once because of a combination of logistic and weather factors. There is no evidence from the data presented in Table 20 or from those obtained in the EPA sampling tours that appreciable contamination reaches this beach from the Neptune STP outfall. There was appreciable and significant contamination of the water from onshore sources as seen from the comparison of enterococci and coliforms levels in the BSZ and WSZ samples. The suggestion that this is also true of the f2 phage brings up the possibility that there are onshore sources of sewage. The Shark River Inlet is a possible source and there is a suggestion from indicator levels at station JC-27 on 8/12/87 (Table 16) that sewage-contaminated water from the river can reach Belmar Beach. This does not appear to be either a good test or control beach.

7.2.2.4.6 Bradley Beach

There are three sources of sewage which could affect the water quality at this beach. They are the Asbury Park ocean outfall, that in Fletcher Lake North of the beach and that in the Shark River Inlet south of the beach (Table 21). Based on preliminary information on beach usage and demographics of the users, this was considered a more acceptable beach then Asbury Park. It would appear from Table 20 that polluted effluents from the outfall do reach the beach on occasion as seen from the levels of the indicators in the BSZ samples. The water along the shore appears to be more affected by on shore sources of the indicators including some sewage as seen from the f2 phage levels. The beach represents a situation of fluctuating water quality due to multiple contamination sources.

7.2.2.4.7 Asbury Park

The indicator levels in the water at this beach can be affected by several sources. The ocean outfall for the Asbury Park STP is 0.31 km offshore from the beach, presently one of the shorter outfall lengths. Other sources are Deal Lake to the north and Fletcher and Wesley Lakes to the south of the beach. There also are stormwater drains in the area. One of the striking aspects of the data in Table 20 was the higher f2 phage levels in the BSZ than in the WSZ samples. The difference in the mean levels was neither significant nor consistent, suggesting infrequent episodic suboptimal disinfection at the treatment plant. It was probably not a lapse in disinfection that produced the elevated indicator levels

TABLE 21

Indicator Levels In Water Bodies Discharging To The New Jersey Coast in 1987 Between Sea Bright And Manasquan And Suspected Nature Of The Indicator Source

		Indicator Level Per 100 ml of Water				
Water Body	Date	C. Perf	F Phage	Enterococci	E.Coli	Type of Contamination
L. Takanassee	8/31	13.5	1.0	7.3	18.7	
Popular Brook	8/31	62.5	8.5	72.3	1500	Sewage
Deal Lake	8/24	11.5	10.	29.7	51.4	Stormwater,
	8/31	62.9	<0.5	15.0	92.3	sewage?
Lake Wesley	8/24	124	<5.0	89.5	165	Stormwater
	8/31	175	1.0	28.5	240	
Fletcher Lake	8/31	612	20	63.7	376	Sewage
Sylvan Lake	8/31	125	<0.5	127	330	Stormwater
Shrk Rver Inlet	7/29	23.5	10.5	10	79	Intermittant
	8/5	1.5	0.5	2	6	sewage
	8/12	18.5	4.0	14	50	
	8/19	4.0	<0.5	12	21	
	8/22	2.9	<0.5	4.2	~4.2	
	8/23	~0.5	<0.5	1.9	9.8	
	8/25	<0.5	<0.5	<1	<1	
	8/30	6.2	<0.5	2.4	5.5	
Lake Como	8/31	20.	<0.5	6.5	9.9	
Wreck Pond	8/31	40.5	19.5	<3300	350	Sewage, wildlife

seen for station JC-21 during the EPA survey on 8/5/87 (Table 16). The coliform but not the enterococci levels in the WSZ samples were significantly higher than those in BSZ samples. In view of the lower coliform than enterococci or f2 phage levels in sewage and the poorer survival of the coliform bacteria in marine environments, the data could be explained by a nearby on shore source of sewage or shed by the bathers themselves. The significantly higher C. perfringens in the shoreline as opposed to the BSZ could be due to resuspension of sedimented spores into the water column as was suggested for Island Beach State Park on sampling days eight and nine. The Asbury Park beach is considered a satisfactory test beach as regards to water quality. However, the illness data from this beach and Bradley Beach will probably have to be segregated by days based on the BSZ indicator levels and their relation to those in the shoreline water samples.

7.2.2.4.8 Long Branch (Seven Presidents)

In the absence of moderate to heavy rainfall, there are only three sources of the indicator organisms found at the beach. These are the Long Branch STP ocean outfall which lies 0.76 Km off shore from the beach, the Laird Street stormwater drain, and the bathers themselves. The levels of enterococci, coliforms and at least a portion of the C. perfringens spores in the water samples collected just beyond the surf zone could derive from on shore sources since the corresponding levels in the WSZ samples were higher, at times significantly so. The phage levels in the samples are another matter and probably derive from the outfall. A more detailed study of the Long Branch outfall along with Seven Presidents Beach and the Laird Street stormwater drain showed that the f2 male-specific phages were not found in the stormwater. The low and inconsistent levels of the f2 phage in the water notwithstanding, Seven Presidents Beach is recommended for an epidemiological study. The finding of low phage levels in the water does not necessarily preclude the presence of larger numbers of the Norwalk virus. The mean levels of f2 phage in the post chlorinated effluents was only 1.6×10^{3} PFU/100 ml (Table 18). As previously discussed, acute gastroenteritis is a common illness, the Norwalk-like viruses are a common etiologic agent for this illness, and the levels of this virus in the feces of all individuals is very high (about 10^{9} - 10^{10} virions/g) (Cabelli, personal communication). Secondly, although f2, one of the f male-specific phages, is as resistant to chlorination as the Norwalk virus, the f phages are inactivated by the combination of elevated temperatures and solar radiation in the water during the summer as compared to the winter. This need not be as true of the Norwalk virus. The conduct of an epidemiological study at this beach should resolve the question whether there is a measurable risk of illness even when these viruses are absent or present at very low levels.

7.2.2.4.9 Sandy Hook, Main Beach

The data Table 20 would support this beach as a control beach. The graduation of C. perfringens levels from north to south as seen from the EPA surveys both in 1980-81 and 1987 suggest that pollution from the Raritan Bay to the north physically reaches the beaches in Sandy Hook. This also appears to be true based on the frequency with which the phage can be recovered from the water. Thus, this could be an extreme case of the condition postulated for the beach at Long Branch. Its use as a study beach has one disadvantage, the lack of a single possible source of pollution, and one advantage, the need for information on whether heavy pollution levels to the north pose any risk to the bathers at Sandy Hook.

7.2.2.5 **Sampling of Selected Sites**

Aside from stormwater drains, there are several lakes, ponds, and rivers which discharge directly or via connecting pipes into the coastal water between Sea Bright and the Manasquan Inlet. The results of the preliminary survey are shown in Table 21. The levels of all four indicators were low in the samples from two of the lakes, Takanassee and Como, and from most of the samples from the inlet to Shark River. Levels were relatively high in the samples from Poplar Brook, Fletcher Lake, Wreck Pond and at times the Shark River Inlet and Deal Lake, suggesting sewage contamination. Coliform and enterococci guidelines were exceeded on several occasions. The water samples from Lake Wesley and Sylvan Lake had high levels of enterococci, E. coli, and C. perfringens but the F phage levels were very low, suggesting the absence of a significant sewage input. These samples represent the highest indicator values for any sampling done.

7.2.3 **Quantitative Risk Assessment**

The data bases were generally too small for a good estimate of the predicted risk of swimming-associated gastroenteritis. With that caveat, the mean enterococci levels in the WSZ and BSZ samples were entered in to the indicator-illness predictive equation developed from EPA epidemiological studies ($Y = 12.17 \log_{10} X + 0.2$ where X in the indicator level and Y is the increase in illness rate) (6). The outputs are given in Table 22. Although this is not strictly accurate, these rates can be thought of as those which would not be exceeded during 50 percent of the days during the swimming season. The enterococci levels in the shoreline samples better describe the quality of the bathing water while those in the samples collected from just beyond the surf zone may be more appropriate for predicting swimming-associated illness in that the water is less likely to contain organisms derived from the fecal wastes of lower animal such as bird dropping or stormwater which do not pose measurable risk of illness. Even the BSZ samples, however, may be contaminated by enterococci from onshore sources and this appears to be especially true at the Seaside Heights and Spring Lake Beaches. The numbers of enterococci contributed by the swimming activity confound the prediction especially if they are large relative to the extrinsic sources.

The risk rate accepted by the EPA was not exceeded at any of the beaches. This does not say, however, that New Jersey should be satisfied with the admittedly high risk rate accepted by the EPA guideline, about 16 cases of swimming-associated gastroenteritis per 1000 swimmers. The mean illness rate for all the beaches as extrapolated from BSZ samples was 3.5 $\pm$ 4 cases/1000 swimmers, and that derived from the shoreline samples was 8.7 $\pm$ 3.8. The rates, however, reflect enterococci which may have come from stormwater discharges, direct contamination from birds, and organisms shed by the bathers themselves. The enterococcus contribution from the bathers themselves as seen from the data from the Island Beach State Park and Brick Township beach is about 2.0/100 ml which extrapolates to an illness rate from the WSZ samples of about 4 cases/1000 persons. This is about the difference in the rates predicted from the WSZ and BSZ samples at the Seven Presidents Beach.

A more conservative standard would be the indicator levels corresponding to risk of illness which would not be exceed on 90 percent of the swimming days. This was estimated by obtaining the 90th percentile values from the frequency distribution of enterococcus densities and entering these values into the illness-indicator regression equation. The

TABLE 22

Mean Enterococcus Levels In The Within Surf Zone (WSZ) And Beyond Surf Zone (BSZ) Samples And Swimming-Associated Predicted Gastroenteritis Rates[a]

Beach	Enterococci/100 ml[b]		Illness Rate per 1000[c]	
	BSZ	WSZ	BSZ	WSZ
Island Beach State Park	<0.63	~2.1	Un[d]	4.1
Seaside Heights	7.1	10.9	10.6	12.8
Brick Township	~0.71	2.0	Un	3.9
Spring Lake	4.3	6.1	7.9	9.8
Bellmar	<0.5	11.2	Un	13.0
Bradley Beach	1.7	3.9	3.0	7.3
Asbury Park	2.1	4.1	4.1	6.3
Long Branch, Seven Presidents	3.2	10.0	6.3	12.4
Sandy Hook, Main Beach	~0.71	<0.5	Un	Un
Mean (SD)			3.5 ± 4.0	8.7 ± 3.8

a The rates which would not be exceeded 50 percent of the time
b As obtained from Table 20
c Obtained by entering the mean enterococcus level (x) in the equation derived from the USEPA epidemiological studies, $y = 12.17\ x + 0.2$
d Unpredictable; set at 0.0 to calculate mean

results were predictions of 5.7 and 9.3 cases/1000 swimmers from the BSZ and WSZ samples from Island Beach State Park, respectively and 9.6 and 17.8 for Bradley Beach.

7.2.4 Assessment of Sources of Contamination on the Basis of the Microbiological Data

The data from each location in the EPA epidemiological studies were grouped in two ways, first by beach and year and then by indicator organism and year (6). Table 20 represents the data in the first analysis mode. The second approach was examined using data from the Bradley and Asbury Park beaches. It is reasonably certain that this type of data handling will have to be done at both these beaches because they are subject to multiple sources of contamination both from human and lower animal fecal wastes. Since the phage appears to offer some hope of separating contamination with sewage (primarily human fecal wastes) from that with stormwater (primarily lower animal fecal wastes), the nine survey days at Bradley Beach and five at Asbury Park were grouped according to the phage levels. The indicator levels in the WSZ and BSZ samples were within a group and across groups were compared statistically. The results of this analysis are presented in Table 23.

Three patterns of indicator levels were produced from the Bradley Beach data. The phage levels in WSZ and BSZ samples for group 1, which was selected to have the highest phage levels, were comparable. The mean levels of the other three indicators in the shoreline samples were appreciably greater from those samples collected just beyond the surf zone. The difference in the C. perfringens levels were statistically significant at $p<0.05$ and those for the other two indicators approached significance. It would appear that these were two sources of

Table 23

Indicator Levels At Bradley And Asbury Park Beaches Grouped By Days According To The F phage Densities

Beach	Group[a]	Days	Site[b]	N[c]	Mean Indicator Level Per 100 ml Water[d,e] (Standard Deviation)			
					C.Perfringens	F Phage	Enterococci	Coliforms
Bradley Beach	1	1,2	WSZ	6	7.3[*] (4.2-13)	5.8[6] (4.2-7.9)	18.1 (5.5-60)	25.2 (12-54)
			BSZ	2	2.3 (2.1-2.6)	6.0[2] (6.0)	2.6 (1.8-3.9)	3.0 (3.0)
	2	4,8,9	WSZ	9	7.1 (1.8-28)	1.1[7] (0.5-2.2)	2.5 (0.7-9.6)	3.6 (0.9-14)
			BSZ	6	1.5 (0.3-6.6)	~0.73 (0.4-1.4)	<1.5 (0.4-5.5)	2.2 (0.9-5.4)
	3	3,5 6,7	WSZ	12	2.6 (0.8-8.9)	<0.5[0]	2.5 (0.9-6.8)	2.1 (0.8-5.7)
			BSZ	7-8	2.3 (0.9-5.5)	<0.5[3]	1.7 (0.4-8.3)	1.1 (0.4-3.4)
Asbury Park	4	7,8,9	WSZ	8	28.8[*] (13-63)	1.5 (0.6-3.8)	4.4 (0.6-31)	16.8 (3.7-77)
			BSZ	4-5	10.1 (5.0-21)	8.1[**] (4.4-15)	4.0 (1.0-15)	5.6 (0.7-43)
	5	5,6	WSZ	5-6	8.7[**] (5.3-14)	<0.5	3.8[*] (1.8-8.1)	42.9[***] (28-66)
			BSZ	4	2.9 (1.8-4.6)	<0.5	1.1 (0.5-2.3)	1.9 (1.1-3.2)

[a] Significant differences between groups

C. Perfringens:	WSZ, 4 vs 5, P<0.01; BSZ, 4 vs 5, P<0.05
F Phage:	WSZ, 1 vs 2+3, P<0.001; 2 vs 3, P<0.01; 4 vs 5, P<0.001
	BSZ, 4 vs 5, P<0.001
Enterococci:	WSZ, 1 vs 2+3, P<0.001
E. Coli:	WSZ, 1 vs 2+3, P<0.001

See Table 20 for other footnotes

contamination, an onshore source which was responsible for the higher enterococci, coliforms, and C. perfringens levels in the WSZ samples and the Asbury Park outfall which was responsible for the high f phage levels in BSZ and possibly in the WSZ samples. It is also possible that some of the phage in the WSZ samples came from a sewage contaminated on shore source. With groups 2 and 3 the difference in the phage, enterococci and coliform levels in the WSZ samples were not appreciably different from those in the samples collected just beyond the surf zone. These data look very much like those from the Long Branch Beach, that is low levels of all four indicators. The enterococcus, coliform and f phage levels in the WSZ samples were significantly higher than those in the combination of groups 2 and 3. This was also true of phage levels in the BSZ samples.

The sources were much better defined when the Asbury Park data were grouped according to the phage levels. In group #4 the phage levels were significantly higher beyond the surf zone than along the shoreline and the enterococci and coliform levels in the WSZ and BSZ samples were not significantly different. This is interpreted as a result of sewage contamination originating at the outfall. The phage was not detectable in the WSZ or BSZ samples in the second group (#5); and the C. perfringens, enterococci and coliform levels were significantly higher along the shoreline. This is interpreted as being due to an onshore source not containing sewage; an alternate explanation is contamination due to the bathers themselves. The WSZ and BSZ levels of both C. perfringens and f phage in group #4 were significantly greater than the corresponding one in group #5. If the differences in the two groups were consistently observed during the course of epidemiological studies then two issues could be address from the data obtained, the risk of illness associated with low f phage levels deriving from chlorinated effluents discharged from the outfall and the risk of illness from an onshore contamination source with no apparent human fecal input.

7.2.5 Beach Water Quality During Phase II Interviews

Table 24 gives the indicator levels in the water at the shoreline and from beyond the surf zone at the Island Beach State Park and Bradley beaches during the Phase II epidemiological study. Almost all the levels of the four indicators during each of the three test days in BSZ samples from Island Beach State Park were below the sensitivity of the assay. The levels from the WSZ samples were low and accountable by contamination from the bathers themselves. The enterococci levels were less than the threshold level from which swimming-associated acute gastroenteritis could be predicted using the regression equation developed in the EPA epidemiological studies.

The indicator levels in both the WSZ and BSZ samples were generally higher at Bradley Beach than at IBSP. This was especially true of the samples collected on 8/30, particularly with regard to the f phage levels. During a full scale epidemiological study, the 8/30 illness data would have been grouped separately from those of the other two days, at least when the levels in the BSZ samples was used as the basis for grouping the trial days. The swimming-associated gastroenteritis rate as predicted from the mean enterococci levels in the BSZ samples for the three days was not predictable while that for 8/30 alone was 4.8 cases/1000 swimmers. The corresponding risks predicted from the WSZ samples were 3.0 and 5.2 cases/1000 swimmers, respectively.

During the pretest of the epidemiological design at Bradley Beach on 8/22, 8/23 and 8/30, samples were also collected from a number of nearby

TABLE 24

Indicator Levels At Island Beach State Park During Phase I Of Epidemiologic Study Design According to Phage Densities

				Mean Indicator Level Per 100 ml Water[d,e] (Standard Deviation)			
Beach	Site	Date	N[c]	C.Perfringens	F Phage	Enterococci	Coliforms
Island Beach State Park	WSZ	8/22	3	<0.63	<0.5[1]	1.4	1.7
		8/23	3	22.4	<0.5	<0.62	2.2
		8/30	3	4.4	<0.5	~1.1	4.6
		$\bar{x}$		4.0	<0.5	1.0	2.6
		SD		(0.8-20)		(0.6-1.8)	(1.4-4.7)
	BSZ	8/22	1	7.5	<0.5	<0.5	<0.5
		8/23	2	<0.5	0.5[2]	<0.5	<0.5
		8/30	2	1.0	<0.5	<0.5	<0.5
		$\bar{x}$		<1.1	<0.5	<0.5	<0.5
		SD		(0.3-3.8)			
Bradley Beach	WSZ	8/22	3	12.9	<0.5	2.1	<0.63
		8/23	3	14.8	0.91[2]	0.91	1.5
		8/30	3	10.6	1.5[2]	2.6	7.9
		$\bar{x}$		12.6	0.88	1.7	1.9
		SD		(4.3-37)	(0.4-1.9)	(0.7-3.9)	(0.5-8.2)
	BSZ	8/22	2	4.5	<0.5	<0.71	<0.5
		8/23	2	0.71	<0.5	<0.5	2.0
		8/30	2	10.0	1.6[2]	~2.4	4.2
		$\bar{x}$		3.2	0.73	0.95	1.6
		SD		(0.8-13)	(0.4-1.4)	(0.3-3.4	(0.6-4.7)

See Table 20 for appropriate footnotes.

locations in an attempt to identify the pollution sources responsible for the indicator levels at the beach and presumably the risk of any subsequent swimming-associated illness among the users. Included were samples from the pre and post-chlorinated effluents at the Asbury Park STP, the shoreline and just beyond the surf zone at the Asbury Park Beach, the Shark River inlet, BSZ stations north of Asbury Park JC-20, and beyond the surf between the inlet to the Shark River and Bradley Beach, JC-25. The data from the assays are presented in Table 25.

It is clear from the indicator levels at the Shark River Inlet and those at station JC-25 that on these three days the source of the indicator levels at Bradley Beach, low as they were, was not the Shark River. The f phage, enterococci and coliform levels along the shoreline were higher on 8/30 than on 8/22 or 8/23. On those days the indicator levels just beyond the surf zone were equally high suggesting a very small effect from an offshore source. On all three days, the higher levels in the BSZ as compared to the WSZ samples indicate that contamination source was the Asbury Park outfall. On 8/22 this was also true of the enterococci and coliform levels as well, suggesting suboptimal disinfection of the wastewater effluents. This was confirmed by the data from the treatment plant. On 8/30, however, the high enterococci levels were in the shoreline samples but this was not also true of the phage levels. The onshore source of the elevated enterococci levels could have been contamination from stormwater drains or from Deal or Wesley lakes to the north and south of the beach, respectively. The bathers themselves are unlikely sources for the contamination because of the elevated enterococci and coliform levels found in both samples.

TABLE 25

Offshore Indicator Levels Between Deal and Shark River Inlet And Their Relationship To Those At Asbury Park and Bradley Beach

Date	Sampling Location[A] Area	Site[b]	N[c]	Indicator Levels Per 100 ml of Water: C. Perfring	F Phage	Enterococci	Coliforms
8/22	Asbury Park STP	Post-Cl2	1	2.0×10^4	2.0×10^4	1.2×10^2	3.3×10^2
				4.2×10^3	1.6×10^4	1.4×10^0	3.8×10^0
	JC - 20	BSZ	2	4.2	9.1	1.0	~1.0
	Asbury Park Beach	WSZ	3	16.0	0.63	1.4	3.3
		BSZ	1	25.5	9.5	2.0	<0.5
	Bradley Beach	WSZ	3	12.8	<0.5	2.1	<0.62
		BSZ	2	5.2	<0.5	~0.71	<0.5
	J - 25	BSZ	2	1.9	<0.5	1.0	1.0
	Shark R. Inlet	BSZ	2	2.9	<0.5	4.2	~4.2
8/23	Asbury Park STP	Post-Cl_2	1	1.7×10^4	2.1×10^4	2.2×10^2	1.2×10^2
	JC - 20	BSZ	2	~0.5	<0.5	~0.71	~0.5
	Asbury Park Beach	WSZ	3	71.9	3.0	1.8	23.9
		BSZ	2	4.5	10.4	101.	43.6
	Bradley Beach	WSZ	3	14.9	~0.91	~0.91	1.5
		BSZ	2	~0.71	<0.5	<0.5	2.0
	J - 25	BSZ	2	<0.5	<0.5	<0.5	<0.5
	Shark R. Inlet	BSZ	2	~0.5	<0.5	1.9	9.8
8/30	Asbury Park STP	Post-Cl_2	1	2.4×10^3	2.4×10^4	$<0.5 \times 10^0$	3.3 x 100
	JC - 20	BSZ	2	13.5	0.71	~0.71	~2.1
	Asbury Park Beach	WSZ	2	17.7	2.2	91.2	132.
		BSZ	2	11.1	5.7	2.0	3.6

TABLE 25 (continued)

Offshore Indicator Levels Between Deal and Shark River Inlet And Their Relationship To Those At Asbury Park and Bradley Beach

Date	Sampling Location[A] Area	Site[b]	N[c]	Indicator Levels Per 100 ml of Water C. Perfring	F Phage	Enterococci	Coliforms
8/30	Bradley Beach	WSZ	3	10.6	~1.5	2.6	7.9
		BSZ	2	10.0	1.6	~2.5	7.8
	J - 25	BSZ	2	3.2	~0.71	~0.87	1.7
	Shark R. Inlet	BSZ	2	6.2	<0.5	~0.71	1.7
	Shark River		2	3.5	~0.5	2.4	5.5

A = Offshore stations (BSZ) North to South
See Table 20 for appropriate footnotes.

7.3 Beach Pollution Transport Dynamics

There was enormous variability in the length of time the dye remained detectable after release in the surf zone. On occasions when there was fairly high wave activity at a large angle of incidence the residence time of the dye was of the order of a few minutes. On other occasions with low wave energy and a nearly perpendicular angle of approach the residence time for the dye in the surf zone was of the order of a few hours. The movement of dyed surf zone water offshore occurred in relatively small areas, rip current regions. In several instances it was apparent that the presence of a jetty or bulkhead promoted the offshore movement and created such a region. There were, however, other instances in which the rip current was not clearly associated with a particular cross shore structure.

An example of the pattern of dye movement is shown in Figure 14. During this particular release the cross shore bulkhead at the location "BM" clearly interrupted the alongshore movement of dye and produced an offshore transport of the surf zone water. It is important to note that the exchange of surf zone water with offshore water at the site can be, on occasion, very sluggish. Residence time of water in the surf zone can be on the order of hours. At these times the bathing area in effect becomes an unchlorinated swimming pool and with high bather density there exists the potential for swimmers to become a source of contamination to each other.

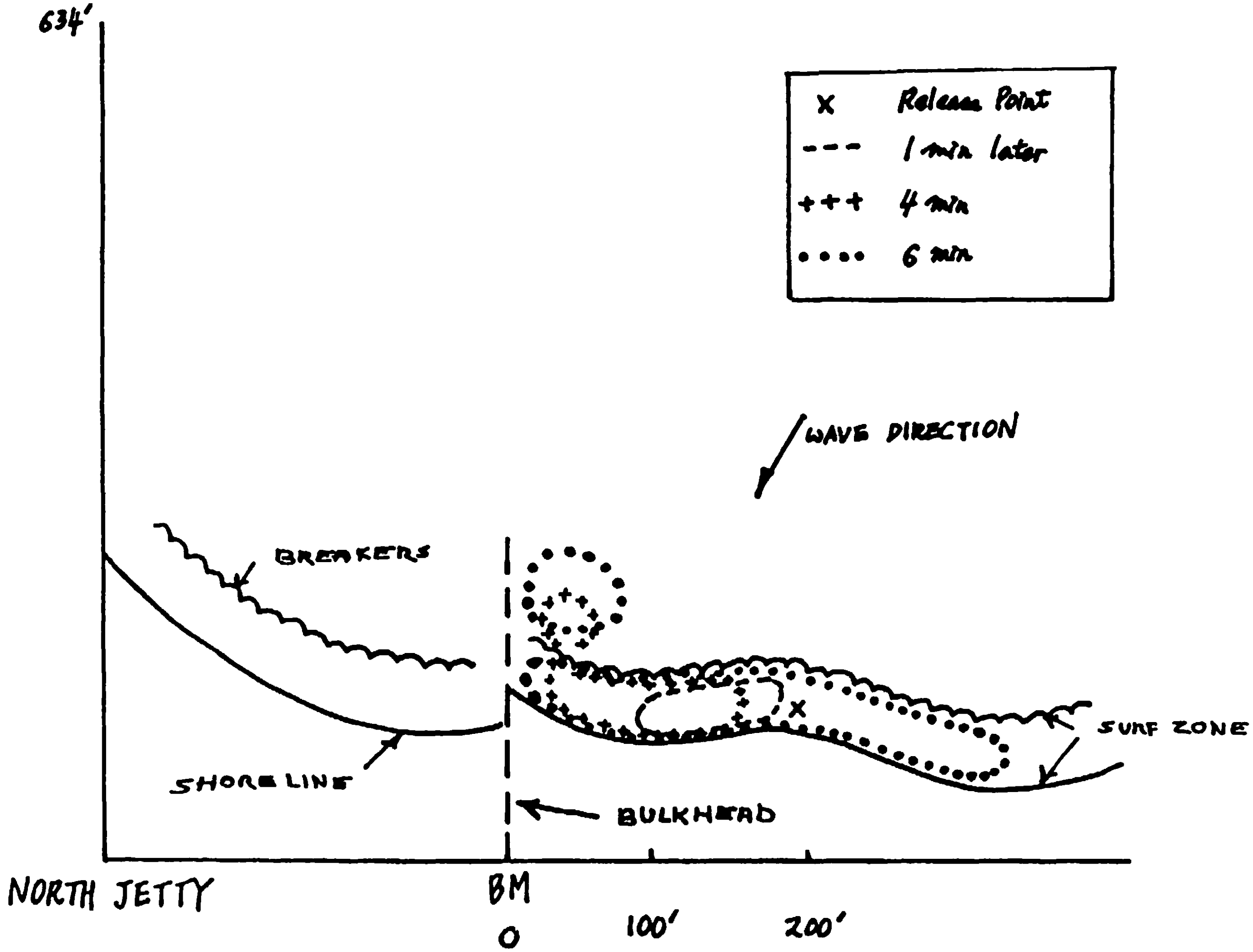

Figure 1. Dye Release Experiment at Bradley Beach on 28 October 1987. The contours show the approximate boundary of the dye at time intervals after its release.

8. DISCUSSION

8.1 Epidemiology

8.1.1 Interview Outcome

The data from the interviews conducted in the preliminary phases were used to evaluate the feasibility of conducting the study as originally designed. Methodological problems were identified during the Phase I and II interview experiences. Insufficient planning time and the use of two institutions to jointly manage the epidemiological data led to several delays.

Infectious illnesses were present in the population coming to the beaches and were readily detected in both the swimming and nonswimming subpopulations following beach visits. The preliminary field work suggest that the observed elevated symptom rates are higher than would be expected according to any of the water quality indices. At the same time syndrome rates for HCGI were low. The finding of elevated symptom rates supports the contention that multiple routes for transmitting infectious agents exist as part of the overall beach environment beyond possible exposure to microbial contamination through sewage outfall discharges into ocean water. Person-to-person transmission is a strong possibility as are inadequate personal hygiene and food contaminated. In addition, the large number of individuals swimming at multiple sites face further infectious exposures. Noninfectious factors such as heat stress may also result in reported symptoms. These possible sources should be evaluated in later phases.

There are three major considerations in planning to conduct the full epidemiological study during for the Summer of 1988. The designed study should produce the necessary information with sufficient statistical power to answer the pertinent questions and be conducted within reasonable limits for effort and cost.

The first consideration is the availability at the beach of sufficient numbers of family units with children and their swimming status. Phase I and II interview data were combined to give the age breakdown for each beach (Table 26). The data were broken down further for the less than 10 years of age group into swimmers and nonswimmers (Table 27). On the basis of this information, there seems to be sufficient populations at the beaches to enter into the initial study, a follow-up of health outcome in populations swimming only at beaches during the weekend. The information in Tables 26 and 27 was additionally helpful in identifying beaches that were primarily family oriented.

The second consideration was finding beaches that were visited by weekend-only swimmers. Intensive microbial water quality monitoring to evaluate exposure is done only on weekends. Furthermore, people who swim elsewhere than the beach under study may swim in water of poorer quality, hence biasing the results toward a higher illness rate in swimmers. As previously shown in Table 10 (see **RESULTS**), New Jersey beachgoers interviewed this summer swim at more than one place over the course of a week. Sixty percent of the interviewed population in Phase I and 50% of those in Phase II swam at more than one place over the course of the week. Therefore, on the basis of the initial study design, between 50% and 60% of the interviewed total population would be ineligible for follow-up.

TABLE 26

Percentage Of Age Groups By Beach Using Combined Phase I And II Data

Beach	Age group (%) <10 years	10-60 years	>60 yrs.	Total
Island Beach St. Pk.	18	70	2	100
Seaside Heights	27	72	1	100
Spring Lake South	19	76	5	100
Bradley Beach	29	68	3	100
Long Branch	25	73	2	100
Asbury Park	21	74	5	100
Spring Lake North	18	76	6	100
Sandy Hook	29	69	2	100
Cheesequake	36	61	3	100
Wharton	44	56	0	100
Keansburg	20	80	0	100
Belmar	32	65	3	100

TABLE 27

Percentage Of Swimmers And Non-Swimmers Less Than 10 Years Of Age At Each Beach

Beach	Swimmer(%)	Non-Swimmer(%)	Total(%)
Island Beach State Pk.	54	46	100
Seaside Heights	59	41	100
Spring Lake S	64	36	100
Bradley Beach	55	45	100
Long Branch	59	41	100
Asbury Park	41	59	100
Spring Lake N	43	57	100
Sandy Hook	39	61	100
Cheesequake	16	84	100
Wharton	25	75	100
Keansburg	0	100	100
Belmar	31	69	100

This high rate of ineligibility has implications for the feasibility of conducting the full scale study this summer due to the availability of the appropriate population. There seems to be sufficient population at the beaches to overcome the 60% ineligibility rate. Higher rates of ineligibility would significantly increase the number of interviews required to reach sufficient sample size for statistical purposes.

The third and final consideration concerns whether people are willing to be contacted about subsequent illnesses following a visit to the New Jersey shore. As Table 28 illustrates, approximately 75 percent of the people interviewed were willing to be recontacted. Optimally most epidemiological studies strive for 80 percent, but realistically settle for 60 to 70 percent follow-up.

In any scenario the proposed full-scale epidemiological study will involve considerable challenge. The available options that need to be considered include:

1) Reject the study design due to the lack of available population size for statistical analysis,

2) Continue with the present study design but increase the size of the population to be interviewed to assure the minimum 20,000 figure suggested by the power calculation,

3) Modify the study design to a longitudinal format including an additional telephone call to extablish baseline illness rates in the families, or

4) Calculate relative risks for <u>both</u> adults and children (compared to children only in the previous design). The repeated interviews of family units would let the individuals serve as their own controls.

TABLE 28

Percentage of People In Beach Interviews Willing To Participate In The Telephone Followup Interview

Study	Yes	No	Total (N)
Phase I	72	28	100% (6087)
Phase II	73	27	100% (3597)

8.2 Water Quality

The New Jersey coast has multiple sources of microbial contamination of ocean waters which may affect water quality. Quantifying the degree of contamination is difficult because of the lack of an assay that directly measures pathogenic organisms or the presence of human wastes. Several indicator organisms exist that are used as evidence of bacterial and viral contamination.

When the contamination source is suspected to be untreated sewage, bacterial indicators will be applicable. Chlorinated sewage may carry viral pathogens but not high coliform counts. Other contamination sources, such as stormwater drainage and seagull colonies, contribute fecal material that will cause elevated coliform counts but have an unknown content of organisms pathogenic to humans. These sources could represent instances where the fecal coliform count suggests a health risk when one in fact does not exist.

As seen from levels of all four indicators in the water samples collected from just beyond the surf zone in the EPA sampling tours and in the zone beyond the surf as compared to the shoreline samples in the beach studies, there is no evidence that sufficient sewage contamination attributed to the municipal wastewater discharged through the relatively long outfalls (>1.5 km) along the central coast of New Jersey is present to cause the alleged swimming associated illnesses. While this does not exclude onshore discharges or the bathers themselves as sources of swimming-associated illness, it speaks well for one aspect of the state's basic strategy of translocating such discharges from rivers, embayments, and estuaries to the ocean via relatively long outfalls.

The quality of the water as seen from fecal coliform levels at beaches in the vicinity of North Wildwood and Wildwood has at times been such as to require beach closures. The source of the organisms appears to be at least in part due to contaminated water passing out through the Hereford Inlet. Municipal wastewater discharges into the embayments which contribute to the indicator loads are to be translocated to an ocean outfall which should be operative in the near future. There are, however, other sources of the coliform indicator organisms which may mask the expected decrease in the risk of both swimming and shellfish associated illness that would follow the removal of the discharges.

The STP investigation suggests that a combination of secondary treatment, chlorination and discharge at a distance from shore are needed to safely dispose of sewage wastes into the ocean. Two of the three STPs of particular concern, Asbury Park and North Wildwood, were previously targeted by the DEP for improvements and plan to have new treatment facilities completed by the summer of 1988. Long outfalls with diffusers as well as secondary treatment facilities are under construction or being considered for all coastal STPs.

Besides the STPs, there are numerous sources of microbial contamination along the shore. Sources of the contamination would be human and animal wastes reaching the water through natural inlets, storm pipes, or as generalized runoff. More extensive testing correlated with rainfall would be necessary to more fully characterize the various sources of contamination along the shore, particularly in the southern region. Preliminary sampling done in various northern lakes and inlets suggests that some of these sources are carrying microbial loads which exceed the standards for water quality. It is not certain if human sewage or animal wastes are contributing to the microbial contamination; the health risk of the latter is low. Additional useful information could be obtained by characterizing the microbial content of stormwater draining from areas where accidental contamination with human sewage cannot take place.

Coastal beaches from Monmouth Beach through Island Beach State Park whose water quality could be affected by the discharges from the ocean outfalls were screened for their suitability as test or control beaches from available information on usage and the characteristic of the beach goers. Special consideration was given to beaches potentially affected by the discharges from short outfalls because of the dependency on wastewater chlorination to reduce the numbers of enterococci and coliforms and presumably the pathogens to levels such that the subsequent dilution and die-off of microorganisms during transport would prevent adverse impact on the water quality at the beaches.

At most beaches along the coast water quality appears to be of sufficiently good quality that it may not be possible to find detectable excess rates of illness above background due to contaminated water or to find differences between swimmers and nonswimmers. The results suggest that one of the Sandy Hook beaches could be used in an epidemiological study to examine the possibility that, because the survival patterns of Norwalk-type viruses are more akin to those of C. perfringens spores and the f phage than even the enterococci, there could be a measurable risk of swimming-associated risk of acute gastroenteritis caused by the Norwalk viruses. The levels of all four indicators at JC21, JC-24 and JC-27 suggested that shoreward beaches, Asbury Park, Bradley and Bellmar would be appropriate for the conduct of epidemiological studies. The former two have the advantage of reflecting a defined offshore pollution source, the outfall for the Asbury Park STP. Two beaches apparently appropriate for epidemiological studies designed to respond to the question of the effectiveness of the phage as an indicator organism are the main beach at Sandy Hook, where the pollution source is not defined, and Seven Presidents, Long Branch, which has the added advantage of being affected by a defined chlorinated source.

The Bradley and Asbury Park beaches are also excellent candidate test beaches for the epidemiological study in spite of or possibly because of the potential effect of a lapse in disinfection at the Asbury Park STP. Since the water will be monitored for all four indicators and the effluents at the STP will also be examined, such lapses can be identified when they occur. The data will respond to the issue of the adequacy of the enterococci as an indicator of sewage contamination and will be used in a comparison of the finding of those from previous epidemiological studies.

The potential for swimming-associated illness at the Asbury Park beach is a classic situation in which there is a heavy dependence on chlorination of the wastewater effluent to meet existing guidelines and standards based on bacterial indicators which are highly susceptible to its bacteriocidal effect. That is, physical decay alone (dilution and sedimentation) relative to the magnitude (flow) of the discharge is insufficient to achieve the desired indicator limits at a nearby water resource. This situation is more typical of discharges into estuaries, embayments and rivers. The possibility of health effects under such conditions, especially when low levels of the two more chlorine-resistant indicators are found at the beach, is a major issue to be addressed by the epidemiological studies with Asbury Park beach functioning as an excellent study beach. It would appear that the Bradley Beach, as also affected by the discharge from the Asbury Park outfall, is a similar but less pronounced condition and that the Seven Presidents and Sandy Hook beaches are also similar but even less pronounced in this regard.

There are suggestions that the use of bacterial indicators is not always a reliable measure of the microbial load of water. Frequent but low phage and C. perfringens levels in the water were identified in the absence of appreciable levels of the two bacterial indicators, enterococci and fecal coliforms, which are the basis of recreational water quality guidelines and standards. In addition, in the event of suboptimal disinfection (days 7, 8, 9, Table 20), or a complete lapse thereof (the indicator levels at JC-21 on 8/5/87, Table 16), there are predictable effects in terms of swimming-associated gastroenteritis and, in the latter case, the water quality guidelines would have been violated if it were a continual occurrence. It is of interest that the fecal coliform level 217 CFU/100 ml was only slightly higher than the limit (a geometric mean of 200 CFU/100 ml) while that for the enterococci was about 20 times its respective guideline (a GM of 35 CFU/100 ml). As noted earlier, the epidemiological data from the Asbury Park and Bradley beaches, when segregated by the enterococci levels in the water, could also be used to reexamine the enterococcus recreational water quality criterion. There are two more practical considerations. The first is that the Asbury Park STP outfall should be lengthened, as has been started. The second consideration is that, until the outfall and sewage treatment system are upgraded, some redundancy should be incorporated into the chlorination system to minimize the probability of a lapse of disinfection. The other relatively short outfalls (< 0.5 km) also should be upgraded. The

Northeast Monmouth outfall is of interest in terms of the design requirements for this outfall through which there is a 7.5 mgd discharge. The original length was 0.75 km. A break in the line was observed in 1980-81 from the sampling data on the EPA coastal network (Table 16) was confirmed visually. It was repaired by the addition of a 0.38 km straight diffuser at the point of the break so that the overall length was about 0.70 km. There was only a slight suggestion from the C. perfringens levels at JC-11 as compared to JC-8 that the effluent reached the surf.

8.3 Beach Pollution Transport Dynamics

Investigation of water movement patterns demonstrated two vital points. Firstly, there can be tremendous variability in the wind, wave, and current conditions at a single beach. This can make it difficult to predict the movement of discharged effluents. Such predictive ability would be particularly desirable in the event of an episode of suboptimal disinfection at an STP. Secondly, it was demonstrated that on occasion the combination of these oceanographic factors can lead to residence times on the order of hours for water in the bathing zone. The importance of person-to-person or local contamination sources in disease transmission would be augmented by such persistence of microorganisms in the water due to extended residence times on a local basis.

8.4 Perception of Illness and Risk Communication

Apart from actual risk, there is apparently an unrealistic public perception of risk and of illness rates for ocean swimming. Without historical data it is difficult to derive conclusions. It appears, however, that local departments of health received considerably more illness reports this year than in previous years, although the water quality in 1987 was improved over previous years. It is quite possible that minor gastrointestinal, respiratory, and skin infectious were reported because of heightened awareness while in other years these infections were not noted as significant or were attributed to food or travel causes. It was also observed that there was poor understanding, even on the part of some physicians, of plausible transmission routes and incubation periods for infectious diseases. For these reasons, there is a need to develop an outreach and risk communication program for physicians and state residents to specifically address the perception of ocean beach-related illnesses. The increase awareness of the science of waterborne illnesses should reduce unnecessary concern surrounding this issue and help focus attention on the issues being addressed by this study and on the programs designed to reduce sewage and solid waste output into the embayments and ocean beaches.

9. RECOMMENDATIONS

The initial goals of the study and its design were based on the assumption that sewage contamination of ocean beach waters occurred at sufficiently high levels to cause detectable increases in infectious disease rates and that water quality monitoring could distinguish the contamination source and level. The water quality monitoring conducted during the preliminary phases of the study indicated that beach water quality met existing state standards and federal guidelines and did not suggest major ocean contamination based on experimental indices for both bacteria and viruses. Based on the current knowledge of the epidemiology of sewage related illnesses and on information about water quality gained during the preliminary phases of the study, low illness rates are predicted among ocean swimmers at all coastal beaches on the majority of swimming days. Beaches cannot be categorized by water quality and illness rates between beaches and between swimmers and nonswimmers may not be distinguishable.

Given the fact that water quality cannot drive the study design, the original goals and objectives of study were modified with subsequent modification of the study design.

9.1 Goals and Objectives

The DOH and the Science Advisory Group conclude that, based on the data from the preliminary phases of the study, the primary goal of the study should be to investigate epidemiologically whether swimming at New Jersey coastal beaches carries with it a significant excess risk of illness beyond that measured in nonswimmers.

The objectives relating to this goal are:

1. To determine the incidence of infectious gastrointestinal and respiratory illnesses following swimming exposure to ocean water,

2. To determine the incidence of infectious illnesses following swimming exposure to ocean water of varying quality as determined by microbial assays, and

3. To determine the water quality index best correlated with illness incidence following exposure to ocean water of varying quality.

9.2 Epidemiology

To meet these goals and objectives the following recommendations are offered for the study design:

1. A full epidemiological study along the modified longitudinal study design as described in Option 4 in **DISCUSSION** should be conducted in the Summer of 1988. Simultaneous monitoring of water would be done with the selected indicator organisms.
2. When possible the study should address the multiple types of water contamination present along the coast. This will be done by investigating beaches in each of the three major coastal regions, north, central, and south (Table 29).

9.3 Characterization of Sources of Beach Contamination

There are many potential coastal sources of water contamination, with the lakes and inlets of particular concern. In order to more fully characterize these other sources the following DEP activities are recommended:

1. Full characterization of pollution sources both in the bays and on the ocean side. This should include the impacts from lakes and rivers which monitoring has shown to be substantial.

Table 29

Recommended Beaches For Summer 1988 Epidemiologic Study

STUDY BEACH	APPLICATION DURING EPIDEMIOLOGIC STUDY
Island Beach State Park[a]	Control beach
Brick Township[b,c]	Control beach
Spring Lake	Alternate control beach
Asbury Park Beach[a]	Test beach after data grouping for: a) adequacy of disinfection b) reevaluation of enterococcus criterion c) effect of stormwater
Bradley Beach[b]	Test beach after data grouping for: a) adequacy of disinfection b) effects from on-shore sources
Long Branch, Seven President Beach[b]	Test beach after data segregation a) adequacy of disinfection b) effect of stormwater
Sandy Hook, Main Beach	Test beach for effects from Raritan Bay
Wildwood or North Wildwood[a]	Test beach for: a) effects of polluted water from inlets b) Improvement due to translocation of wastewater discharges to the ocean
Unknown[A]	Test beach for effect of "pure" stormwater discharges

a First Priority Beach
b Second Priority Beach
c Midweek swimmers at same beach need not be excluded

2. Full biological and chemical characterization of sewage treatment plants, influent and effluent. This should include routine monitoring.
3. Reevaluation of New Jersey's industrial pretreatment program with specific emphasis on preventing toxic pollutant discharge into the ocean. This should include a strategy to reduce toxic components in sludge making land based disposal a viable option.
4. Reevaluation of all ocean discharge permits including upgrading of discharge and monitoring requirements where appropriate.
5. Targeted unannounced compliance monitoring to evaluate effectiveness of current ocean discharge and dumping enforcement efforts.
6. Evaluation of the impact of storm water including characterization of sewerage cross connections.
7. Fast tracking of ongoing upgrades of coastal sewage treatment plants, including extension of outfalls where appropriate.
8. Expansion of ongoing Cooperative Coastal Monitoring Program through increased number of samples per week and inclusion of additional biological and chemical indicators.

9.4 Health Education and Risk Communication

To address the risk perception concerns regarding ocean-related illnesses, the DOH, in cooperation with the DEP, should develop risk communication materials for public dissemination. In addition, the DOH should work with the New Jersey Medical Society to develop educational materials for physicians so that they may be better able to address their patients concerns about swimming in New Jersey Beaches and to increase their ability to properly diagnose ocean-related illnesses.

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11. APPENDICES

APPENDIX 1 Consent form

The consent form was in two parts. The first tinted section was retained by the respondent. A telephone number was listed for the respondent to obtain further information or to report episodes of illness.

The second part of the consent form was signed and returned to the interviewer. Signing of the consent form preceded the interview.

BEACH SURVEY PROJECT:
(201) 463-4500

UMD NEW JERSEY
University of Medicine & Dentistry of New Jersey
Robert Wood Johnson Medical School

675 Hoes Lane
Piscataway, New Jersey 08854-5635

DEAR RESPONDENT:

We want you to know the following:

1. You can stop this inverview at any point and can refuse to answer any question.
2. The answers you give as legally representing all members of your household, including minors, are strictly confidential and will never be used in connection with household names.
3. The information you give will never be circulated beyond the BEACH SURVEY project. Use of the information will be limited to the objectives of the BEACH SURVEY project.
4. You can call the number above any time should any questions or issues arise regarding the survey.
5. Items 1-4 apply to your participation in any follow-up to this survey.

Although no risk is anticipated in this project, govenment regulations require that in all studies involving human subjects, the consent form shall include the following statement:

UMDNJ will provide free medical treatment at its own facilities for human subjects who suffer physical or psychological injury or illness as a direct result of participation in research activity conducted by UMDNJ. Monetary compensation for physical or psychological injury or illness is not available.

This form will be kept in a separate, confidential file for your protection. If you have read this and understand your rights, would you kindly sign your name and the date? Thank you.

Respondent	Date	Interviewer

APPENDIX 2 Phase I Beach and Telephone Interview Forms

The beach interview was conducted after signing of the consent form.

PHASE I BEACH INTERVIEW

Hello, my name is __________. I'm with ____________ and we are conducting a three minute beach survey. We are interested in families who will leave the beach by Sunday night/tonight and won't be on a beach again before next Saturday morning. If this includes you, would you like to participate? (IF NO, THANK THEM AND GO TO FORM # 3, IF YES REVERIFY, THEN GO TO CONSENT FORM). 1-4

FILL OUT THE FOLLOWING BEFORE BEGINNING THE INTERVIEW

Beach Location:____________________ Interviewer I.D.:__________ 5-6 7-

Date:____________________________ Start Time:________________ 9-10 11

1. What time did you arrive today? _______ When will you leave? _____ 12-15

2. We're interested in how far people go to get to the beach. What is your regular zip code? ______________. 16-19

3. Is that zip code here at the shore? 20-21

   Yes _______ Are you close enough to walk if you want to? 24-28

   Yes _____ No _____ 29

   No _______ Are you just at the shore for the day?

   Yes _____ No _____ 30-31 32

   (IF NO) How many days have you been here? _______
   What day are you leaving? ___________

RECORD ITEMS 4-6 ON TABLE BELOW CONTINUE ON BACK IF NECESSARY. 33 34-35 36 37

4.a) Are there any family members here today who stay out of the water completely? (RECORD AGE AND SEX). 38-41

b) Are there any who get in the water but do not get their head wet? 42-45

c) Who gets in and gets their head wet?

d) Are there any family members who are not here today? 46 47-48 49 50

(CIRCLE RESPONDENT'S NUMBER)

5. Has any family member been swimming in the last week aside from this trip to the beach/shore? We're including wading pools; possible beach trips with day care; anything you can think of. 51-54 55-58

6. We are interested in the summertime health of families. Has any any family member had stomach cramps in the last week? Nausea? Vomiting? Diarrhea? Does anyone now have these symptoms? (IF YES) Has a fever accompanied any of these incidences? 59 60-61 62 63 64-67

7. Would you be interested in responding to a phone survey this week regarding your family's health? (IF NO, THANK THEM AND SKIP TO #8). 107-110

We would call in the afternoon or evening of this Thursday or Friday. Would you be available during one of those times? Yes_____ No _____ 111

What day is best?____________ What time would be best? ________ 112

How should we ask for you when we call?_______________________

What is your phone number? (   ) ________________________ 113 114

We won't be calling everyone but if you are contacted the caller will state that she or he is from this project.

8. If a family member sees a doctor for a new illness within six weeks, would you be willing to call this number and report the illness? 115

   Yes _____ No _______ 116-117

I appreciate your time. Enjoy your day at the beach. End Time:__________

RECORD OBSERVATIONS OR SUPPLEMENTARY INFORMATION ON BACK OF PAGE.

PHASE I TELEPHONE INTERVIEW

Hello, is _______ home? (IF NO, OBTAIN A NUMBER OR ARRANGE TO CALL BACK).

My name is ______ and I am conducting the phone follow-up to the survey you participated in last weekend at the beach. Do you have 5 minutes now? (IF NO) Could I call back? (IF NO, OR IF YOU CAN'T RESCHEDULE THURSDAY OR FRIDAY, GO TO FORM 4. OTHERWISE MAKE THE APPOINTMENT). ☐☐☐☐ 1-4

Interviewer: ______________________ Four Digit Number __________ ☐☐ 5-6 ☐ 7 ☐ 8

Date: ______________________ Start Time: __________ ☐ 9

1. REFER BACK TO "TODAY" SECTION ON THE PRETEST TABLE FOR FAMILY MEMBERS AT THE BEACH ON THE DAY OF THE PRETEST. ASK ONE OF THE FOLLOWING FOR EACH. RECORD ANSWERS ON TABLE BELOW (CONTINUED ON BACK).

   (a) Last weekend you said that a ____ year old (sex) family member was staying completely out of the water. Did he/she get in the water before you left the beach/shore? (IF YES) did he/she get his/her head wet?

   (b) Last weekend you said a ___ year old (sex) family member was getting in the water but not getting his/her head wet. Did he/she in fact get in the water while at the beach/shore? Did his/her head get wet for any reason before you left the beach/shore. For example, did he/she fall in or get caught in a wave, etc.?

   (c) Last weekend you said a ____ year old (sex) family member gets in the water and gets his/her hair wet. Was this the case last weekend? ☐ 10 ☐ 11 ☐ 12

2. During your visit to the beach/shore when you were surveyed, were any family members swimming anywhere in addition to the ocean? (IF YES) Who and where? ☐☐☐☐ 13-16 ☐☐☐ 17-19

3. Has any family member been swimming since the beach/shore visit when you were last interviewed? Again we are interested in wading pools, day care activities, anything? (IF YES) Who and where? ☐ 20 ☐ 21 ☐ 22 ☐☐☐☐ 23-26 ☐☐☐ 27-29

4. Since you were last surveyed, has any family member had stomach cramps? Nausea? Vomiting? Diarrhea? Ear problems or ear infection? Eye problems or eye infection? Skin problems or skin infection? (IF YES) Has fever accompanied any of these symptoms? ☐ 30 ☐ 31 ☐ 32 ☐☐☐☐ 33-36 ☐☐☐ 37-39

	PRACTICE A	B	C	D	OTHER DURING	OTHER SINCE	HEALTH C/F	N/F	V/F	D/F	EY/E	ER/Y	S/F
1.													
2.													
3.													
4.													
5.													
6.													

☐ 40 ☐ 41 ☐ 42 ☐☐☐☐ 43-46 ☐☐☐ 47-49 ☐ 50 ☐ 51 ☐ 52 ☐☐☐☐ 53-56 ☐☐☐ 57-59 ☐ 60 ☐ 61 ☐ 62 ☐☐☐☐ 63-66 ☐☐☐ 67-69

5. Did your family leave the beach/shore on ____ as planned ☐ 70 ☐ 71 ☐ 72
   Yes _____ No _____

   Did any family members leave after that date? (IF YES, WRITE THE DAY NEXT TO THEIR NUMBER. ☐ 73 ☐ 74 ☐ 75

6. END TIME: ______________________ ☐☐ 76-77

APPENDIX 3 Phase II Beach and Telephone Interview Forms

BEACH TRIAL

Hello, I'm__. I'm with ___ and we are conducting a three minute beach survey. We are interested in families who will leave the beach this weekend and will not be on a beach again before next Saturday. If this includes you, would you like to participate?

GO TO FORM 3 OR REVERIFY AND GO TO CONSENT FORM.

FILL OUT THE FOLLOWING BEFORE BEGINNING THE INTERVIEW:

Beach Code_____ 01 Interview Code_______ 02-05 Canvasser Code______ 06-07

Day______ 08-09 Month ______ 10 Time______

Ethnic origin (CIRCLE ONE) 1=white 2=black 3=Hispanic 4=other 11_____

Home language (CIRCLE ONE) 1=Eng 2=Span 3=Portugese 4=other 12_____

- -

1. First, we are just trying to get some general information about how far people travel to get here, how long they stay, etc. What is your regular zipcode? _____ 13-17

2. Is that within walking distance? 1=yes (IF YES SKIP TO #4). _____ 18

2=no

3. Are you just at the shore for the day? (IF NO): _____ 19

What day did you get here, and when do you plan on leaving?

1=here for day
2=came during week, leaving weekend
3=coming and going weekend
4=staying past weekend (END INTERVIEW)

RECORD ITEMS 4a-4d ON CHART AT BOTTOM OF PAGE.

4a. Is there anyone in your household here today who is staying out of the water completely? (RECORD AGE AND SEX OR GO TO 4b).

Can you tell me why they are staying out?

Is there anyone else?

4b. Is there anyone here today who is getting in the water but not getting their head wet? (RECORD AGE AND SEX OR GO TO 4c).

Is there anyone else?

4c. Is there anyone who is getting in and getting their head wet? (RECORD AGE AND SEX OR GO TO 4d).

Is there anyone else?

4d. Are any household members not here today? (RECORD AGE AND SEX FOR ALL).

	PERSON							
	1	2	3	4	5	6	7	8
	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)
Stays out completely:								
dirty water	1	1	1	1	1	1	1	1
ill	2	2	2	2	2	2	2	2
other	3	3	3	3	3	3	3	3
Gets in, head dry	4	4	4	4	4	4	4	4
Gets in, head wet	5	5	5	5	5	5	5	5
Not here today	6	6	6	6	6	6	6	6
Age (RECORD TWO DIGITS)	_/_ 28-29	_/_ 30-31	_/_ 32-33	_/_ 34-35	_/_ 36-37	_/_ 38-39	_/_ 40-41	_/_ 42-43
Sex:								
Male	1	1	1	1	1	1	1	1
Female	2	2	2	2	2	2	2	2
	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(51)

5. Has any household member been in ANY water in the last week besides the ocean water at this beach. This include wading pools, swimming pools here at the shore or elsewhere, trips to other beaches, etc.

	PERSON							
	1 (52)	2 (53)	3 (54)	4 (55)	5 (56)	6 (57)	7 (58)	8 (59)
Yes, other beach	1	1	1	1	1	1	1	1
Yes, fresh water	2	2	2	2	2	2	2	2
Yes, private pool	3	3	3	3	3	3	3	3
Yes, public pool	4	4	4	4	4	4	4	4
Yes, salt water pool, this beach	5	5	5	5	5	5	5	5
Yes, other salt pool	6	6	6	6	6	6	6	6
Yes, wading pool	7	7	7	7	7	7	7	7
Yes, other	8	8	8	8	8	8	8	8
No	9	9	9	9	9	9	9	

6. We are interested in summertime household health. I'm going to to name some symptoms and would like you to tell me if ANYONE in your home has had any of them in the last 24 hours. 1=yes 2=nc

Fever (specific temp.)	___ (60)	___ (61)	___ (62)	___ (63)	___ (64)	___ (65)	___ (66)	___ (67)
Cough	___ (68)	___ (69)	___ (70)	___ (71)	___ (72)	___ (73)	___ (74)	___ (75)
Sore throat	___ (76)	___ (77)	___ (78)	___ (79)	___ (80)	___ (81)	___ (82)	___ (83)
Runny nose	___ (84)	___ (85)	___ (86)	___ (87)	___ (88)	___ (89)	___ (90)	___ (91)
Stomach ache/ intestinal cramps	___ (92)	___ (93)	___ (94)	___ (95)	___ (96)	___ (97)	___ (98)	___ (99)
Nausea	___ (100)	___ (101)	___ (102)	___ (103)	___ (104)	___ (105)	___ (106)	___ (107)
Vomiting	___ (108)	___ (109)	___ (110)	___ (111)	___ (112)	___ (113)	___ (114)	___ (115)
Diarrhea	___ (116)	___ (117)	___ (118)	___ (119)	___ (120)	___ (121)	___ (122)	___ (123)

7. If a household member sees a doctor for a new illness within six weeks, would you call this number and report it for our records?   1=yes 2=no   124

8. Finally, we're doing a phone follow-up on household health this Thursday and Friday in the afternoons and evenings. Would you be available during one of those times? (IF YES):   12

Are both Thursday or Friday alright, or do you prefer one?

1= either
2= Thursday
3= Friday
4= Saturday, eligible
5= other
6=no

9. Is there a time that you prefer? (FOR INTERVIEWER REFERENCE ONLY). ____________

10. What is your phone number?________________

11. How should we ask for you when we call?__________________

We won't be calling everyone we interview today, but if you are contacted the caller will state that they are with this project.

Thank you for your time.

Enjoy your day at the beach.

Close.

TRIAL FOLLOW-UP

Interview Code_____ (04-06) Caller Code_____ (05-06) Day 1=Th 2=Fri 3=Other_____ (07)

Hello, is ___home? (IF NO, OBTAIN A NUMBER AND ARRANGE TO CALL BACK. RECORD ALL NONINTERVIEW CALLS ON FORM 4).

My name is ____ and I am conducting the phone follow-up to the survey you answered at the beach last weekend. Do you have five minutes now? (IF NO) When can I call back? (FORM 4)

1. REFERRING TO BEACH INTERVIEW IDENTIFY ALL HOUSEHOLD MEMBERS REPORTED AS NOT GETTING THEIR HEAD WET, INCLUDING THOSE NOT AT THE BEACH. ONE AT A TIME AND IN ORDER, DETERMINE IF THE HEAD GOT WET BEFORE THE BEACH TRIP ENDED. PROBE FOR ACCIDENTAL HEAD WET. 1=CHANGE 2=NO CHANGE

	PERSON							
	1	2	3	4	5	6	7	8
	(08)	(09)	(10)	(11)	(12)	(13)	(14)	(15)
Changed to in, head wet	1	1	1	1	1	1	1	1
Did not change	2	2	2	2	2	2	2	2

2. As of the interview last weekend you reported: (REPEAT THE INFORMATION ON OTHER WATER USE). After the interview did any household members get into ANY water besides the ocean during the beach visit? Again, we are considering wading pools, salt water pools, other beaches, etc.

	PERSON							
	1	2	3	4	5	6	7	8
	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Yes, private pool	1	1	1	1	1	1	1	1
Yes, pub. pool, salt	2	2	2	2	2	2	2	2
Yes, pub. pool, nonsalt	3	3	3	3	3	3	3	3
Yes, other	4	4	4	4	4	4	4	4
No	5	5	5	5	5	5	5	5

3. Has any household member been in ANY water since the weekend?

	PERSON							
	1	2	3	4	5	6	7	8
	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)
Yes, same beach	1	1	1	1	1	1	1	1
Yes, other beach	2	2	2	2	2	2	2	2
Yes, fresh water	3	3	3	3	3	3	3	3
Yes, private pool	4	4	4	4	4	4	4	4
Yes, pub. pool not salt	5	5	5	5	5	5	5	5
Yes, pub. pool salt	6	6	6	6	6	6	6	6
Yes, wading pool	7	7	7	7	7	7	7	7
Yes, other	8	8	8	8	8	8	8	8
No	9	9	9	9	9	9	9	9

4. Did any household member leave the beach Monday or later?
1=yes 2=no

	PERSON							
	1	2	3	4	5	6	7	8
	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)
Left later	1	1	1	1	1	1	1	1
Did not leave later	2	2	2	2	2	2	2	2

5. Did any of your household members who were at the beach last weekend eat shellfish while they were there? 1=yes 2= no

	PERSON							
	1	2	3	4	5	6	7	8
	(40)	(41)	(42)	(43)	(44)	(45)	(46)	(47)
Ate shellfish	1	1	1	1	1	1	1	1
Did not eat shellfish	2	2	2	2	2	2	2	2

6. I'm going to name some symptoms and would like you to tell me if they have occured to any household member since you were last interviewed. 1=yes 2=no

	PERSON 1	2	3	4	5	6	7	8
Stomach ache/ intestinal cramps	___ (48)	___ (49)	___ (50)	___ (51)	___ (52)	___ (53)	___ (54)	___ (55)
Diarrhea or loose stools	___ (56)	___ (57)	___ (58)	___ (59)	___ (60)	___ (61)	___ (62)	___ (63)
Nausea or feeling nauseous	___ (64)	___ (65)	___ (66)	___ (67)	___ (68)	___ (69)	___ (70)	___ (71)
Vomiting or throwing up	___ (72)	___ (73)	___ (74)	___ (75)	___ (76)	___ (77)	___ (78)	___ (79)
Sore throat	___ (80)	___ (81)	___ (82)	___ (83)	___ (84)	___ (85)	___ (86)	___ (87)
Bad cough	___ (88)	___ (89)	___ (90)	___ (91)	___ (92)	___ (93)	___ (94)	___ (95)
Chest cold	___ (96)	___ (97)	___ (98)	___ (99)	___ (100)	___ (101)	___ (102)	___ (103)
Fever (specific temp.)	___ (104)	___ (105)	___ (106)	___ (107)	___ (108)	___ (109)	___ (110)	___ (111)
Runny or stuffy nose	___ (112)	___ (113)	___ (114)	___ (115)	___ (116)	___ (117)	___ (118)	___ (119)
Earache or runny ears	___ (120)	___ (121)	___ (122)	___ (123)	___ (124)	___ (125)	___ (126)	___ (127)
Sties; red, itchy or watery eyes > 1 day	___ (128)	___ (129)	___ (130)	___ (131)	___ (132)	___ (133)	___ (134)	___ (135)
Welts, rash or itchy skin	___ (136)	___ (137)	___ (138)	___ (139)	___ (140)	___ (141)	___ (142)	___ (143)
IF YES TO ANY, DID THEY:								
Stay home	___ (144)	___ (145)	___ (146)	___ (147)	___ (148)	___ (149)	___ (150)	___ (151)
Stay in bed	___ (152)	___ (153)	___ (154)	___ (155)	___ (156)	___ (157)	___ (158)	___ (159)
Seek medical help	___ (160)	___ (161)	___ (162)	___ (163)	___ (164)	___ (165)	___ (166)	___ (167)
Obtain diagnosis (WHAT)	___ (168)	___ (169)	___ (170)	___ (171)	___ (172)	___ (173)	___ (174)	___ (175)
Require hospitalization	___ (176)	___ (177)	___ (178)	___ (179)	___ (180)	___ (181)	___ (182)	___ (183)

This completes our survey. Thank you very much for your time.

APPENDIX 4

Coastal Monitoring Sites

Site	DEP Address	DEP Number	EPA Number
Sandy Hook	Army Rec Beach	CCMPMC1004	JC01A
Sandy Hook	Fort Hancock	CCMPMC1006	JC02
Sandy Hook	South Beach	CCMPMC1008	JC03
Sandy Hook	Surf Beach	CCMPMC1010	JC05
Sea Bright	Public Beach	CCMPMC1013	JC08
Sea Bright	Lwr Sea Bright	CCMPMC1015	
Monmouth Bch	Monmouth Club	CCMPMC1016	JC11
Monmouth Bch	City Line	CCMPMC1018	
Long Branch	Joline	CCMPMC1019	
Long Branch	Laird	CCMPMC1039	
Long Branch	South Bath	CCMPMC1020	JC14
Elberon	Plaza	CCMPMC1040	
Elberon	Elberon Club	CCMPMC1021	
Deal	Deal Casino	CCMPMC1041	
Loch Arbour	Edgemont	CCMPMC1042	
Asbury Park	Sunset	CCMPMC1023	JC21
Asbury Park	3rd	CCMPMC1024	
Ocean Grove	Ocean Pathway	CCMPMC1025	JC24
Bradley Beach	Brinley	CCMPMC1026	JC26
Avon	Sylvania	CCMPMC1027	JC27
Belmar	10th	CCMPMC1029	
Belmar	19th	CCMPMC1028	
Spring Lake	Ludlow	CCMPMC1032	
Spring Lake	Essex	CCMPMC1043	JC30
Sea Girt	Beacon	CCMPMC1033	JC33
Manasquan	East Main	CCMPMC1036	
Manasquan	3rd	CCMPMC1034	
Pt Pleasant	Broadway	CCMPOC1001	JC37
Pt Pleasant	Central	CCMPOC1002	
Pt Pleasant	Sea	CCMPOC1003	
Bay Head	Mount	CCMPOC1004	
Bay Head	Johnson	CCMPOC1005	JC41
Mantoloking	Lyman	CCMPOC1012	
Mantoloking	Princeton	CCMPOC1014	JC44
Brick	Brick Bch	CCMPOC1019	
Brick	7th	CCMPOC1020	
Chadwick	East Tuna Way	CCMPOC1089	JC47A
Lavalette	Bryn Mawr	CCMPOC1094	
Lavalette	Guyer	CCMPOC1025	
Lavalette	Brooklyn	CCMPOC1024	JC49
Lavalette	Jersey City	CCMPOC1027	
Lavalette	Trenton	CCMPOC1029	
Lavalette	North Beach	CCMPOC1033	
Dover	4th	CCMPOC1130	

Dover	Fielder	CCMPOC1129	
Seaside Hts	Sheridan	CCMPOC1035	
Seaside Hts	Grant	CCMPOC1037	JC53
Seaside Hts	Lincoln	CCMPOC1095	
Seaside Park	O St	CCMPOC1044	
Seaside Park	Brighton	CCMPOC1096	
Seaside Park	12th	CCMPOC1042	
South Seaside	23rd	CCMPOC1046	
Island Beach	USCG100	CCMPOC1086	JC55
Island Beach	Ocean Area	CCMPOC1085	JC57
Island Beach	Access Road	CCMPOC1090	JC59
Island Beach	A23	CCMPOC1084	
Barnegat Lt	10th	CCMPOC1048	JC61
Barnegat Lt	24th	CCMPOC1050	
Loveladies	Loveladies	CCMPOC1052	
Harvey Cedars	75th	CCMPOC1054	JC63
Harvey Cedar	Essex	CCMPOC1056	
Harvey Cedar	Atlantic	CCMPOC1097	
Harvey Cedar	Bergen	CCMPOC1058	
North Beach	Roxie	CCMPOC1098	
North Beach	Bayshore	CCMPOC1060	
Surf City	23rd	CCMPOC1062	
Surf City	North 10th	CCMPOC1099	
Surf City	North 1st	CCMPOC1064	
Ship Bottom	South 3rd	CCMPOC1100	
Ship Bottom	5th	CCMPOC1066	
Ship Bottom	14th	CCMPOC1068	JC65
Ship Bottom	25th	CCMPOC1070	
Brant Beach	50th	CCMPOC1091	
Bch Haven Cst	Stockton	CCMPOC1072	
Haven Beach	Florida	CCMPOC1101	
Haven Beach	South Carolina	CCMPOC1074	
Hav Bch Terr	New Jersey	CCMPOC1076	JC67
Beach Haven	14th	CCMPOC1102	
Beach Haven	Taylor	CCMPOC1078	
Beach Haven	Berkeley	CCMPOC1092	
Beach Haven	Leeward	CCMPOC1080	
Beach Haven	Webster	CCMPOC1093	
S Bch Haven	Joan	CCMPOC1082	JC69
Brigantine	North Beach	CCMPAC1001	
Brigantine	10th South	CCMPAC1003	
Brigantine	10th South	CCMPAC1067	
Brigantine	15th South	CCMPAC1004	JC73
Brigantine	27th	CCMPAC1066	
Brigantine	40th South	CCMPAC1006	
Brigantine	44th South	CCMPAC1068	
Brigantine	South Beach	CCMPAC1007	
Atlantic City	New Hampshire	CCMPAC1012	
Atlantic City	Connecticut	CCMPAC1071	
Atlantic City	Pennsylvania	CCMPAC1015	
Atlantic City	Kentucky	CCMPAC1070	
Atlantic City	Arkansas	CCMPAC1016	JC75
Atlantic City	Chelsea	CCMPAC1017	
Atlantic City	Hartford	CCMPAC1069	

Atlantic City	Raleigh	CCMPAC1018	
Ventnor	Oakland	CCMPAC1024	
Ventnor	Newport	CCMPAC1031	JC77
Margate	Granville	CCMPAC1038	
Margate	Decauter	CCMPAC1040	
Longport	28th	CCMPAC1041	JC79
Longport	15th	CCMPAC1043	
Longport	11th	CCMPAC1044	
Ocean City	Surf Rd	CCMPCC1101	
Ocean City	3rd	CCMPCC1102	JC81
Ocean City	9th	CCMPCC1103	
Ocean City	23rd	CCMPCC1048	
Ocean City	34th	CCMPCC1104	JC83
Ocean City	55th	CCMPCC1105	
Upper Twp	Harbor Rd	CCMPCC1106	JC85
Sea Isle	5th	CCMPCC1049	
Sea Isle	34th	CCMPCC1107	
Sea Isle	40th	CCMPCC1108	JC87
Sea Isle	60th	CCMPCC1050	
Sea Isle	79th	CCMPCC1109	
Avalon	8th	CCMPCC1110	
Avalon	21st	CCMPCC1111	
Avalon	40th	CCMPCC1051	JC89
Stone Harbor	83rd	CCMPCC1112	JC91
Stone Harbor	111th	CCMPCC1113	
N Wildwood	Walnut&Central	CCMPCC1114	
N Wildwood	2nd&JFK	CCMPCC1116	
N Wildwood	4th&JFK	CCMPCC1117	
N Wildwood	15th&Ocean	CCMPCC1118	
Wildwood	Maple&Ocean	CCMPCC1119	JC93
Wildwood	Schell&Ocean	CCMPCC1120	
Wildwood	Montg&Ocean	CCMPCC1121	
Wildwood	Bennett&Ocean	CCMPCC1122	
Wildwood Cst	Forget&Ocean	CCMPCC1123	
Wildwood Cst	Miami&Ocean	CCMPCC1124	
Wildwood Cst	Jeff&Ocean	CCMPCC1125	
Wildwood Cst	Raleigh&Ocean	CCMPCC1126	
Cape May City	CM Beach Club	CCMPCC1127	JC95
Cape May City	Wilmington	CCMPCC1128	
Cape May City	Queen North	CCMPCC1129	
Cape May City	Queen South	CCMPCC1130	JC97
Cape May City	Ocean	CCMPCC1132	
Cape May City	Congress	CCMPCC1133	
Cape May City	Grant	CCMPCC1134	
Cape May City	Broadway	CCMPCC1135	
Cape May City	2nd	CCMPCC1136	
Cape May Pt	Lighthouse	CCMPCC1140	JC99
Cape May Pt	Cape	CCMPCC1139	
Cape May Pt	Central	CCMPCC1138	
Cape May Pt	Sunset	CCMPCC1137	

APPENDIX 5

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