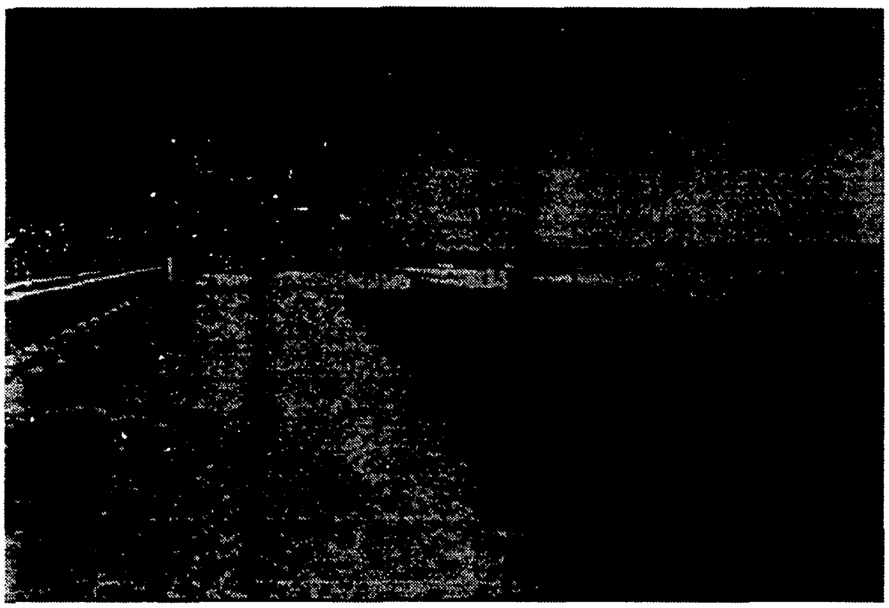
COASTAL HAZARD MANAGEMENT PLAN

New Jersey's Shoreline Future
Preparing for Tomorrow

Part III
Critical Issues and Approaches



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Sea-Level Rise[1]

The issue of sea-level rise has become a driving force behind coastal management strategies. The problem is not simply an increase of the water level against the land, but an increase of exposure to storm effects and an increase in the inundation and penetration of coastal storms acting upon higher water levels. Both international and national organizations have studied the rates of sea level rise on a global basis. The amount of sea-level rise along the New Jersey coast can be clearly identified through analysis of tide gage records. Its effects are manifested in a variety of changes that have occurred through the decades. As sea-level continues to rise, the coastal zone will be heavily impacted. This condition is further complicated by intense urban development that has occurred along much of our coastline. Therefore, it is incumbent that coastal decision-makers anticipate the effects of sea-level rise on the coastal zone and incorporate mitigation strategies which enhance public safety and reduce the exposure of the coastal zone from direct and indirect effects of sea-level rise.

ABSOLUTE AND RELATIVE SEA-LEVEL RISE

Sea-level rise is composed of a combination of several factors. The most basic factor is the increase in the amount of water in the ocean. The melting of mountain glaciers and snow fields, along with a general expansion of the ocean as it warms, cause the ocean's surface to become elevated. This change in the amount of water in the oceans is referred to as the eustatic effect, or the absolute elevation of the water surface. A second factor of sea-level rise is that the coastal zone is subsiding or slowly sinking. Referred to as the tectonic effect, this is a characteristic of the older coastal margins of continents. Further, the new sediments which comprise barrier islands undergo some compaction because of their thickness and weight. As these sediments compact, it causes the overall lowering of the surface. The total change of sea-level is caused by the combination of these three factors which produce a net displacement of the water against the land. This is the referred to as relative sea-level rise. In discussing relative sea-level rise, it doesn't matter whether the land is subsiding or whether the sea is rising. Relative sea-level is the measure of how fast the land is becoming inundated. It is a measure of how fast you are getting wet.

THE EFFECTS OF SEA-LEVEL RISE

The issue of sea-level rise is multifaceted because so many indirect effects are associated with it. The problem is not simply the increasing water level of the ocean, but sea-level rise is also related to the general displacement of the shoreline at all of the margins of the barrier islands, and on all of the bayside communities, including those on the mainland. Further, as sea-level rises, the effects of storm conditions are able to reach farther inland. The smaller storms are able

[1] This is a summary of the information contained in the White Paper on Sea-Level Rise, included as an appendix to this document.

to reach levels and locations which were attained only by the rare event in the past. As sea-level rises, the effects of a diminishing sediment supply are also magnified. Whereas, the displacement of shoreline is perceived to be shoreline erosion, it is also a combination of elevated water levels as well. Therefore, an effect of sea-level rise is to contribute to the measurable displacement of the shoreline, and additional sand will be required just to maintain a constant position. Other issues include the change in the extent of and distribution of wetlands, habitats primarily in estuarine areas, the intrusion of saltwater into upper portions of estuaries, the salinity intrusion into groundwater, increased frequency of the inundation of evacuation routes, and effects on hazardous waste sites.

THE APPLICATION OF SEA-LEVEL RISE INFORMATION

In the 1981 SPMP, the issue of sea-level rise was introduced as a variable that is changing the condition of the coast. Some general information was known and there was a record of water level changes that was observed in the tidal gages. However, there were few studies on sea-level change in New Jersey. Further, most of the discussion that occurred was theoretical and focused on the problems associated with future sea-level rise. A major advance in the investigation of this phenomenon occurred when additional information about sea-level rise became easily accessible. This influx of information has made it possible to describe long-term records of sea level change, immediate past conditions of sea level, place the two in perspective, and produce a more confident statement about the consideration of future rates.

There are two major sources of information on regional sea-level rise: 1). The United States Environmental Protection Agency (USEPA) and 2). the Intergovernmental Panel on Climatic Change (IPCC), created as a joint effort of the United Nations Environmental Programme and the World Meteorological Organization. Both sources have been attempting to address the issue by compiling information and analyzing the current state of knowledge. In addition, the U. S. National Research Council has produced a report on its findings related to the issue of sea-level rise (1987).

The existing rates of sea-level rise are determined by analyzing tidal records at the several stations in and adjacent to New Jersey. They show a persistent increase over the past century of from 0.11 inches/year (2.74 mm/yr) at New York to 0.15 inches/year (3.85 mm) at Atlantic City (Table 1). These past rates would increase in the future, according to various estimates (Table 2), and produce greater inundation.

SEA-LEVEL RISE RATES IN NEW JERSEY

A number of studies have looked at the rate of sea-level rise in New Jersey. They have found sea level has been rising during the past several thousand years. Although these rates have fluctuated, they have continued to rise. An analysis of radio-

HISTORIC RATE OF SEA-LEVEL RISE AT VARIOUS LOCATIONS IN THE UNITED STATES
(mm/yr) (in/year)

Locations	(mm/yr)	(in/yr)
New York, NY	2.74	0.11
Sandy Hook, NJ	4.06	0.16
Atlantic City, NJ	3.85	0.15
Lewes, DE	3.11	0.122

Table 1. Source: NOAA, 1987-1994. Yearly Mean Sea Levels and Monthly Tidal Summary Reports for: Atlantic City, NJ; Battery, NY; Lewes, DE; Philadelphia, PA; and Sandy Hook, NJ. U.S. Dept of Commerce, National Ocean Service, Rockville, MD

ELEVATION OF SEA LEVEL AT ATLANTIC CITY UNDER VARIOUS SCENARIOS, INCORPORATING SUBSIDENCE
(elevation in centimeters, relative to 1990)

	Year 2000	Year 2025	Year 2050	Year 2100
EPA (1984)*				
Conservative	4.9	19.35	36.4	81.3
Mid-range, moderate	6.9	30.55	62.9	167.3
National Research Council (1987)*				
Low	7.1	25.2	43.1	78.6
Middle	11.2	39.4	67.6	123.8
IPCC (1990)*				
Conservative	4.5	15.5	32.0	58.5
Moderate	5.5	20.5	44.0	93.5
EPA (1995)*				
Best Estimate	5.0	18.7	33.5	68.1

Table 2. * Year of publication

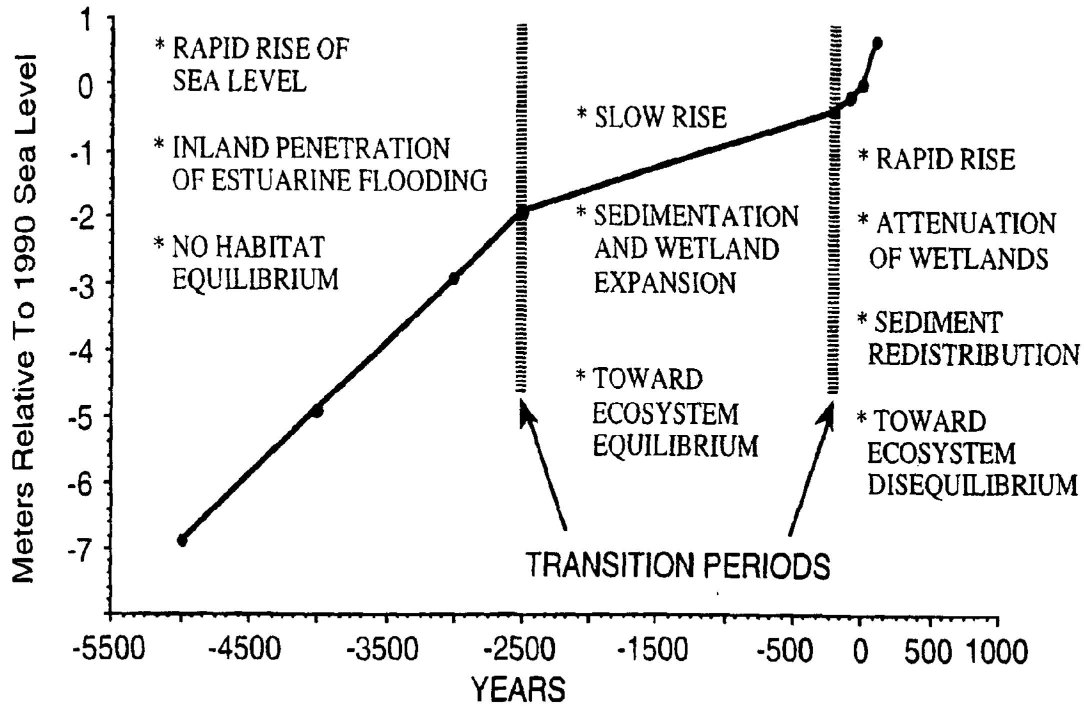

Figure 2. Coastal barrier islands and wetland development related to rate of sea-level rise. System disequilibrium is associated with high rates of rise (Psuty, 1992).

APPLICATION OF SEA-LEVEL RISE

Storm surge levels vary as a function of the storm's strength. However, there is another variable that determines the comparable level to which any storm can raise the water elevation and penetrate inland. That variable is the change in relative sea level through time. Sea level is rising. Therefore, the base upon which storms have occurred is changing. Thus, recent storms are now capable of reaching similar historical flood levels with lower surges. In addition, a rise in sea level allows stronger, less frequent events to reach coastal areas that where once safe from storm activity, exposing more areas to the erosional and flooding effects of a storm.

Nearly all of the management options discussed have focused on the effects of sea-level rise at the ocean shoreline. Accordingly, much of the discussion has also focused on approaches to defending the ocean shoreline. However, the effects of sea-level rise will be manifested on the shorelines of bays and estuaries in the coastal zone and they will likely be without the protective buffer of a beach and dunes. These locations are usually very low-lying initially and are very exposed to the effects of flooding. Much of the local infrastructure is near sea level at this time and will have increasing episodes of flooding as sea-level continues to rise. Therefore, the bay margins will need to be the first locations for the application of state policy development recognizing the effects of sea-level rise due to the high risks associated with sea-level rise.

CONCLUSION

Relative sea level in New Jersey has risen about 39 cm in the past century and will increase in the next century. The issue of sea level rise is a multifaceted phenomenon involving global and regional efforts. Yet these efforts have not established a single value of sea-level rise. Regardless of the rate that is considered, water levels are rising and the coastal zone is becoming inundated. The population and the development at the shore are at risk. The beaches have shifted and barrier islands have become narrower due to the displacement of the water-land contact. Low-lying bay shorelines are especially vulnerable as sea level rises. These risks will continue to increase in association with an increasing rate of rise. Thus, it is vital that coastal decision-makers anticipate the effects of sea-level rise on the coastal zone and develop policies that will enhance public safety and reduce the exposure of the coastal zone from direct and indirect effects of sea-level rise.

Although beach replenishment or construction of seawalls confront a portion of the problems associated with sea-level rise, neither can eliminate flooding or the high risk of damage from storms operating on elevated water levels. Policies are needed to direct the investment of public funds into projects that will enhance areas of adequate elevation to accommodate sea-level rise for some time period. Conversely, a policy is needed to reduce public expenditure for locations in high hazard areas that will require continuous repairs to both development and infrastructure. Further, there is a need to introduce a measure of flexibility into the designation of land use, building lines, and densities. Zones and boundary lines must be adjusted on some timely basis to reflect the changing exposure and risk brought about by a rising sea level.

carbon dates of organic materials accumulating in estuarine sediments has been reported by Psuty (1986) (Fig. 1). This study shows a general increase in sea level on the average of about 2.1 mm (0.08 in) per year until about 2500 years ago when the rise slowed to an average rate of about 0.8 mm (0.03 in) per year. The slower rate of rise was responsible for the last 2.0 m of inundation at the coast. It was during this time that a general stability of the coastal forms and habitats began to develop. However recent data from the local area indicate that sea-level rise is now occurring at a faster rate.

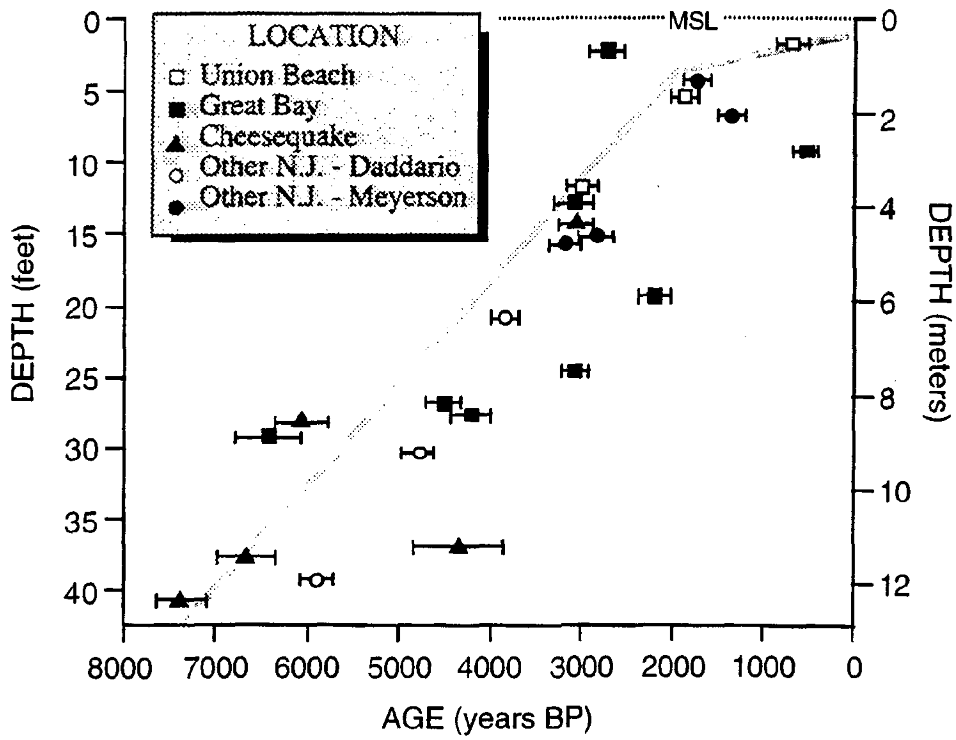

Figure 1. Trend of Recent Geologic Sea Level. The point on the scatter diagram are radio-carbon ages on materials taken from cores in New Jersey. The shaded line is the interpreted trend in elevation of sea level. The horizontal bars on the points represent the standard deviation in the age determination. Note the rapid rate of rise until 2500 Years BP and the ensuing slower rate of rise. (Psuty, 1986)

The rate of sea-level rise at present is higher than any time in the past 7500 years (Fig. 2). It is very likely that the combination of sea-level rise and the paucity of sediment available in the system are causing adjustments in the coastal morphology and coastal habitats. Whereas the barrier island and wetlands were in adjustment with the slow rise of sea level of the past several thousand years, the faster rise is inducing disequilibrium conditions at the coast and in the estuaries. In the past 50 years, the undeveloped Rainbow Islands in Great Egg Harbor have lost about 5% of their area, one island has completely disappeared (Psuty, et al., 1993). As the still higher rates of sea-level rise develop, they will drive continual new adjustments and force new displacements in the coastal zone. However, it is the rate at which these wetlands are being submerged and it is largely responsible for the loss of wetland area on the Rainbow Islands.

Coastal Storms[1]

Northeasters and other severe weather systems are major contributors in shaping, eroding, and redefining New Jersey's beaches. Since 1980, New Jersey has experienced an increase in storm activity. In an attempt to compare and rate storm events, storm classification systems have evolved, such as the Saffir-Simpson scale for hurricanes and the Dolan-Davis scale for northeasters. Another method developed to classify storms is the use of frequency curves. Frequency curves can be used to predict the occurrence intervals of specific water levels as well as rate storms events. Secondly, various rates of sea-level rise can be incorporated into frequency curves to predict future storm water elevations. When projected into the future, similar events will be capable of reaching areas once safe from storm activity. Therefore, it is crucial that coastal decision-makers recognize the effects of storms and a rising sea level upon the coastal zone and incorporate mitigation strategies which enhance public safety and reduce further exposure.

POST-1980 STORMY WEATHER

This section is an update of the recent storm activity along the coastal zone of New Jersey and their characteristics. The information was taken from several different sources including the National Weather Service, The Department of Environmental Protection (DEP), the U.S. Army Corps of Engineers (USACOE), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), and the local newspapers along the New Jersey coastal region. Water level elevation data were taken from two main source; USACOE and the NOS. High tide predictions were obtained from NOAA and NOS.[2]

There have been several severe northeaster storms and hurricanes that have touched upon the New Jersey coast since 1980. Eight of these storms were considered "major" northeasters, and the damages produced by them were clearly documented. These include the storms of March 1984, January 1987, Halloween 1991, January 1992, December 1992, March 1993, March 1994 and, the Blizzard of 1996. The information collected from these storms is a good indication of the continual hazards at the New Jersey coast.

Significant Northeasters Since 1980

Since 1980, the New Jersey coast has been affected by approximately fourteen northeasters. Eight of these storm systems were considered major storms because of several

[1] This is a brief version of the information incorporated in the White Paper on coastal storms, included in the appendix to this report.

[2] The information obtained from these sources may vary due to the differences in data collection and processing of this data. Location of gages, measuring units(such as Mean Low Level Water, National Geodetic Vertical Datum of 1929 (NGVD), Feet, and Meters) and time of measurements may also vary. Thus, there may be inconsistency in data for each storm. Adjustments have been accomplished in presenting this information in similar terms and to reconcile differences. However, some small differences remain.

variables. They tended to have an unusual long duration, high water levels, extensive damage, or a combination of these factors. In some cases, the media focused on particular northeasters, due to the factors mentioned above and the dates at which these storms occurred. Presented below is a description of each of the eight significant storms which have occurred since 1980. They will be depicted by several factors; their duration along the New Jersey coast, maximum water level elevations, maximum wave elevation, and the damages they produced along the coastline. Water level elevations are presented in reference to the National Geodetic Vertical Datum of 1929 (NGVD). NGVD is a national reference plane, which was established in 1929. This datum represents a constant surface and it is often used as the base level for measuring water levels in the coastal zone. At present, the NGVD plane is .59ft (.16m) below mean sea level. Because it is a constant surface, it does not have to be adjusted to the rise of sea level or subsidence of land. Thus, we are able to compare storms and their water levels with reference to NGVD.

The dynamics of the New Jersey coast are always changing and storms play a large role in this never-ending cycle. Since 1980, there have been approximately seventeen coastal storms (Table 1) which have affected the New Jersey coastline in some manner. Some of these storms produced very high water level elevations above NGVD, such as the March 1984 storm, December 1992, and March 1994 storm. Typically, storms produce a peak storm surge at the height of the storm, with water levels building up, then receding accordingly. This increase in water level elevations can produce some damaging effects. They can erode New Jersey's beaches and dunes, flood low-lying areas, produce structural damages to buildings, boardwalks and other man-made structures, and be hazardous to coastal communities in general. Thus, understanding these storms and the frequency at which they occur can be utilized to assist mitigation efforts to reduce the public exposure to their effects and enhance public safety.

RECURRENCE INTERVALS

The occurrence of severe storms brings forth the appellation 'storm of the century', or some similar designation. The severity of storms can be indicated by the measure of associated damage or erosion, or loss of life, or a combination of these factors. In an attempt to establish some comparative measure of storms and apply a scale to these events, storm classification systems have evolved. The Saffir-Simpson scale has been developed for categorizing the severity of hurricanes and the Dolan-Davis scale has been developed to classify northeasters.

FREQUENCY CURVES

Another method which has been developed to compare storms is the use of frequency curves. Storm magnitudes and duration may vary considerably. Storm water levels may build up over several tidal cycles or pass quickly. However, one common denominator of storms is the elevation of the water. This characteristic determines the magnitude of erosional effect of the waves, penetration of the dunes, potential overwash, and the flooding of barrier islands and bayside communities. When estimating or comparing different storm strengths, flood frequency curves help reduce the characteristics of a storm to a single variable or common denominator, water level. Although storm water level is only one of several storm variables, it is perhaps the best single descriptor of the impact of a storm on the shoreline and its attendant characteristics.

Table 1: Summary of Severe Storms 1980-1996

Storm Date	Storm Type	Water Level Meters/Feet, NGVD	Maximum Wave Height (M/Ft)	Duration Hours
October 25, 1982	Northeaster	1.31m(4.3ft)	NA	~32hrs
September. 30, 1983	Hurricane	1.25m(4.1ft)	NA	~12hrs
March 29, 1984	Northeaster	2.19m(7.2ft)	2.4m(7.9ft)	~36hrs
October 13, 1984	Hurricane	1.43m(4.7ft)	NA	~60hrs
September 27, 1985	Hurricane	~2.1 m(7.1ft)	2.2m(7.2ft)	~24hrs
January 2, 1987	Northeaster	1.8m(5.9ft)	~2.4m(8.0ft)	50hrs
August 19, 1991	Hurricane	1.12m(3.7ft)	2.2m(7.2ft)	~12hrs
October 30, 1991	Northeaster	2.0m(6.6ft)	~2.6m(8.5ft)	~114hrs
January 4, 1992	Northeaster	1.93m6.3ft)	~2.4m(8.0ft)	~32hrs
September 23, 1992	Northeaster	1.7m(5.6ft)	~2.6m(8.6ft)	~36hrs
December 11, 1992	Northeaster	2.32m(7.6ft)	~3.0m(9.8ft)	~140hrs
March 13, 1993	Northeaster	1.68m(5.5ft)	~1.74m(5.7ft)	~40hrs
March 1994	Northeaster	2.3m(7.6ft)	~2.7m(9.0ft)	~60hrs
December 1994	Northeaster	1.3m(4.3ft)	~2.4m(8.0ft)	~24hrs
August 17, 1995	Hurricane	1.65m(5.4ft)	~2.74m(9.0ft)	~96hrs
November 14, 1995	Northeaster	1.52m(5.0ft)	~2.29m(7.5ft)	~36hrs
January 7, 1996	Northeaster	1.66m(5.4ft)	~1.6m(5.3ft)	~48hrs

Frequency curves entail the analysis of the elevation of the water that occurred in conjunction with storms. The assumption is that stronger storms are associated with higher storm surges and flooding in the coastal zone. Through time, storm events and their associated water levels have been measured at many coastal locations enables comparisons to be made. This type of comparison organizes the historical numerical data at a site to construct a frequency curve and to calculate the probabilities of storm water levels. Flood frequency curves are often used along the coast to describe flood events, which has application to planning and event categorization.

A variety of methods exist for determining flood frequency curves. However, each method may result in slightly different values. Percent chance exeedance and expected probability are the two methods most frequently used in USACOE and Federal Emergency Management Agency (FEMA) literature. Annual percent chance exceedance is the percent chance that exists for exceeding a corresponding water level in a given year. Expected probability attempts to determine the chance that certain water levels will occur. This latter method is used by FEMA to evaluate the 100-year flood elevations and for V-zone determination.

The variety of methods and sources used to depict frequencies of water levels may produce different water levels for the same intervals (Fig. 1).

Absolute storm water levels can be related to a common base using elevation of water levels or probabilities derived from sea level frequency curves as well. Figure 1 incorporates the 5-, 10- 50-, and 100- year storm surge water levels and ranks past events according to the NGVD water levels reached. For example, a 5.8 ft. water level has a recurrence interval of 1 in 5 years or a 20% probability of occurring in any single year.

APPLICATION OF SEA-LEVEL RISE

Storm surge levels vary as a function of the storm's strength. However, there is another variable that determines the comparable level to which any storm can raise the water elevation and penetrate inland. That variable is the change in relative sea level through time. Sea level is rising. Therefore, the base upon which storms have occurred is changing. Thus, recent storms are now capable of reaching similar historical flood levels with lower surges. In addition, a rise in sea level allows stronger, less frequent events to reach coastal areas that where once safe from storm activity, exposing more areas to the erosional and flooding effects of a storm.

When comparing storms, it is possible to describe its surge level to a fixed datum, such as NGVD (Figure 1), or to a changing datum, such as sea level at the time of the storm. However, when comparing storms that are separated by several decades, some of the differences will be a product of sea level rise. For example, although Hurricane Gloria and the March 1962 storm were equal in water elevations reached [7.2 ft. (2.19m) above NGVD], Gloria operated on a sea level 0.276 ft. (0.07m) higher than the 1962 storm. Thus, because the March 1962 storm operated on a lower water base than Hurricane Gloria, the 1962 storm had a stronger storm surge than Hurricane Gloria in order to reach the same water levels.

Future Storm Levels**

Continuation of Previous Century's Rate

The impacts of sea-level rise through time are depicted in Figure 1. Column A contains the water level elevations of the major storms that have reached New Jersey. Eleven storms are

** The predictions of future sea levels are discussed in Sea-Level Rise (Psuty, et.al., 1996), a Coastal Hazard Management Plan White Paper accompanying this report.

listed and portrayed according to their peak water levels above NGVD. In addition, the elevation of the water level is referenced to the FEMA frequency water levels. For example, the January 1987 storm is shown as having a storm peak water level of 5.9 ft and it is about a 1 in 5 year storm. This storm is labeled Number 2 and this storm and its number are incorporated in each of the other columns in Figure 1.

The left column is a compilation of the major storms of the past 52 years, including many of the post-1980 storms. In each case, the storm water elevation is the level achieved at the time of the storm relative to NGVD. This procedure does not identify the effects of sea-level rise during the period of record, although it is incorporated in the storm surge value. By way of example, the March 1962 storm had water levels equal to that of Hurricane Gloria in 1985, 7.2 ft. above NGVD. Yet, if those two storms were to occur in 1996, their comparative raised water levels would be different today because of sea-level rise. Their storm surges would be adjusted and raised at the rate of the past sea-level rise rate, 3.84 mm/yr (0.012 ft/yr). Thus, a storm equivalent to the March 1962 storm occurring in 1996 would produce a water level of 7.99 ft.(2.43m) above NGVD [compared to 7.2 ft.(2.2m) above 1962 NGVD] with an occurrence interval of 1 in 35 years. If an event similar to Hurricane Gloria were to occur in 1996, water elevations would reach 7.33 ft.(2.24m) above NGVD [compared to 7.2 ft.(2.2m) above NGVD in 1985]. In other words, if the 1962 storm were to occur today, it would surpass the flood levels of Hurricane Gloria, its water levels would be higher than the December 1992 storm, and its levels would even surpass the 1944 Hurricane.

Extending the effect of sea-level rise on future storms, Figure 1 projects the occurrence of past storm water levels to their equivalents in the year 2050 and illustrates the difference between storm surges of the older verse the more recent events.

MANAGEMENT IMPLICATIONS

Coastal storms will continue to occur and to inundate the New Jersey shoreline. These storms often result in the loss of life, extensive damage to property, and coastal erosion As sea level continues to rise, the effects of storms will be felt farther inland and across more of the coast. Efforts need to be taken to minimize potential losses from less frequent severe storms, as well as frequent low magnitude storms. Several issues must be considered prior to implementing any management strategies:

- Identification of high hazard areas.
- Identification, on a reach basis, of the level of protection from coastal storms desired.
- Creation of goals and objectives to be achieved in the year 2050, taking into consideration rising water levels.

Coastal decision makers must determine, on a regional basis, the level of protection desired to alleviate the effects of the probabilistic occurrence of storm waters to barrier islands and bayside communities. Options to protect reaches against a 1 in 5 year storm water levels differ from strategies to protect reaches from a 1 in 50 year storm. Although, protection from a 1

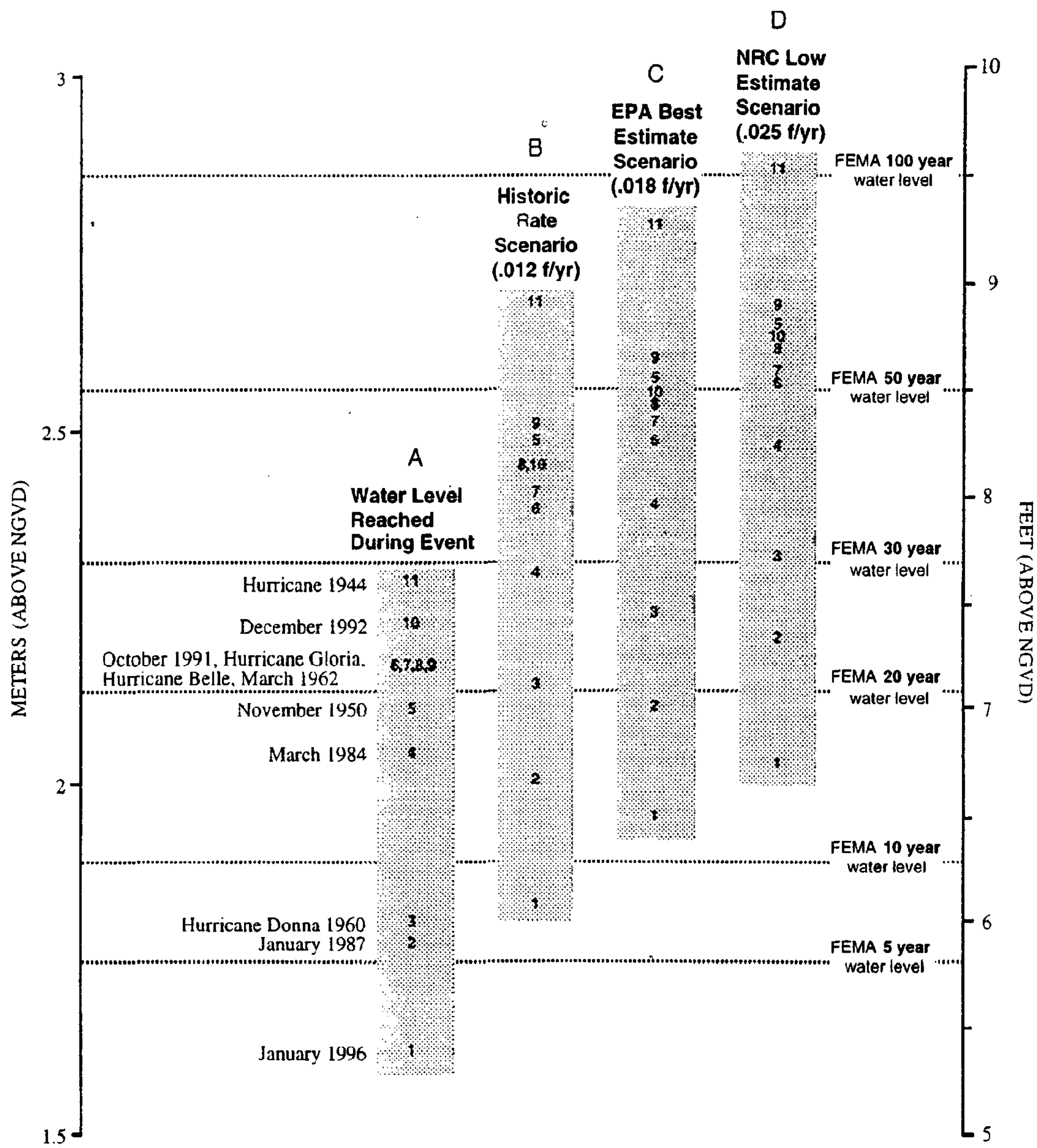

Figure 1. Projection of Historic Storm water Levels to the Year 2050 Utilizing Three Predicted Sea-Level Rise Scenarios A) Storm surge at time of storm related to NGVD, B) Past Rate, \C) EPA's estimate, D) National Research Counsel estimate

in 5 year storm requires less immediate investment than a 1 in 50 year storm, providing protection from a 1 in 5 year storm will require continuous post-disaster clean-up and repairs. Conversely, to provide protection against a 1 in 50 year storm will prevent flooding from frequent less severe storms; however, it may require expensive structural solutions such as dikes and may not be economically feasible or realistic. However, some level of protection against storms must be afforded. Thus, an intermediate approach such as providing protection from a 1 in 20 year storm may be the most feasible option. By providing protection from a 1 in 20 year storm, communities will be protected from the effects of both moderately-severe less frequent storms and well as frequent storms.

It must be recognized that increasing sea levels compromise any storm management efforts. As sea-level rise increases the water elevations of frequent low magnitude storms, it will become increasingly important to develop a long-term management strategy.

Conclusion

Coastal storms are a constant threat to the New Jersey coastline, often resulting in loss of life, property damage, and beach erosion. The interim between 1980 and 1996 is considered a "stormy" period, producing over seventeen storms. In an attempt to establish some comparative measure of storms and to rate events, storm classification systems have evolved. By incorporating the impact of sea-level rise through time, one can compare the elevations reached at the time of the storm. If these storms are projected into the future, similar events would cause more damage than when they originally occurred. In addition, a rise in sea level allows stronger, less frequent events to reach coastal areas that where once safe from storm activity, exposing more areas to the erosional and flooding effects of a storm.

Although the construction of barriers confront some of the hazards associated with coastal storms, they can not eliminate the high risks of storms acting on elevated water levels. Therefore, it is crucial that appropriations led by a State policy that anticipates the effects of a rising sea level on coastal storms and develops policy that will enhance public safety and reduce public exposure to coastal storms. Policies are needed that direct the investment of public funds into projects that will enhance public safety from coastal storms. Conversely, policies are needed to reduce expenditures in areas prone to overwash, flooding, and hazardous areas which are subject to continuous repairs of infrastructure and structures.

SHORELINE EROSION

Shoreline erosion is an easy concept to understand because it represents the loss of sediment from the coastal system and the spatial displacement of the water line to some inland position. However the causes of shoreline erosion and the measurement of erosion offer some complications. There is inherent natural variability in the coastal system and the result is shifting of the shoreline in a variety of time spans. In the long term, as sea level rises, the shoreline will shift inland much because of the encroachment of the sea. Within that shift may be variations produced by variations in sediment supply, the variations in storminess, and the general pulsing of sediments through the system. There are so many short-term variations that the trend of shoreline change may take decades or longer to decipher. But with longer term records and information on the beach characteristics, the dune forms, and the offshore profiles, it will be possible to understand the three-dimensional components of shoreline change and incorporate that understanding into effective management. At present, the two most important variables that are driving shoreline change are the quantity of sediments available to the system and the rate of sea-level rise.

SEDIMENT SUPPLY

Beaches are traditionally maintained by the natural processes of sediment transport from some external source to accumulate at the water-land contact. Generally, the most important source of beach sand are the rivers that transport sediment eroded from the continent and discharge their loads in the vicinity of the shoreline. A quick glance at the map of New Jersey shows that there are no major rivers discharging at the shoreline (Fig. 1). Most of the rivers in the State enter bays or estuaries which catch and trap the available sediment and, therefore, a riverine source of sediment is unavailable under present conditions. A second source is the erosion of the continental margin by waves and currents. This is an area of cliffs and bluffs at the waters edge. There are portions of Monmouth County which is composed of eroding bluffs. Although this is a source of sand that can be transported to supply adjacent

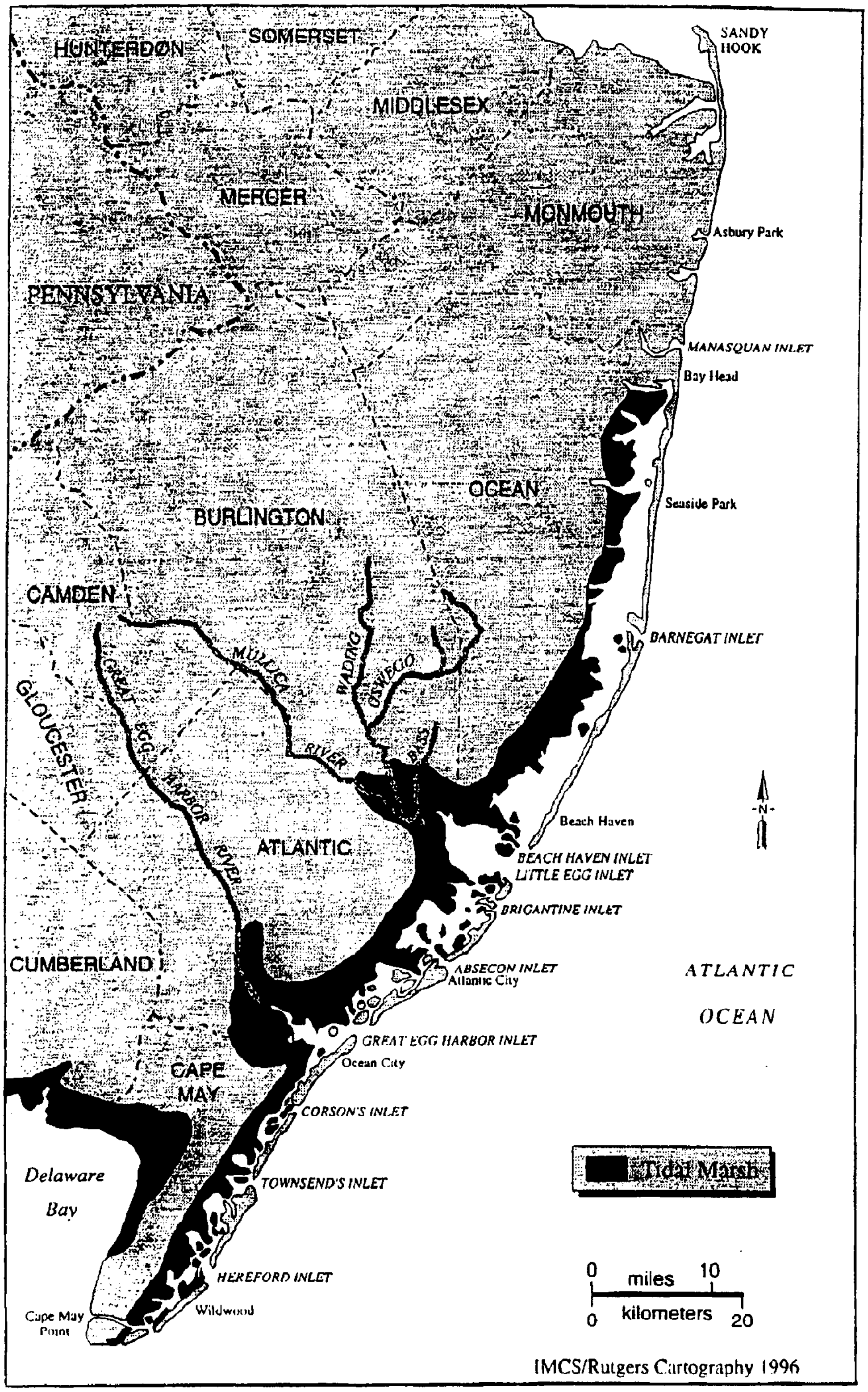

Figure 1. Map of Coastal New Jersey

beaches, the rate of sediment delivery is very slow and the amounts are insufficient to maintain the beaches. The supply has been further diminished by the many structures and walls that have been erected to slow the rate of bluff recession, thus the erosional bluff source of sediment is of minor importance. The remaining source of sand to the New Jersey beaches is from the offshore. It is likely that during the rise of sea level that occurred over the past several thousand years that considerable quantities of sand were submerged as the ocean rose to inundate the sandy coastal plain. Waves can move sand landward along the bottom and cause accretion at the beach. Indeed, the recovery of the beaches following a storm is the process of wave transport of sand from the offshore to the position of the beach. However, the offshore source is finite, and once the available sand has been mobilized and transported, the supply is exhausted. There are no new sands being generated to replace the materials that have been moved. Thus, over some time period, the offshore sand supply has contributed as much as is available. That limit has been reached. There are sand sources that remain in the offshore zone that are too deep or too far offshore to be mobilized by the waves and currents present in the offshore. Thus, these formerly-available offshore sources of sediment have been effectively exhausted in terms of being transferred landward by the natural processes. However, there are deep water sand sources that may be moved by dredging or some other human-induced process.

A fundamental characteristic of the New Jersey shoreline is the slow but continuing loss of sediment through time. There are no new natural sources of sediment entering the beach environment to balance the losses caused by the processes of wave and current transport from the beaches into deeper water offshore or downdrift. The losses are slow but through time there is a net decrease of sand in the beach zone, in the barrier islands, and in front of the low bluffs that front the Atlantic coast of New Jersey. The net result of the sediment loss is a slow displacement of the shoreline that is recognized as shore erosion, or the inland shift of the shoreline because some of the sand has been removed and not replaced. This is a natural process and nearly all of the world's shoreline is experiencing a similar condition because of the absence of new sand being contributed to the world's beaches.

If the shoreline were in equilibrium and not undergoing erosion, the problems of coastal management would be significantly reduced. However, the situation at the coast is one of slow sediment loss that is displacing the shoreline inland. Some of the rate of shoreline displacement had been reduced in the past by erosion of the sand that had accumulated in the form of large dunes on the barrier islands. This dune sand contributed sediment to the slow the losses and thus buffered the rate of displacement. However, the dunes have been removed in much of coastal New Jersey and that source of sand is not available in most of the coastal zone.

Rates of sand loss are also affected by human intervention in the coastal system. Some of the structures which have been placed to maintain inlets or to protect development interfere with the natural transport processes and in some instances direct some of the sand into deeper water where it is less likely to return to nourish the beaches. Other structures affect the distribution and rate of alongshore transport to produce accumulations in one location while causing greater erosion in an adjacent location. These structures may not diminish the overall sediment supply but do cause a redistribution that is beneficial to one area and adverse to another.

New sand may be added to the beach/dune system by physically transferring sand by truck or by pipeline. Sediment dredged from offshore sites more than a mile or so and from depths greater than about 50-60 feet are additions to the existing beaches. Likewise sediment brought by trucks from the mainland to the beaches is new material that affects the short-term sediment budgets. Moving sand by these means is costly and each program to add sand to the beaches must be carefully evaluated. Any quantity of sand added to the beaches will eventually be removed by the natural processes. Any quantity of sand added to the system modifies the sediment budget but does not reverse the causes of sediment removal and the longer term losses. Sand management is an issue in the coastal area, both the retention of the sand that is being lost and the opportunity to bring new sand into the system.

SEA-LEVEL RISE

Essentially, as sea rises the shoreline is displaced inland, except in those areas where sufficient sediment is accumulating to build the shoreline seaward. A shortage of sediment accompanied by sea-level rise compounds the problem and produces a faster rate of displacement. In areas of gentle slopes, such as those in association with barrier islands, the amount of horizontal shift is thought to be on the order of 100 times the amount of vertical rise. However, at coastal bluffs, the horizontal shift is much less. It is likely that the response of the shoreline to sea-level rise has some time lag associated with it. The change will not occur each year, but some major storm that mobilizes large quantities of sediment. The lack of the beach to return to its original position may be the stepwise manifestation of the effect of sea-level rise as well as changes in the sediment budget.

CHANGES IN SHORELINE POSITION

In addition to sediment supply and sea-level rise, the variety of coastal geomorphological features, the variable exposures, differing persistence in alongshore drift, sediment delivery and the occurrence of beach protection structures all lead to a variation in the rates of shoreline erosion and displacement. There are major differences in the responses on the barrier islands versus the cliffed coast of the Northern Highlands. There are also variations along the barrier islands, and there is an additional difference in response to the effects of groins, jetties, and seawalls at the coast.

An analysis of the historical changes of the shoreline reveals considerable variation both spatially and temporally. Many coastal areas show periods of erosion interspersed with periods of accumulation. This variation was amply demonstrated in the comparison of shoreline positions depicted in Nordstrom et al (1978) that apply rates of positive and negative displacement over some time period (Fig. 2). This concept is updated and

I = [1836-1886], 1932-1957
J = [1842-1899], 1928-1965
K = [1885-1937], 1937-1963
L = [1842-1899], 1899-1955
M = [1842-1899], 1899-1936

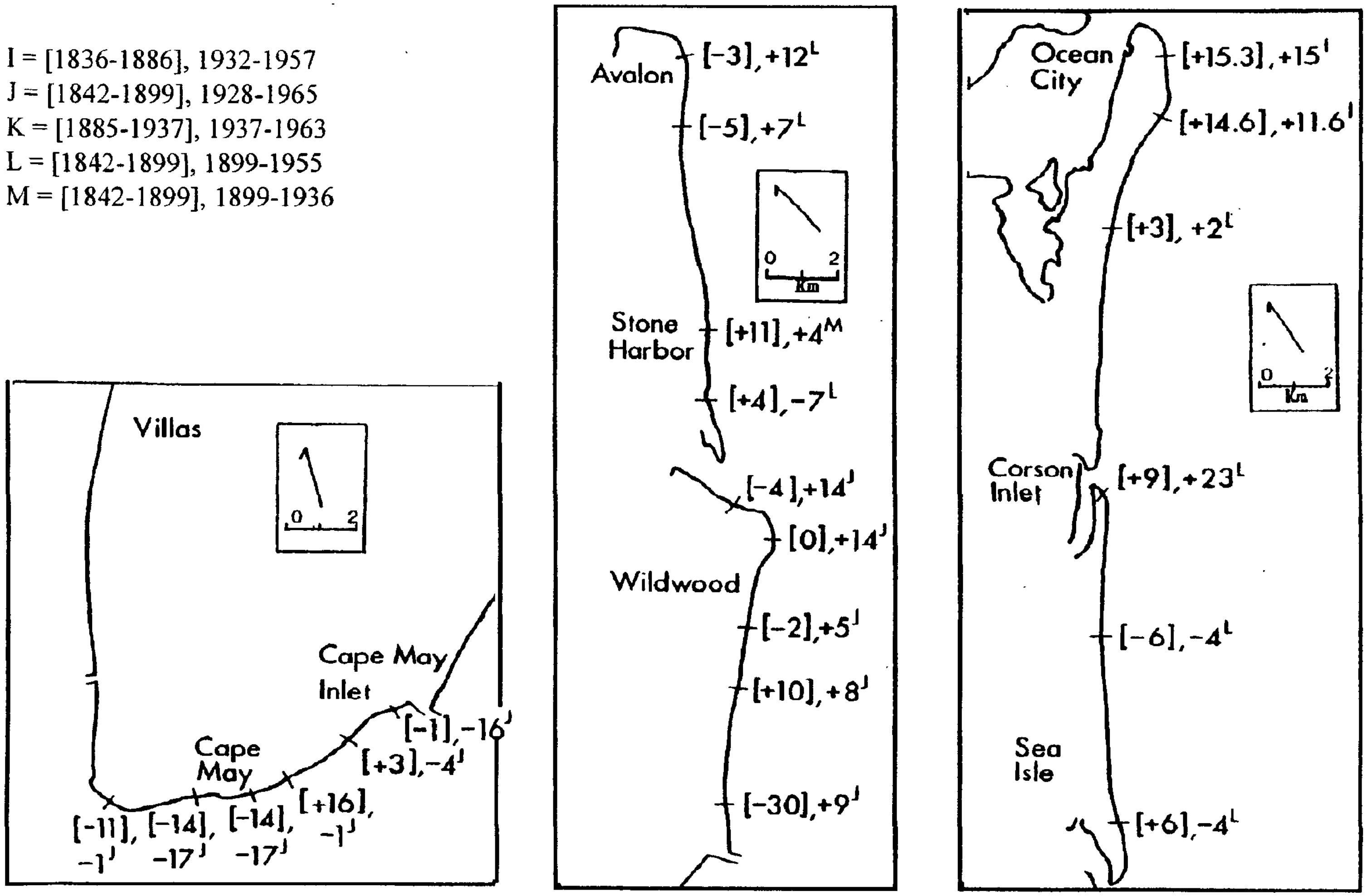

Fig. 2. An example of variations in shoreline displacement rates in feet per year in Cape May County, Covering approximately on century of record (Nordstrom, et al., 1977). Time span comparisons are largely rates of the 19th century [in brackets] versus those of the 20th century. The latter period incorporates the construction of structures at the shoreline and at the inlets.

incorporated on the NJDEP CD-ROM (1995) that portrays shoreline positions at differing times and permits the measurements to be made between any combination of shoreline positions relative to the base map shoreline of 1986 (Fig. 3).

Complications to the general trend of shoreline displacement are the products of attempts to stop or reverse the history of shoreline erosion. The use of shore parallel structures such as seawalls creates an artificial shoreline position while permitting continued erosion in the subaqueous zone and an oversteepening of the slopes seaward of the seawall. Shore perpendicular structures such as groins and jetties interfere with the alongshore transport of sand in the beach zone and cause offsets in the shoreline. Sand accumulates on the updrift side of the shore perpendicular structures but is withheld from the downdrift portion, causing an accelerated inland displacement. Beach nourishment projects rebuild the beach and temporarily displace the shoreline seaward.

All of the above approaches to shoreline protection manipulate the shoreline position and affect the general analysis of trends of shoreline displacement. Therefore, it is necessary to qualify any identification of change or rate of change relative to the natural as well as the cultural processes that have affected the outcome of the shoreline position through time.

Despite the temporal variations, nearly all of the New Jersey shoreline was eroding and being displaced inland prior to the advent of massive, areally-limited beach nourishment projects (USACOE, 1971; Nordstrom, et al., 1978; USACOE, 1990). The downdrift ends of barrier islands or the tips of barrier spits were exceptions to the trend, but these accumulations were primarily elongations of the islands/spits and downdrift shifts rather than seaward displacements. The bulbous, updrift ends of the barrier islands have been accumulating and losing sand on some lengthy cycle and they show this variation in the historic charts and aerial photos of this century. Further, as the updrift bulbous ends of the barriers release sand, they buffer the shoreline displacements of the downdrift portions of the islands. Thus, there are

Historical Shoreline Positions
Brigantine Island

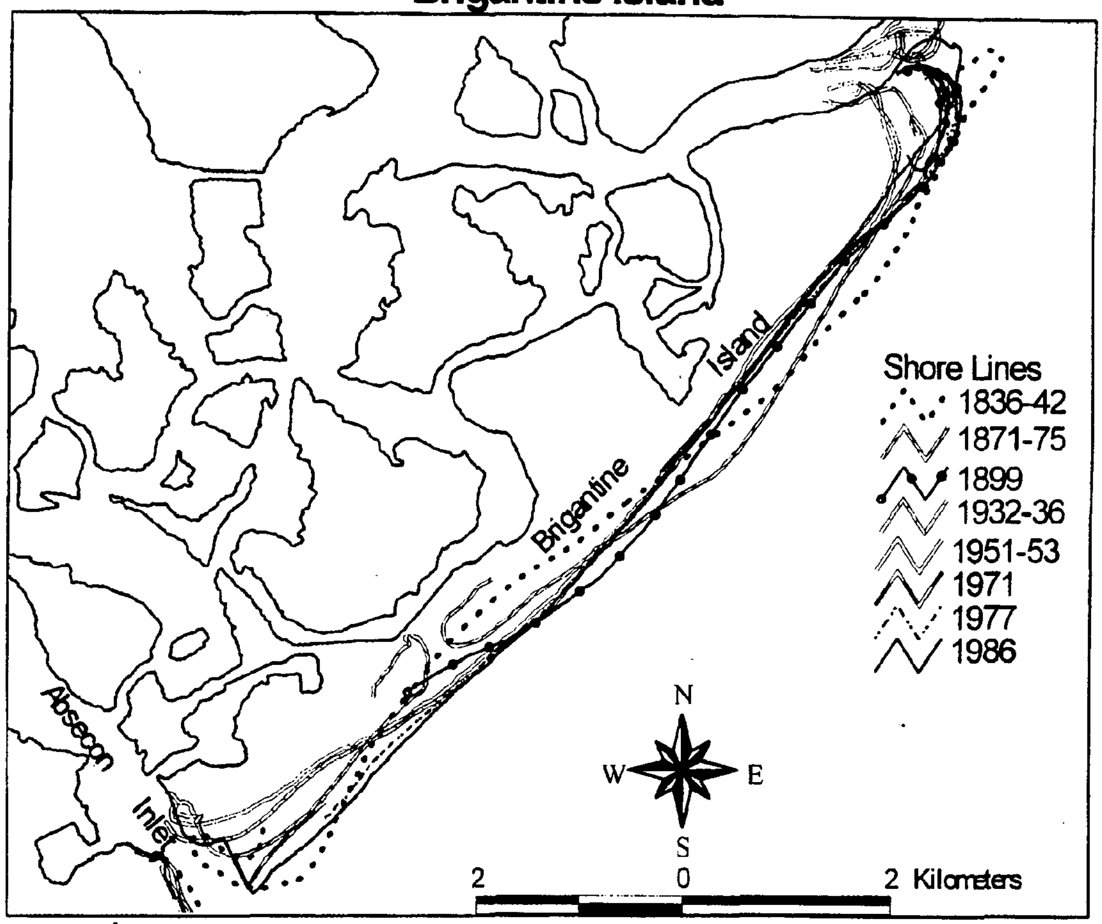

Fig. 3. A comparison of shoreline positions on Brigantine Island, 1836-1842 to 1986. data have been entered into a GIS program and recorded on CD-ROM. The effects of the Absecon Inlet jetty are apparent in the seaward displacement of the southern shoreline, whereas the northern half of the island has an erosional trend as well as elongating into Brigantine Inlet. An old inlet position cutting through the island is shown about 2 miles north of Absecon Inlet. (NJDEP, 1995).

changes in the position of the shoreline that are responding to long-term and short-term processes of sediment exchange. Any description of the shore position necessarily incorporates the variety of natural cycles and cultural attempts at stabilization. Any description of the trend of shoreline displacement, therefore, should be posed within some temporal period and extended beyond that period with caution. Obviously, an analysis of change over longer time periods would tend to smooth the naturally- and culturally-produced variations and identify the general situation.

New Jersey Beach Profile Network

A new data set has been developed to describe beach change. Beginning in 1985, beach profiles have been surveyed at approximately one mile intervals for most of the new Jersey shoreline. Some of the public holdings (parks and wildlife areas) were added in the 1990s. These profiles provide complementary information to the spatially-contiguous photo comparisons. These profiles include the dune zone, the beach, and the offshore area. Originally, the profiles extended to wading depth but they now extend to about -20 ft NGVD. Although each of these surveys portrays the conditions at a single line, there are now 9 years of record at most of the lines and the broad spatial associations deliver a heretofore unavailable data set about the quantities of sand on the profile. The data derived from the profiles represent the changes in cross-section of the total profile. If an equal amount of sand shifts from dune to the offshore or vice versa, for example, the net change in the profile measurement is zero. Therefore, any net positive or negative change is actually a gain or loss to the total profile cross-section and not just a shift of sand from one position on the profile to another position, within the profile limits. This is especially important because these profiles are surveyed only once per year (in the fall) and there is the possibility that more spatially-restricted profiles (to shallow wading depth, for example) would miss and misrepresent the cross-shore transfers of sediment associated with storms and post-storm recovery at the beach. These more recent, deeper surveys are not so affected by the balanced exchanges associated with cross-shore transfers that do not leave the general profile area.

The profiles are affected by the localized manipulations of the beach profile such as dune building or beach nourishment projects that emplace volumes of sand on the beach on the survey lines. These nourishment episodes create a large positive gain on the profile and would skew any average condition for the site.

Sediment Budget

Each of the profiles records the configuration of the topography at a site in cross-section. A comparison of successive cross-sections provides a measure of two-dimensional area change on the profile line between the surveys. Through convention, the cross-section is extended along the beach to create a volume measure of the amount of sand that was gained or lost on the profile line. Thus, an expression such as a change of 10 cubic yards per foot of beach would indicate that the profile cross-sections differed by 270 square feet. Extending this information to a stretch of beach between adjacent two profile lines is accomplished by calculating the cross-section change for successive surveys on and the two profiles, summing them and dividing by two. This calculation will produce the average volume change in cubic yards per foot of beach between the two profile lines. The total volume change may be derived by multiplying the average value by the length of beach between the adjacent profile lines.

A portrayal of the net profile changes in cubic yards of sand per foot of alongshore beach length (1986-1995) provides information on the scale of the changes and their spatial distribution (Fig. 4A & B). The net change data set averaged for the total survey period is a subject of considerable analysis (Table 1). Many of the positive numbers in this portrayal are at sites of beach nourishment, such as at Sandy Hook, lines 284-185; Atlantic City, lines 130-128; Ocean City, lines 122-225; Avalon, lines 115-216; and Cape May, lines 104-108. Other positive effects are caused by structures, such as the areas updrift of the Barnegat Inlet jetty, the Absecon Inlet jetty, and the Cape May jetty. There are also downdrift negative effects but they have been countered temporarily in most cases by beach nourishment. With the

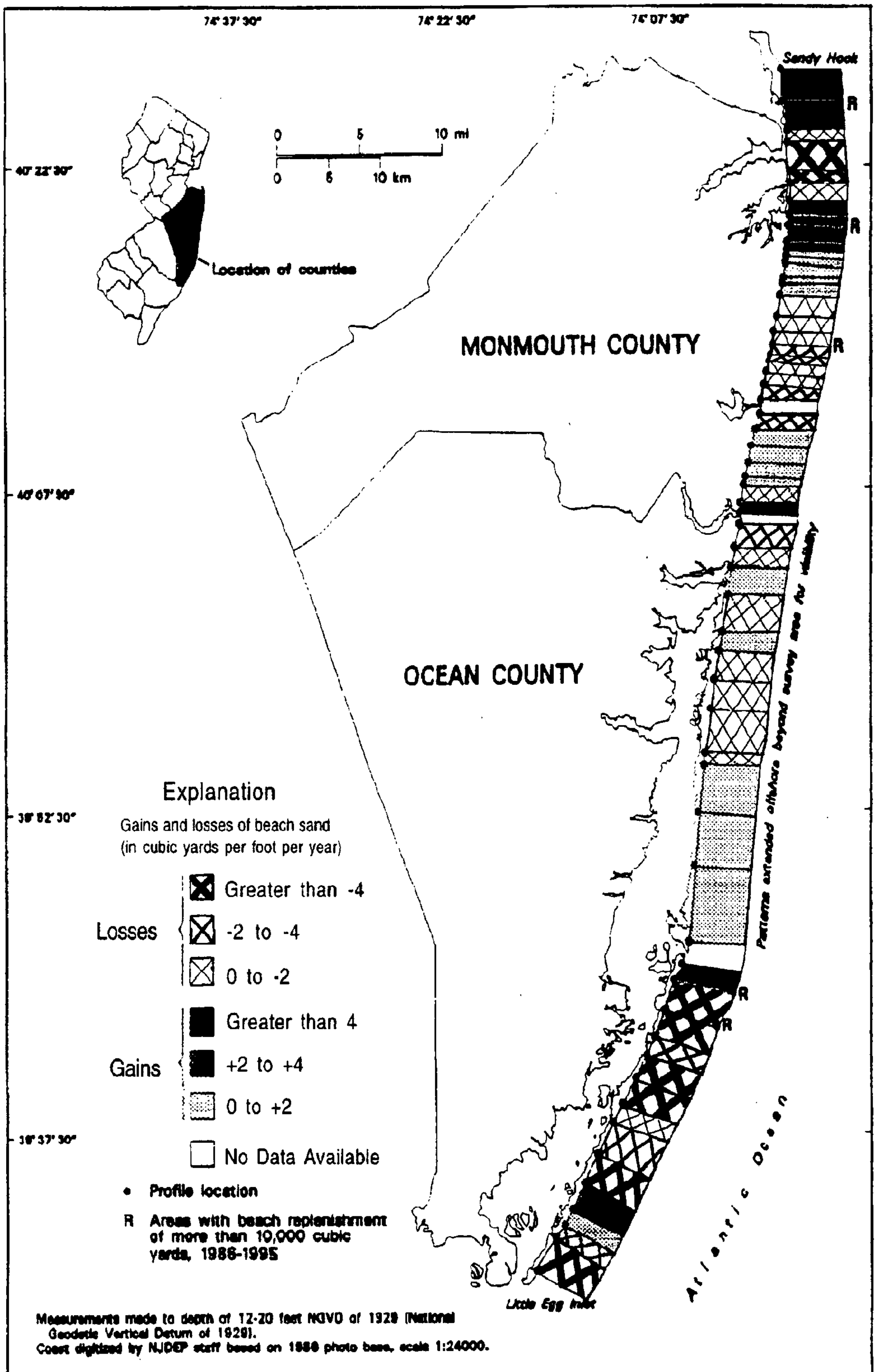

Figure 4A. Average annual change in volume of sediment on profile segments, 1986-1995, Monmount County and Ocean County. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

et al., 1995.

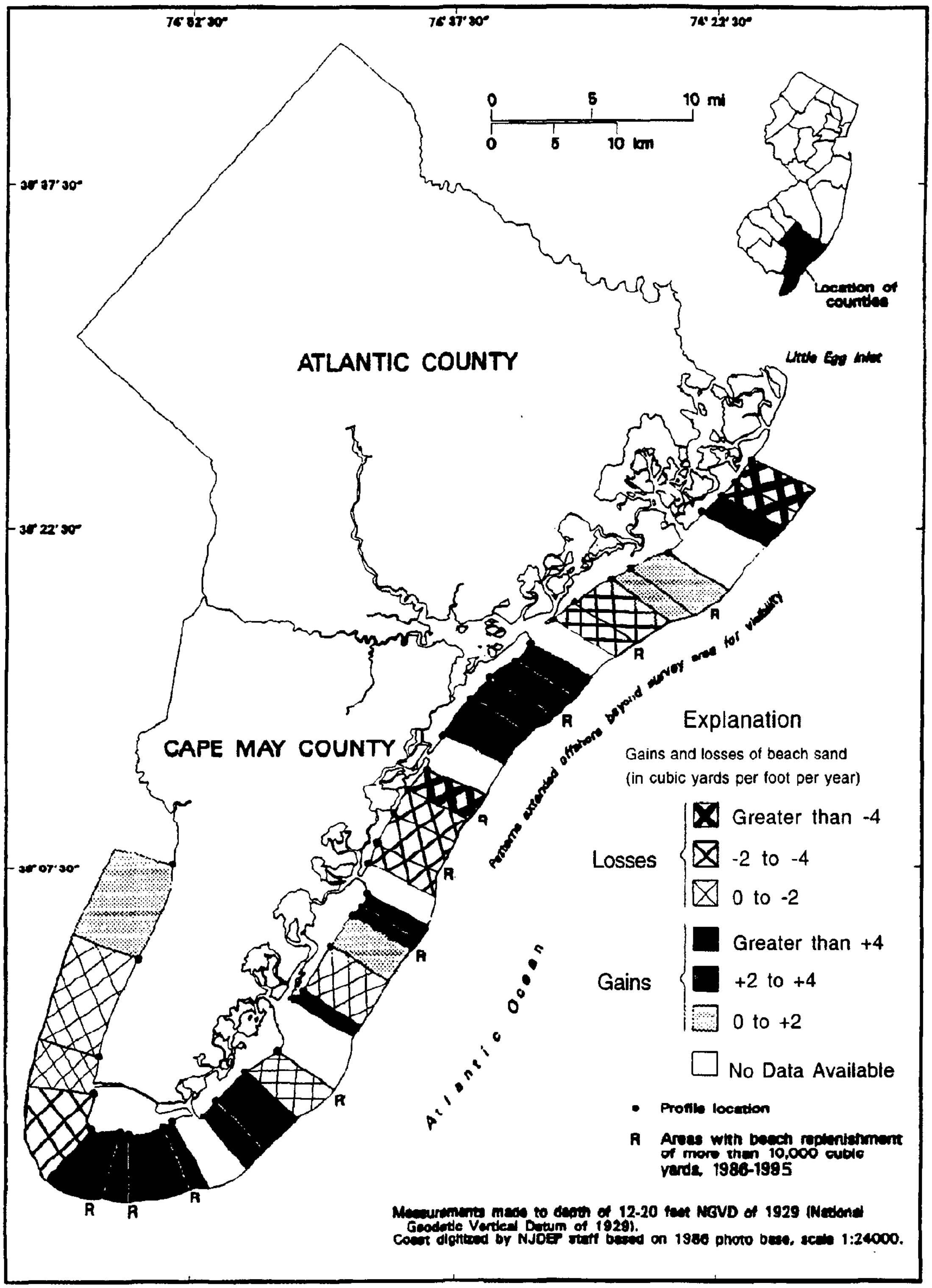

Figure 4B. Average annual change in volume of sediment on profile segments, 1986-1995, Atlantic County and Ocean County. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995

Table 1. Absolute values of average annual volume changes of profile segments, 1986-1995, ocean front profiles, cubic yards per foot of beach length.

Stations	Avg. for Area	Category	Stations	Avg. for Area	Category
185-285	21.6	> +4	**Manasquan Inlet**		
285-284	15.885	> +4	156-155	-2.0485	-2 to -4
Gateway entrance			155-154	-1.239	0 to -2
184-183	0.46	0 to -2	**Metadeconk River**		
183-new	-12.824	> -4	154-153	0.901	0 to +2
new-182	-13.83	> -4	153-152	-0.73	0 to -2
182-181	-0.228	0 to -2	152-151	0.572	0 to +2
181-180	11.432	> +4	151-150	-0.068	0 to -2
180-179	15.492	> +4	150-149	-1.155	0 to -2
179-178	16.962	> +4	149-148	-0.925	0 to -2
Long Branch City Limits			148-147	-0.596	0 to -2
178-177	13.487	> +4	147-247	0.566	0 to +2
177-176	1.0435	0 to +2	247-246	1.2035	0 to +2
176-175	0.6345	0 to +2	246-146	1.2585	0 to +2
175-174	0.625	0 to +2	**Barnegat Inlet**		
174-173	0.3225	0 to +2	245-145	9.3	> +4
173-172	0.4105	0 to +2	145-144	-10.96	> -4
172-171	-0.785	0 to -2	144-143	-10.725	> -4
171-170	-0.895	0 to -2	143-142	-2.155	-2 to -4
169-168	-1.365	0 to -2	142-241	-5.745	> -4
168-267	-2.94	-2 to -4	241-141	-5.51	> -4
267-167	-3.68	> -4	141-140	-1.22	0 to -2
167-166	-1.865	0 to -2	140-139	-3.76	-2 to -4
166-165	-0.925	0 to -2	139-138	-5.125	> -4
165-164	-2.52	-2 to -4	138-137	2.567	+2 to +4
Shark River Inlet			137-136	1.857	0 to +2
163-162	-2.288	-2 to -4	136-135	-3.739	-2 to -4
162-161	0.547	0 to +2	135-234	-9.9695	> -4
161-160	0.715	0 to +2	**Little Egg Inlet**		
160-159	0.18	0 to +2	134-133	-9.705	> -4
159-158	0.54	0 to +2	133-132	-6.15	> -4
158-157	-0.61	0 to -2	132-131	5.375	> +4
157-256	4.29	> +4			

(con't) Table 1.

Stations	Avg. for Area	Category
Abescon Inlet		
130-129	1.4285	0 to +2
129-128	0.3235	0 to +2
128-127	-3.91	-2 to -4
127-126	-3.305	-2 to -4
Great Egg Harbor Inlet		
225-125	40.03	> +4
125-124	12.465	> +4
124-123	18.94	> +4
123-122	5.279	> +4
Corsons Inlet		
121-120	-10.02	> -4
120-119	-2.455	-2 to -4
119-118	-2.895	-2 to -4
118-117	-2.0315	-2 to -4
Townsends Inlet		
216-116	133.315	> +4
116-115	5.41	> +4
115-114	1.41	0 to +2
114-113	-1.59	0 to -2
113-212	15.365	> +4
Hereford Inlet		
111-110	-0.585	0 to -2
110-109	4.365	> +4
109-208	21.97	> +4
Cape May Inlet		
108-107	21.775	> +4
107-106	4.405	> +4
106-105	8.355	> +4
105-104	10.61	> +4
Cape May Point		
104-103	-2.695	-2 to -4
103-102	-1.735	0 to -2
102-101	-0.5265	0 to -2
101-100	1.1	0 to +2

Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al.,

exception of the numbers for Long Beach Island and the locations obviously affected by beach nourishment or structures, the amounts of change are small for this time period. The largest negative changes are in front of the seawall near the entrance to the Sandy Hook Unit of Gateway. This is a continuation of the oversteepening in front of the seawall and it is a short record. Otherwise, the losses are greatest in the overwashed section of northern Brigantine Island. The numbers are small in front of the Northern Highlands (Monmouth County) because there is very little sand there initially, the continental bedrock is more resistant to erosion than loose sand, and the profiles are very short. Conversely, the numbers are high in front of Long Beach Island because there is a large amount of sand on the profile initially and these profiles are very long.

The tabulation of the individual surveys by year provides additional insight into the sediment transport picture (Table 2). There are very few profile lines that have been consistently positive or negative throughout the survey period. Further, there are no reaches which are consistently positive or negative. Although a reach may have a net positive or negative budget, the pattern seems to be one of variation or periodicity within the reach, perhaps indicative of the alongshore transfers of sediment in pulses or units of sand. Yet another observation in the annual surveys is the large positive values in Long Branch (Lines 177-173) during 1995. It is likely that the beach fill from Monmouth Beach is extending southerly to more than compensate for the longer term erosional history of this section of the Northern Headlands.

Shoreline Displacement

Another view of the shoreline change is presented as the variation in location of the NGVD water line (shoreline) on the profile through time (Figs. 5A & B, Table 3). Although used frequently to plot the displacements of the shoreline, there is considerable short-term variation in the NGVD intercept on the profiles because of transfers of sand on the profile and because of the alongshore variation in the beach planform (Table 4). The year to year variation is especially instructive in portraying the effects of beach nourishment and the subsequent

Table 2. Annual volume change from previous year on profiles, 1986-1995, ocean front profiles, cubic yards per foot of beach length.

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
•	185							13.8	-10.99	-3.57	-0.76	-0.25
1	285								new	42.57	42.57	42.57
	284								new	-10.82	-10.82	-10.82
Gateway Entrance												
	184	4.16	-1.04	1.01	-6.41	2.47	-0.81	-4.55	8.9	-3.92	-0.19	-0.02
	183	5.76	3.39	-3.77	0.33	-1.98	2.43	-2.33	-1.11	5.85	8.57	0.95
	282								new	-26.59	-26.59	-26.59
	182	1.34	6.7	-9.47	9.34	-1.8	-6.92	3.25	-16.35	4.38	-9.53	-1.06
	181	9.52	3.54	-9.94	18	-10	5.32	-35.54	-28.43	52.97	5.44	0.60
2	180	-3.55	1.3	-3.08	5.4	-8.67	1.25	-3.44	-0.94	212.06	200.33	22.26
	179	5.91	-4.14	0.32	7.19	-10	-1.41	-8.1	199.75	-111	78.52	8.72
	178	14.83	-1.47	-7.03	11.11	2.65	-19.24	-9.54	348.1	-112.61	226.8	25.20
Long Branch City Limits												
	177	8.44	4.58	-7.22	10.15	0.58	0.52	-19.07	-17.6	35.59	15.97	1.77
	176	28.64	-23.32	3.08	1.64	-15.03	-11.08	-6.94	6.45	19.38	2.82	0.31
	175	19.79	-3.05	6.85	-1.85	-4.07	-9.26	-12.04	-7.88	20.11	8.6	0.96
	174	6.78	1.26	-13.38	3.45	1.6	7.43	-0.36	-15.77	11.64	2.65	0.29
	173	-1.27	-0.96	-1.86	5.36	1.67	-7.21	5.29	-20.52	22.66	3.16	0.35
	172	2.27	14.9	-24.23	-10.12	19.89	0.11				2.82	0.47
3	171	10.63	-8.25	-9.14	0.34	-1.3	0.23	-5.32	-5.11	-0.43	-18.35	-2.04
	170	-6.6	15.07	-21.51	16.95	-0.87	-13.42	-16.09	17.06	2.49	-6.92	-0.77
	169	-6.48	4.92	-10.75	5.86	5.17	9.48	-3.9	-10.16	-3.35	-9.21	-1.02
	168	-6.34	32.76	79.56	-25.43	-53.9	-27.81	-22.65	13	-4.58	-15.39	-1.71
	267	-0.53	-8.32	-3.4	-4.42	4.27	-14.19	-1.6	-14.73	5.35	-37.57	-4.17
	167	17.92	-13.43	-2.3	8.53	7.05	-36.69	-18.31	3.98	4.51	-28.74	-3.19
	166	-12	11.65	-12.47	7.78	0.88	1.46	-30.25	18.76	9.31	-4.88	-0.54
	165	5.49	0.1	-13.31	5.54	1.63	0.51	-11.51	-4.91	4.68	-11.78	-1.31
	164	-5.12	-1.78	-7.58	7.41	-1.66	-21.42	-4.7	19.21	-17.9	-33.54	-3.73
Shark River Inlet												
	163	-1.24	-5.24	-16.59	-3.44	-5.18	-1.06	-12.72	-20.42	14.99	-50.9	-5.66
	162	3.44	11.48	-5.1	0.16	-4.72	4.97	-8.96	7.37	1.12	9.76	1.08
	161	-3.6	-1.56	2.19	8.28	-3.05	-2.58	-6.87	8.57	-1.29	0.09	0.01
4	160	3.44	4.74	-8.23	-2.03	-4.51	8.89	-4.22	8.48	6.22	12.78	1.42
	159	2.34	4.14	-8.02	7	-1.37	-15.67	-26.46	9.69	18.85	-9.5	-1.06
	158	11.7	3.62	-3.51	-5	-7.13	5.42	-35.1	13.14	16.64	-0.22	-0.02
	157	11.67	-5.08	-2.06	8.87	-13.51	0.34	24.37	-46.78	11.39	-10.79	-1.20
	256								new	9.78	9.78	9.78

(con't) Table 2.

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
Manasquan Inlet												
	156	-12.8	15.73	-6.84	31.9	-24.29	14.21	-14.77	6.44	10.7	20.28	2.25
5	155	20.52	-27.92	-12.9	4.54	0.53	-17.07	-50.21	0.41	24.91	-57.19	-6.35
Metedeconk R.												
	154	5.8	0.74	-1.06	16.4	-2.5	-6.92	5.09	1.24	15.98	34.85	3.87
	153	7.15	-13.53	-4.36	4.84	-31.22	30.33	-38.71	11.86	15.01	-18.63	-2.07
	152	-1.21	11.01	-11.76	6.57	-2.16	4.97	-9.56	-8.93	16.56	5.49	0.61
	151	-2.04	0.96	-23.86	16.65	-22.72	12.07	13.98	7.87	1.9	4.81	0.53
	150	-5.44	9.74	0.61	-0.61	-13.74	-10.13	-3.07	-9.91	26.5	-6.05	-0.67
6	149	1.4	-6.97	0.47	-12.1	-11.1	22.87	-22.07	1.47	11.29	-14.74	-1.64
	148	11.63	0.5	-6.66	6.62	-19.8	13.26	9.91	-12.26	-5.09	-1.89	-0.21
	147	-5.2	12.34	-21.53	14.2	-0.6	-1.73	33.71	-18.87	0.3	12.62	1.40
	247	8.52	-10.32	8.62	3.64	-9.66	12.25	-56.36	52.89	-12.02	-2.44	-0.27
	246	4.38	8.69	-22.47			17.44	-37.45	11.88	36.27	18.74	2.08
	146	8.67	-7.59	0.84	-9.49	6.64	-38.86	39.79	-9.46	7.99	-1.47	-0.16
Barnegat Inlet												
	245								new	21.22	21.22	21.22
	145	17.2	-2.31	-7.95	-6.65	-3.97	17.37	-63.98	22.35	4.37	-23.57	-2.62
	144	-2.2	-127.43	-6.35	10.81	-8.64	-16.73	-42.14	21.88	-2.96	-173.76	-19.31
	143	-0.5	-9.7	-6.05	7.26	-5.19	-33.37	-10.02	-2.75	41.01	-19.31	-2.15
	142	13.54	-3.42	27.83	-30.11	11.46	-49.94	-12.74	13.03	10.95	-19.4	-2.16
	241								new	-9.33	-9.33	-9.33
7	141	-5.16	1.44	-0.01	-1.94	10.04	-66.24	46.89	-9.25	9	-15.23	-1.69
	140	0.91	-15.99	10.45	-7.37	3.42	14.79	-23.17	-21.3	31.52	-6.74	-0.75
	139	-12.27	15.41	-5.77	2.71	-33.06	9.4	-21.73	13.3	-28.93	-60.94	-6.77
	138	-14.51	5.98	-2.25	-2.47	-7.11	-12.92	11.61	-14.16	4.47	-31.36	-3.48
	137	5.27	110.53	-5.09	-6.88	3.05	-15.09	2.75	-14.98	-2.03	77.53	8.61
	136	5.79	-4.04	-9.19	4.52	-21.57	-12.53	10.67	-4.89	-12.9	-44.14	-4.90
	135	-0.19	11.03	-0.56	-2.56	-15.66	9.21	-4.52	-14.98	31.38	13.15	1.46
	234								new	-21.36	-21.36	-21.36
Little Egg Inlet												
	134		11.32	-17.53	5.18	-4	-70.12	43.48	-65.45	16.06	-81.06	-9.01
8	133	2.98	-28.85	2.91	3.65	-9.73	-36.13	-27.68	-20.88	20.46	-93.27	-10.36
	132	-15.24	10.78	-17.35	16.18	-10.33	7.47	-4.94	1.37	-5.05	-17.11	-1.90
	131	31.15	7.29	28.92	-23.24	12.88	11.89	-4.96	37.28	12.6	113.81	12.65

(con't) Table 2.

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
Absecon Inlet												
	130	33.08	-15.64	-17.58	15.81	-5.84	2.98	-19.38	9.71	-4.26	-1.12	-0.12
	129	18.12	-8.13	7.95	30.89	-23.59	8.25	-8.26	2.02	-0.46	26.79	2.98
9	128	-8.74	-0.68	25.59	5.46	-13.75	-5.62	-34.48	-12.92	24.16	-20.98	-2.33
	127	-12.12	4.24	-2.98	9.73	-7.76	-29.77	39.35	-20.42	-29.68	-49.41	-5.49
	126	7.59	-11.19	-23.87	44.33	-29	11.28	-24.6	-10.14	25.56	-10.04	-1.12
Great Egg Harbor Inlet												
	225								new	82.7	82.7	82.70
	125	-2.75	-1.96	-12.6	5.04	1.18	128.88	-36.08	-137.56	32.05	-23.8	-2.64
	124	-15.24	5.74	-5.81	5.45	-8.8	-44.7	282.3	-4.18	33.35	248.11	27.57
10	123	-28.81	4.95	3.2	4.67	1.48	-15.05	132.55	-18.21	8	92.78	10.31
	122	-7.56	4.66	-21.56	12.68	-9	14.94	-6.41	-0.96	15.44	2.23	0.25
Corson's Inlet												
	121	-14.03	18.53	-47.92	60.9	-29.33	-110.9	-4.27	22.71	-46.03	-150.34	-16.70
	120	-20.41	9.21	-17.28	19.19	0.4	-49.24	-19.93	-8.74	56.75	-30.05	-3.34
11	119	14.15	1.43	2.15	16.54	-3.33	-17.78	-18.48	-19.43	10.66	-14.09	-1.57
	118	0.59	-12.08	-12.76	17.86	7.86	-16.55	-6.87	-15.4	-0.63	-37.98	-4.22
	117	16.49	-22.08	0.28	-12.96	-2.29	91	-34.88	-23.58	-10.59	1.39	0.15
Towmsends Inlet												
	216								new	255.52	255.52	255.52
	116	-26.66	34.01	6.44	30.47	8.84	75.03	30.96	-70.06	11.18	100.21	11.13
12	115	-1.06	-0.53	8.12	0.14	-7.23	-12.69	-16.56	8.33	18.67	-2.81	-0.31
	114	-20.88	14.75	10.15	9.94	-2.41	-43.06	27.43	-3.4	26.65	19.17	2.13
	113	-38.12	8.36	-12.14	0.8	-6.48	4.63	-2.46	-2.96	0.59	-47.78	-5.31
	212								new	36.1	36.1	36.10
Hereford Inlet												
	111	-55.64	34.06	1.55	-35.65	52.28	-15.44	21.31	-76.41	-28.84	-102.78	-11.42
13	110	-2.88	46.24	6.6	15.1	-108.13	110.31	1.59	10.18	13.09	92.1	10.23
	109	-21.27	15.19	-9.12	25.61	-1.13	-10	-35.32	-5.6	28.1	-13.54	-1.50

(con't) Table 2.

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
Cape May Inlet												
	108	2.03	5.22	41.58	10.91	69.49	12.37	76.64	-19.57	33.1	231.77	25.7522
	107	-1.14	-0.02	-1.07	10.91	91.03	-4.92	43.4	-7.84	29.83	160.18	17.7978
14	106	-34.67	5.55	-17.62	14.14	-8.21	-30.46	-32.68	17.11	5.97	-80.87	-8.9856
	105	-4.89	27.26	19.23	32.74	-26.25	66.76	110.51	-5.93	11.83	231.26	25.6956
	104	-12.84	-4.69	-0.01	-7.84	10.84	-11.84	-8.3	8.68	-14.31	-40.31	-4.4789
Cape May Point												
	103							0.92	0.38	-4.02	-2.72	-0.9067
Delaware	102							-7.53	1.34	-1.49	-7.68	-2.56
Bay	101							4.37	0.84	-0.69	4.52	1.50667
beaches	100							-0.82	1.9	1	2.08	0.69333

Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al.,

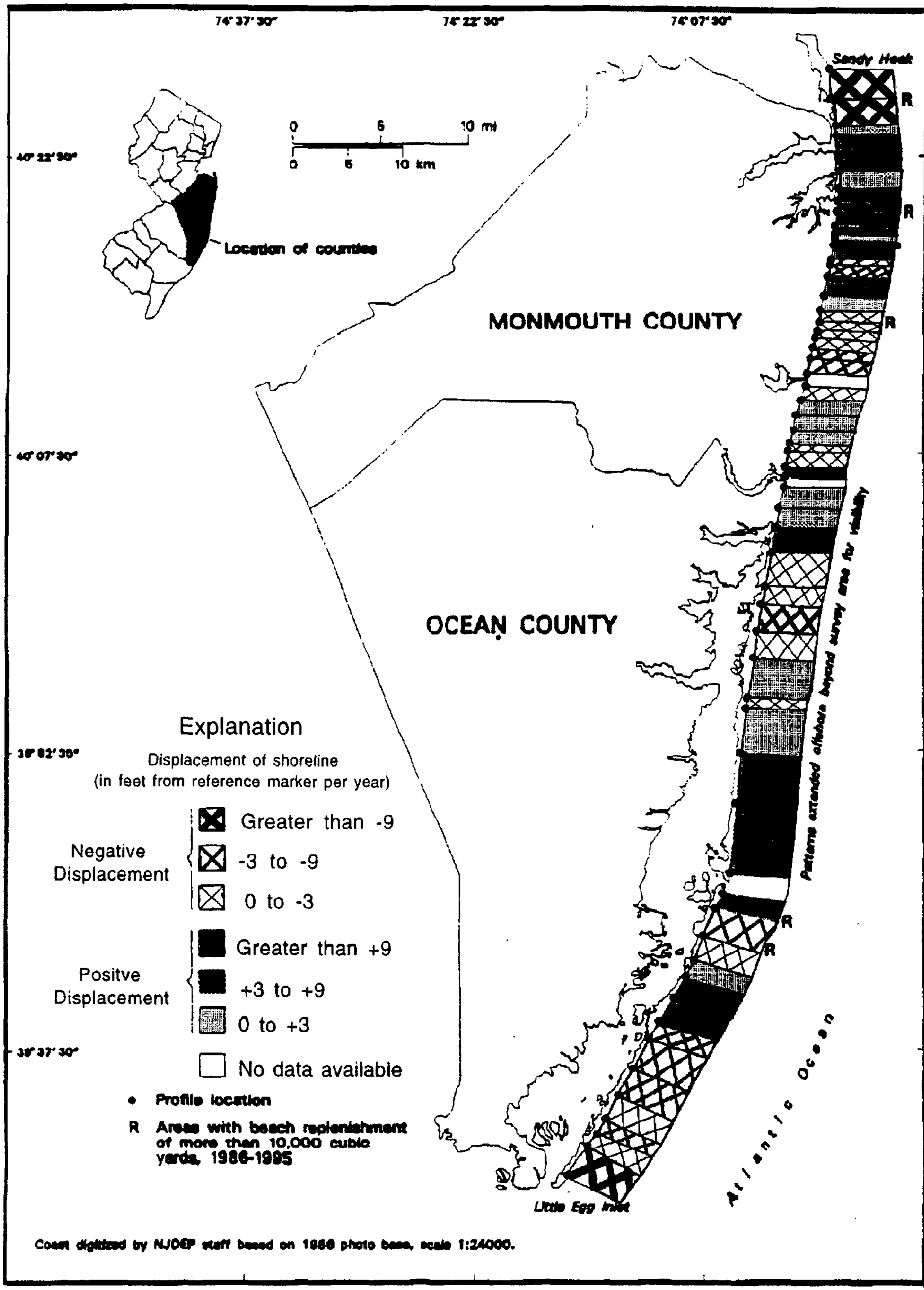

Figure 5A. Average shoreline displacement, NGVD intercept on profile, in feet, 1986-1995, Monmouth County and Ocean County. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

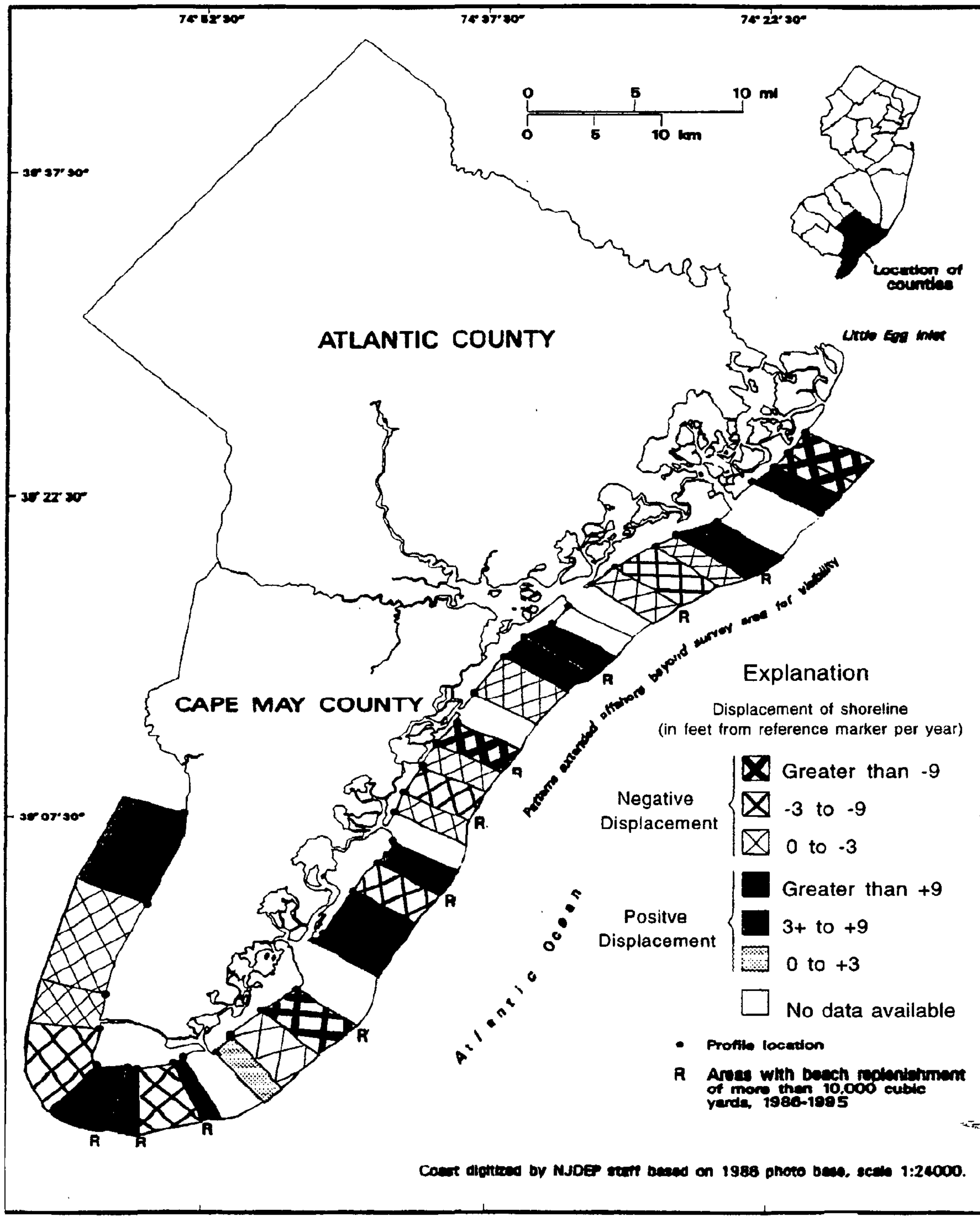

Figure 5B. Average shoreline displacement, NGVD intercept on profile, in feet, 1986-1995,Atlantic County and Cape MayCounty. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

Table 3. Annual displacement of shoreline segments on profiles, in feet, ocean front profiles.

Stations	Avg. for Area	Category	Stations	Avg. for Area	Category
285-284	-19.9	**Less than -9**	**Manasquan Inlet**		
Gateway entrance			156-155	0.456	0 to 3
184-183	1.11	0 to 3	155-154	2.74	0 to 3
183-282	8.45	+3 to +9	154-153	4.185	+3 to +9
282-182	7.42	+3 to +9	153-152	-1.42	0 to -3
182-181	0.465	0 to 3	152-151	-2.69	0 to -3
181-180	17.1	Greater than +9	151-150	-3.945	-3 to -9
180-179	41.78	Greater than +9	150-149	-2.83	0 to -3
179-178	41.685	Greater than +9	149-148	0.181	0 to 3
178-177	16.48	Greater than +9	148-147	-2	0 to -3
177-176	1.605	0 to 3	147-247	0.085	0 to 3
176-175	4.415	+3 to +9	247-246	3.185	+3 to +9
175-174	4.27	+3 to +9	246-146	4.305	+3 to +9
174-173	-0.85	0 to -3	**Barnegat Inlet**		
173-172	-3.68	-3 to -9	245-145	18.45	Greater than +9
172-171	-0.36	0 to -3	145-144	-3.885	-3 to -9
171-170	4.26	+3 to +9	144-143	-0.26	0 to -3
170-169	1.34	0 to 3	143-142	2.75	0 to 3
169-168	-1.62	0 to -3	142-241	4.55	+3 to +9
168-267	-2.31	0 to -3	241-141	3.7	+3 to +9
267-167	-2.88	0 to -3	141-140	-3.35	-3 to -9
167-166	-1.87	0 to -3	140-139	-5.565	-3 to -9
166-165	-5.21	-3 to -9	139-138	-3.655	-3 to -9
165-164	-6.4	-3 to -9	138-137	-1.4255	0 to -3
Shark River Inlet			137-136	-4.268	-3 to -9
163-162	-1.77	0 to -3	136-135	-1.76	0 to -3
162-161	0.185	0 to 3	135-234	-13.67	Greater than -9
161-160	2.975	0 to 3	**Little Egg Inlet**		
160-159	2.365	0 to 3	134-133	-23.41	Greater than -9
159-158	-0.251	0 to -3	133-132	-12.53	Greater than -9
158-157	-0.196	0 to -3	132-131	8.49	+3 to +9
157-256	31.72	Greater than +9			

(con't) Table 3.

Stations	Avg. for Area	Category
Abescon Inlet		
130-129	3.23	+3 to +9
129-128	-0.33	0 to -3
128-127	-8.79	-3 to -9
127-126	-1.87	0 to -3
Great Egg Harbor Inlet		
225-125	N/A	
125-124	20.33	Greater than +9
124-123	13.31	Greater than +9
123-122	-0.662	0 to -3
Corsons Inlet		
121-120	-17.8	Greater than -9
120-119	-2.045	0 to -3
119-118	-3.2	-3 to -9
118-117	2.16	0 to 3
Townsends Inlet		
216-116	148.92	Greater than +9
116-115	5.522	+3 to +9
115-114	-4.164	-3 to -9
114-113	9.83	Greater than +9
113-212	-7.04	-3 to -9
Hereford Inlet		
111-110	-21.01	Greater than -9
110-109	-1.59	0 to -3
109-208	1.615	0 to 3
Cape May Inlet		
108-107	25.93	Greater than +9
107-106	-4.145	-3 to -9
106-105	4.95	+3 to +9
105-104	13.905	Greater than +9
Cape May Point		
104-103	-5.26	-3 to -9
103-102	-2.34	0 to -3
102-101	-1.26	0 to -3
101-100	6.33	+3 to +9

Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al.,

Table 4. Annual displacement of shoreline, in feet, at each ocean profile location, compared to previous year.

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
	285									15.92	15.92	15.92
	284									-55.72	-55.72	-55.72
Gateway Entrance												
	184	-0.31	0.78	0.49	-2.29	-0.55	2.82	0.94	6.25	7.96	16.09	1.23
	183	0	-0.84	3.63	-0.57	2.75	2	0	-3.98	3.98	6.97	1.00
	282									15.92	15.92	15.92
	182	-10.16	11.74	-33.13	26.87	-5.12	0.01	-39.8	-23.88	63.68	-9.79	-1.09
	181	16.04	14.84	-27.24	47.72	-22.43	-3.64	-39	3.98	27.86	18.13	2.01
2	180	-33.13	-24.72	15.11	22.7	-9.59	0.34	-39	35.82	322.23	289.76	32.20
	179	19.07	-18.97	1.6	25.82	-12.38	9.19	-7.6	628.84	-183.08	462.49	51.39
	178	20.44	-16.9	-20.65	50.66	-7.29	-14.89	-41.79	461.68	-143.28	287.98	32.00
Long Branch City Limits												
	177	24.24	-9.84	-13.9	15.99	13.97	-1.8	-47.76	-11.94	39.8	8.76	0.97
	176	47.95	-59.37	2.84	79.49	-61.14	-5.47	-15.92	31.84	0	20.22	2.25
	175	53.61	-33.02	40.46	-24.82	6.79	-15.52	-23.88	-3.98	59.7	59.34	6.59
	174	26.24	17.59	-51.03	21.41	-7.07	14.6	-39.98	31.84	3.98	17.58	1.95
	173	-63.24	6.08	-11.58	21.82	-1.52	-8.37	-3.98	-27.86	55.72	-32.93	-3.66
	172	-38.13	40.62	-60.82	-4.89	31.75	9.21				-22.26	-3.71
	171	89.9	-44.88	-3.27	0.79	2.24	-1.55	-19.04	0	47.75	71.94	7.99
3	170	-4.01	3.88	-3.47	2.64	1.52	1.51	0	39.8	7.96	49.83	5.54
	169	-25.65	-3.08	-1.45	17.91	3.62	42.68	-67.66	0	7.96	-25.67	-2.85
	168	-0.12	-0.82	1.18	18.97	-18.75	0.01	0	27.86	-31.84	-3.51	-0.39
	267	11.79	-43.4	15.66	-21.38	7.2	3.83	-3.98	-7.96	0	-38.24	-4.25
	167	31.04	-35.35	10.08	3.84	5.73	0.8	-29.85	0	0	-13.71	-1.52
	166	-24.03	21.61	-19.35	7.25	9.56	-7.14	-35.82	35.82	-7.96	-20.06	-2.23
	165	-7.72	4.6	-66.62	36.7	-5.19	-19.48	-23.88	15.92	-8.13	-73.8	-8.20
	164	15.86	-19.53	-8.05	-7.22	3.24	2	-23.88	-3.98	0	-41.56	-4.62

(con't) Table 4

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
Shark River Inlet												
	163	6.82	-17.2	4.21	57.48	-53.06	-0.64	0	-27.86	0	-30.25	-3.36
	162	8.68	39.52	-55.54	4.78	-12.74	21.63	-23.88	27.86	-11.94	-1.63	-0.18
	161	-19.3	3.62	8.56	15.72	-19.29	23.65	-23.88	0	15.92	5	0.56
4	160	-13.53	8.72	-4.78	-3.79	-4.69	18.98	-31.84	23.88	55.72	48.67	5.41
	159	-3.17	16.95	-35.94	6.62	7.1	-9.04	-11.67	23.12	0	-6.03	-0.67
	158	-8.09	25.78	-14.68	13.61	-31.1	12.96	-31.84	0	31.84	-1.52	-0.17
	157	-1.97	-11.22	7.21	36.73	-33.5	4.71	31.84	-59.7	23.88	-2.02	-0.22
	256									63.68	63.68	63.68
Manasquan Inlet												
	156	-39.28	39.31	-11.16	54.27	-39.05	14.83	-17.91	27.86	3.64	32.51	3.61
5	155	67.1	-45.26	-18.85	3.67	1.27	-4.2	-43.78	-15.92	31.84	-24.13	-2.68
	154	36.3	-5.94	20.62	12.99	25.65	-23.86	0	-23.88	31.6	73.48	8.16
Metedeconk R.												
	153	2.83	-12.55	-1.29	2.64	-20.62	30.95	-39.8	35.82	3.98	1.96	0.22
	152	-20.35	24.72	-2.52	-10.38	11.14	-10.19	-19.9	0	0	-27.48	-3.05
	151	-2.34	16.4	-57.04	11.11	-17.08	25.83	-15.92	0	17.91	-21.13	-2.35
	150	-74.49	14.09	10.2	-10.2	16.89	-10.37	-11.94	-27.86	43.78	-49.9	-5.54
6	149	7.54	-26.57	-10.03	-28.66	11.63	56.88	-79.6	-11.94	79.6	-1.15	-0.13
	148	-15.08	3.38	-21.88	15.03	-2.3	1.44	-3.98	15.92	11.94	4.47	0.50
	147	-39.22	14.31	-35.23	25.38	-3.97	-5.79	3.98	-31.84	31.84	-40.54	-4.50
	247	5.64	-15.98	26.04	3.28	-33.66	36.87	-27.86	63.68	-15.92	42.09	4.68
	246	-10.52	6.2	-22.81	-243.44	229.7	11.2	-11.94	-15.92	55.72	-1.81	-0.20
	146	398.36	23.69	5.63	-8.66	18.41	-39.75	19.9	12.24	23.88	453.7	50.41
Barnegat Inlet												
	245									39.8	39.8	39.80
	145	0.55	-1.07	-8.92	12.95	14.98	-44.66	-35.82	3.98	31.84	-26.17	-2.91
	144	-7.6	0.59	-9.47	11.05	3.72	1.62	-43.78	15.92	-15.92	-43.87	-4.87
	143	-8.35	-31.95	0.53	12.18	-11.59	8.52	-5.97	8.12	67.66	39.15	4.35
	142	-21.05	-14.61	38.07	-10.19	58.57	-82.7	0	2.46	39.88	10.43	1.16
	241									7.96	7.96	7.96
7	141	8.68	-1.69	-22.03	-1.8	18.15	-52.05	33.83	-11.94	23.88	-4.97	-0.55

(con't) Table 4

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
	140	-10.72	-31.18	16.23	-13.08	2.69	16.42	-11.94	-79.6	55.72	-55.46	-6.16
	139	-39.65	64.77	-53.88	38.49	-67.42	30.55	-11.94	30.13	-35.82	-44.77	-4.97
	138	-26.57	12.4	17.86	-11.89	-19.98	-11.53	27.35	-11.94	3.184	-21.116	-2.35
	137	-18.58	29.61	-13.95	-26.23	11.65	-7	11.94	-27.86	35.82	-4.6	-0.51
	136	-23.65	1.24	-32.48	12.56	-25.62	-19.78	39.8	-19.9	-4.4	-72.23	-8.03
	135	-17.56	87.59	-35.05	1.91	-49.08	32.81	3.98	-7.96	23.9	40.54	4.50
	234									-31.84	-31.84	-31.84
Little Egg Inlet												
	134		404.24	-83.41	0.02	24.29	-131.46	15.92	-15.92	-15.92	197.76	24.72
8	133	-1.62	-99.11	-30.78	-291	295.86	-29.36	-23.88	-7.96	31.84	-156.01	-17.33
	132	-103.59	40.41	-38.76	-3.46	8.61	39.04	-11.94	0	0	-69.69	-7.74
	131	85.59	-21.33	68.54	-20.07	41.57	-8.17	-2.786	95.52	-16.3	222.564	24.73
Absecon Inlet												
	130	59.58	-39.82	-53.23	49.52	-39.64	18.49	1.19	-15.92	15.84	-3.99	-0.44
	129	22.64	-20.72	4.77	38.52	47.17	-38.06	-19.9	-31.84	59.7	62.28	6.92
9	128	-13.45	-31.42	66.25	21.42	-30.08	-9.56	-23.7	-47.76	0	-68.3	-7.59
	127	-30.77	-3.52	-32.85	71.44	26.17	-88.66	7.96	0	-39.8	-90.03	-10.00
	126	52.28	-75.71	-57.74	107	-52.91	91.13	-7.7	-31.84	31.84	56.35	6.26
Great Egg Harbor Inlet												
	225										N/A	N/A
	125	-0.01	0	-98.46	34.87	63.59	403.82	-19.9	-175.12	39.8	248.59	27.62
	124	-48.48	0.09	-63.15	47.68	-17.9	-62.83	222.88	23.08	16	117.37	13.04
10	123	-30.03	-6.94	7	-6.89	12.56	-24.57	155.22	-15.92	31.84	122.27	13.59
	122	-35.12	13.48	-75.5	61.02	-53.67	-12.51	0	-31.84	0	-134.14	-14.90
Corson's Inlet												
	121	-23.24	19.31	-119.4	140.44	-13.93	-157.5	-11.94	7.96	-143.28	-301.58	-33.51
	120	1.98	32.37	-61.58	49.16	-16.93	-11.96	-19.9	7.96	0	-18.9	-2.10
11	119	6.45	-5.27	45.28	-12.24	-27.17	-13.06	-11.94	0	0	-17.95	-1.99
	118	-18.91	-6.62	-25.175	54.105	-3.01	-4.32	-3.98	-15.92	-15.92	-39.75	-4.42
	117	30.3	-56.31	-20.47	-17.19	-7.29	191.32	-19.9	0	-21.88	78.58	8.73

(con't) Table 4

reach #	profile #	1987	1988	1989	1990	1991	1992	1993	1994	1995	net	mean
Townsends Inlet												
	216									278.6	278.6	278.60
	116	196.94	-133	17.33	119.83	-49.79	123.93	0	-47.76	-55.72	171.76	19.08
12	115	-34.05	-8.71	26.82	20.55	13.21	-42.47	-23.88	-47.76	23.88	-72.41	-8.05
	114	-23.9	4.69	28.38	13.94	0.13	-37.86	-3.98	-7.96	24.02	-2.54	-0.28
	113	-140.73	46.15	-12.35	-11.8	-10.96	10.96	15.92	-7.96	-63.68	-174.45	-19.38
	212									47.76	47.76	5.31
Hereford Inlet												
	111	-151.87	79.77	-25.71	-90.09	-68.99	-67.54	51.74	-39.8	-151.24	-463.73	-51.53
13	110	24.78	94.57	6.76	75.96	-160.76	99.91	-39.8	-63.68	47.76	85.5	9.50
	109	-154.99	46.1	-29.6	58.42	0.44	-33.88	15.2	0	-15.92	-114.23	-12.69
	208									15.92	15.92	15.92
Cape May Inlet												
	108	14.56	-6.5	121.58	-0.96	90.96	33.45	67.66	-47.76	54.6	327.59	36.40
	107	-12.78	-4.4	3.65	18.7	174.41	3.56	43.78	-19.9	-67.66	139.36	15.48
14	106	-111.41	17.73	-44.63	36.39	-3.79	-64.58	-59.7	20.1	-4.08	-213.97	-23.77
	105	-16.21	58.54	33.69	89.07	18.29	139.61	218.9	-175.12	-63.68	303.09	33.68
	104	-17.01	-7.74	6.5	-20.35	22.35	-24.57	0	0	-11.94	-52.76	-5.86
Cape May Point												

Sources: Uptegrove, et.al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

adjustment. With a lengthy record the smaller variations will become less significant and the general trend will emerge. Once again, the episodes of beach nourishment and effects ofstructures will influence the measurements and add to the variation. Thus, Monmouth Beach (lines 180-178) and most of Ocean City (lines 125-123) show large net seaward displacements in the areas of beach fill. Most of the changes of shoreline position over the 9 years are within the widths of the beach and thus could just be the interannual variation. The presence of bulkheads, seawalls, artificial dune lines, and other cultural manipulations tend to further limit the inland penetration of the shoreline and partially constrain the displacement of the total profile. Despite the problems of applying and interpreting this measure of the shoreline position, this data set can be used in combination with other measures of change to determine the trend of the shoreline.

Identification of High Hazard Areas

Eventually, it will become necessary to begin to identify the coastal areas which are most exposed and at the highest risk. Those areas can be targeted for hazard mitigation programs that serve to reduce the financial exposure as well as the physical exposure. There is a basis for this areal designation in the data sets detailed above and there are existing characterizations that have made qualitative judgements about the vulnerability at the shore. The earliest reference to hazardous areas is in the National Shoreline Study, North Atlantic Region (USACOE, 1971), which describes and portrays about 82% of the coast as critically eroding (Fig 5), the most severe category. The Shore Protection Master Plan (NJDEP, 1981) also portrayed the areas of critical erosion on the basis of development at risk (Fig. 6), and determined that about 32% of the shore was in that category. Later, Nordstrom, et al (1986) described the areas of critical erosion (Fig. 7) and reduced the percentage to about 20%.

In the process of classifying the shore in the erosion categories, the above reports have developed some criteria that can be applied to determine high risk areas at the shore. These will have value in conducting a more systematic identification of exposed locations. These criteria and their applications are:

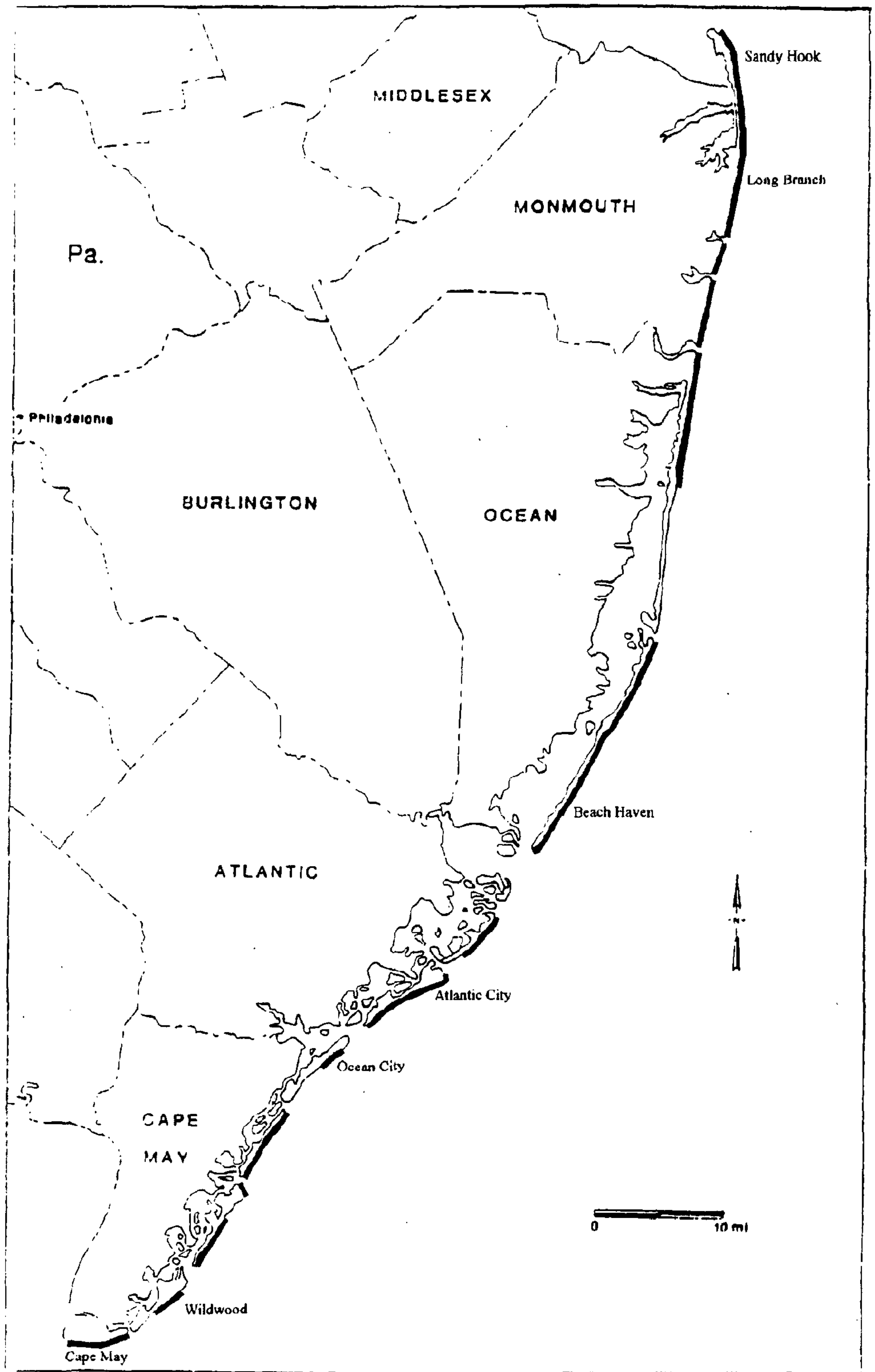

Figure 5. Distribution of critically-eroding shoreline (USACOE, 1971).

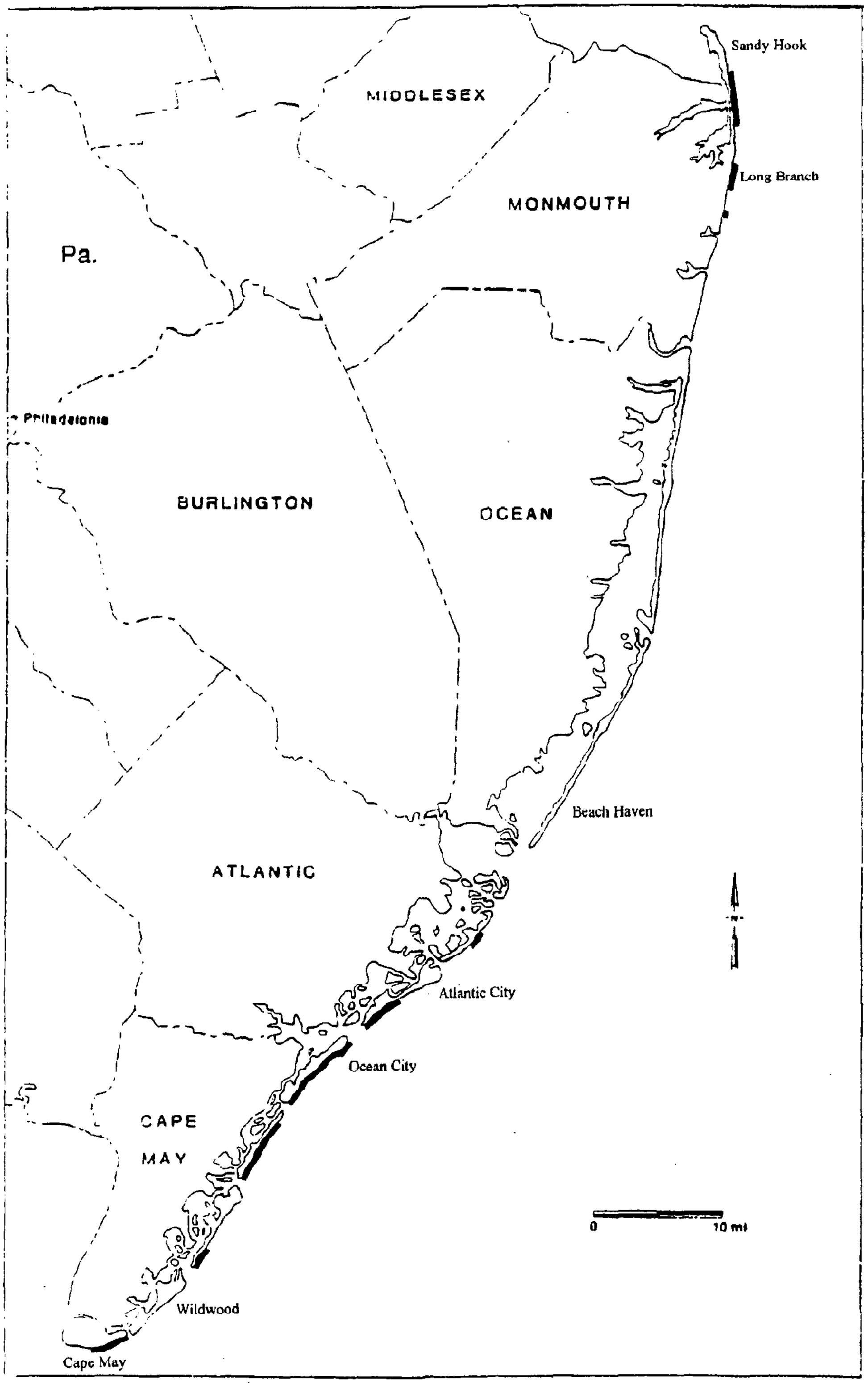

Figure 6. Distribution of critically-eroding shoreline (NJDEP, 1981).

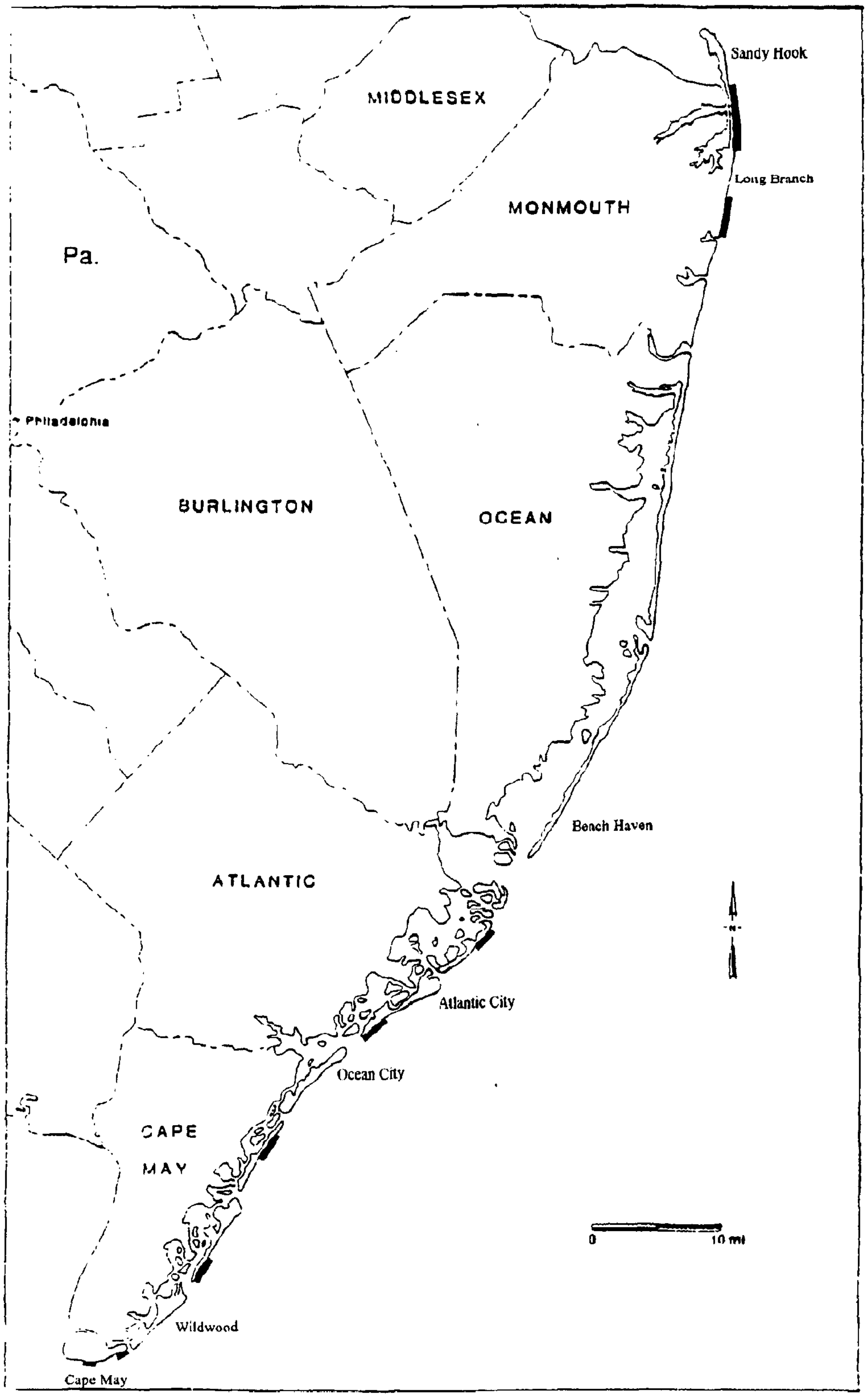
Sandy Hook
MIDDLESEX
Long Branch
MONMOUTH
Pa.
Philadelphia
BURLINGTON
OCEAN
Beach Haven
ATLANTIC
N
Atlantic City
Ocean City
CAPE
MAY
0
10 mi
Wildwood
Cape May

Figure 7. Distribution of critically-eroding shoreline (Nordstrom, et al, 1986).

Erosion rate/Shoreline mobility: Erosion hazard areas can be delineated by using factors such as beach width and height, presence of dunes, sediment budget and density of development (NJDEP, 1981). Property situated in high erosion areas will be exposed to the effects of coastal storms at higher intervals; thus these properties will be subject to repetitive damage. However, in areas of structures and beach nourishment episodes, other variables will be needed to determine shoreline stability/mobility

Inlet proximity: By their nature, inlets are highly dynamic and therefore, adjacent areas are subject to frequent cycles of erosion and accretion (NJDEP, 1985). Barrier island termini are often low and exposed on the downstream end of the islands. The updrift ends are frequently characterized by severe erosion. Structures are also important in affecting mobility at inlets.

Island breaches: Areas of former inlet breaching and locations of former inlets can be identified through historical records. (NJDEP, 1985) Many of these areas are still vulnerable to further breaching during severe storms because they are low and because the sediments are not as cohesive as adjacent sediments. During severe storms these locations are more likely to erode or to breach. Development located in these areas will have higher instances of flood and storm-related damage. Harvey Cedars is a good example of this vulnerability. During the 1962 storm, the community lost almost 50% of their ratables due to the storm and resulting island breaching at the location of an old inlet. (Savadove, 1993)

Overwash areas: Previous overwash areas can also be identified through historical storm damage records and aerial photographs. (NJDEP, 1985) These areas are susceptible to repetitive flooding and therefore, structures situated near these areas are also be prone to flood-related damage.

Application to Management

The New Jersey shoreline does not freely evolve at the present time. There are many barriers to sediment transport and so many episodes of sediment manipulation that the snapshots of the beach at different points in time may be inadequate to fully document the conditions characteristic at the shoreline. The shoreline position data sets are most helpful when they are accompanied by a narrative of the human efforts to alter the shoreline. This is especially true when shore-parallel structures or exceptionally-long shore-perpendicular structures have been constructed that have interfered with the transport of sand. In some cases, attempts have been made to repair the effects of the structures, and in other cases the effects have continued.

Shoreline management may be described as sand management. There is a net long-term loss of sand in New Jersey, as reported in the 1981 Shore Protection Master Plan (NJDEP) and the Corps' Limited Reconnaissance Report (1990). Some portions of the state's shoreline are undergoing critical erosion, whereas other portions are only eroding at a moderate rate or are stable. Management options will vary in accordance with the history of sediment loss, as well as the presence of structures, and the objectives for continued use of that portion of the shore. However, there are several messages that can be gained from the shoreline data sets.

1) Shoreline change and sediment management must be approached on a regional scale.

2) Incorporate volume of sediment as a measure of change; use three-dimensional data rather than the two dimensional shoreline position if possible

3) Establish an objective that is attainable within the reach (region), with cognizance of the natural variation in shoreline change, especially at inlets.

4) Much of the Northern Highlands shoreline has been relatively stable because it is sediment poor and the bluffs are not as easily eroded as the barrier island sediments.

5) Structures, especially at inlets, cause updrift and downdrift shoreline displacements.

6) The exchange of sediment has many short-term variations, longer-term records are needed to denote trends.

7) Beach nourishment causes short-term positive displacements in local areas.

8) Prepare for an inland displacement of the shoreline in the medium- to long-term because of sediment deficits and the effects of sea-level rise.

9) The identification of high risk areas is a step toward the application of mitigation measures to reduce loss and damage. Criteria and level of risk should be assigned to the exposed locations.

References

Farrell, S. C., B. Sullivan, S. Hafner, and T. Lepp, 1994. New Jersey Beach Profile Network: Analysis of the Shoreline Changes in New Jersey, Coastal Reaches One Through Fifteen, Raritan Bay to Delaware Bay. Coastal Research Center, Richard Stockton College, Pomona, NJ, 144 p.

Farrell, S. C., B. Sullivan, S. Hafner, T. Lepp, and K. Cadmus 1995. New Jersey Beach Profile Network: Analysis of the Shoreline Changes in New Jersey, Coastal Reaches One Through Fifteen, Raritan Bay to Delaware Bay. Coastal Research Center, Richard Stockton College, Pomona, NJ, 156 p.

New Jersey Department of Environmental Protection, 1981. Shore Protection Master Plan, 3 Vols., Trenton, NJ.

New Jersey Department of Environmental Protection, 1995. CD-ROM title, et al

Nordstrom, K. F., S. Fisher, M. Burr, E. Frankel, T. Buckalew, and G. Kucma, 1977. Coastal Geomorphology of New Jersey, 2 vols., Rutgers University, Center for Coastal and Environmental Studies, New Brunswick,___

Uptegrove, J., L. Mullikin, J. Waldner, jr. Sheridan, D. Hall, J. Gilroy, and S. Farrell, 1995. Characterization of Offshore Sediments in Federal Waters as Potential Sources of Beach Replenishment Sand -- Phase I. New Jersey Geological Survey Open-File Report)FR 95-1, New Jersey Department of Environmental Protection, Trenton, NJ, 148 p.

U.S. Army, Corps of Engineers, 1990. Limited Reconnaissance Report, Philadelphia District, ___.

FIGURES

Figure 5B. Average shoreline displacement, NGVD intercept on profile, in feet, 1986-1995, Atlantic County and Cape May County. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

TABLES

Table 1. Absolute values of average annual volume changes of profile segments, 1986-1995, ocean front profiles, cubic yards per foot of beach length. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

Table 2. Annual change on profiles, 1986-1995, ocean front profiles, cubic yards per foot of beach length. Sources: Uptegrove, et al., 1995; Farrell, et al., 1994; Farrell, et al., 1995.

Table 3. Annual displacement of shoreline on profiles, in feet, ocean front profiles. Sources: Uptegrove, et al., 1995; Farrell, et al., 1995; Farrell, et al., 1995.

COASTAL ECONOMICS[1]

The application of economic theory and economic techniques can aid in the understanding and evaluation of shore protection policy and coastal erosion issues. Through a presentation of basic economic methodologies appropriate to coastal matters, including Cost-Benefit Analysis, and a review of the pertinent literature, information is presented that leads to an economic analysis of beach use and shore protection. Although several oft-quoted publications are among those reviewed herein, most of the studies to date have internal biases or double-counting in their calculations that reduce their merit in assessing the economic value of beach use and coastal tourism.

WILLINGNESS TO PAY AND BEACH VALUE

Not surprisingly, many of the studies related to the economics of tourism and beach use have been conducted in Florida. Early investigations attempted to assess the economic value of recreational beach use (Curtis and Shows, 1982; 1984) on the basis of willingness to pay to access the beach. In 1981, Curtis and Shows (1982) report that a survey at Delray Beach indicated that residents were willing to pay $1.88/person/day, whereas non-residents (tourists) would pay $2.15/person/day. A survey at Jacksonville Beach (Curtis and Shows, 1984) indicated that residents were willing to pay $4.44/person/day and the tourists would pay $4.88/person/day for beach use.

The concept was expanded by Bell and Leeworthin (1985; 1986; 1990) in a study of the economic importance and value of beaches in Florida. Using surveys, the studies found the residents were willing to pay $1.31/person/day (1984$) and the tourists would pay $1.45/person/day. In addition the study showed that the economic value of beach use amounted to $10.23/person/day for residents and $29.32/person/day for the tourists. This value provides an estimate of the value of the beach in economic terms. Further, the study reported that residents would be at the beach 14.68 days/person annually whereas the nonresidents would be there 8.64 days/person.

VALUE OF BEACH PROTECTION

In a study of the economic benefits of beach protection in New Jersey, Silberman and Klock (1988) and Silberman, et al (1992) surveyed beach users in the area from Sea Bright to Deal for the purpose of assessing the use and nonuse (existence) values attributable to beach protection. In 1985$, the survey showed a willingness to pay $3.90/person/day for a nourished beach versus $3.60/person/day for a non-nourished beach. Further, the application of existence

[1] This portion of the report is a summary of the information included in an accompanying White Paper on Coastal Economics

value reported an average one-time contribution of $16.31/person (1985$) for a nourished beach.

A range of the estimated average net economic value associated with beach protection was derived from several studies, yielding a low estimate of net economic value of $.35/person/day (1992$) and a high estimate of $.39/person/day. Similarly, there was a range of net economic value from $.35/person/day-trip to $.39/person/day-trip (1992$).

BEACHES, TOURISM AND ECONOMIC DEVELOPMENT

Recently, several articles have examined the role of beaches in tourism activity, economic activity, and in economic development (Stronge, 1994, 1995; Houston, 1995a, 1995b). The basic theme is that tourism expenditures in beach communities are attributable to the presence of a beach and that beach tourism spending can contribute significantly to local, regional, and national economies. Although there is certainly an impact of tourism in beach communities, there is a question whether 1) spending in beach communities contributes significantly to local economies and/or state/regional/national economies, and 2) if all tourism expenditures are directly related to the presence or proximity of a beach.

Notwithstanding that the nature of tourism in coastal areas can create impact effects (spending effects over and above residents' spending) and possibly contribute to economic development if the tourism effect is large enough, several shortcomings of the papers reviewed weaken their results. These limitations differ by paper and include the following: 1) in several papers projects economic impacts were based on a misinterpretation of aggregate economic activity measures (i.e., GDP); 2) the estimated participation rate of beach use in one paper was based on a misleading procedure that could have introduced an upward bias in the projected estimates of coastal tourism spending and impacts; 3) another paper used statistics from secondary, unofficial sources -- such statistics can be quite misleading and the potential bias and error inherent in secondary source statistics limits the accuracy and usefulness of any research based on such data; 4) other miscellaneous limitations concern the research design, the survey design, interpretation of expenditure data and impact estimates, derivation of impact estimates, sample size and representativeness of sample data. Because projected expenses of beach use can become easily inflated and unrepresentative, the limitations and results found in the studies reviewed raise a general word of caution for research in this area. Future studies should be rigorous, based on accepted research approaches and designs, and use appropriate statistical data, otherwise results will be of little use and will only cloud the issue of the relative economic importance of coastal tourism vis a vis investment in shore protection.

EXPENDITURES AND IMPACTS OF TOURISM ON THE NJ SHORE

The usefulness of the Longwoods study is in the generation of projected direct expenditures discussed above and not in economic impacts. Direct expenditures represent the closest activity to aggregate GNP estimates, because they represent the sales of final goods and services sold, and do not contain double-counting. Regarding coastal tourism, the Barrier Island (long-term beach rentals)(LTBR) component of the Longwoods study represents only one segment of beach travel and underestimates the importance and magnitude of tourism expenditure activity (expenditures other than LTBR) in the coastal region of New Jersey. To develop an estimate of all expenditures associated with beach travel, similar estimates for day trips and other overnight trips (i.e., hotel/motel/resort, campgrounds-private and public, and those that stay with friends/relatives) for the four-coastal counties are necessary. On the basis of the estimated number of trips and the estimated average trip expense, an upper bound for expenditures of all beach-related travel was estimated at $2,095.877 million ($1,917.92 million without gambling (by long-term renters)) for 1993. The Barrier Island (LTBR) component represented 41.74% of the 1993 estimated tourist beach-related expenditures. If this proportion is representative across other years, the three-year (1992-94) estimated average expense for beach trips would account for an estimated $1,887.64 million average/year (45.57% of the estimated total) and an estimated $1,726.75 million average/year without gambling in 1992 dollars. However, the reader is cautioned in reading too much into these estimates; they were developed for illustrative purposes. Little confidence can be placed in the estimates; such estimates should be developed from a single sample base rather than from two, and should be developed as part of an objective of the travel and tourism studies in the form of a range. The estimates developed are meant to illustrate the point that projected tourism expenses associated with beach trips based on the Barrier Island component are underestimates of such activity, whereas the county-level estimates of the four-coastal counties are overestimates of beach-related economic activity. The derived estimate, $1,887.64 million average/year over the 1992-94 period in 1992 dollars, represents 18% of the four-coastal county three-year average, and 9.8% of the state three-year average (without gambling expenditures the estimate is $1726.75 million/year representing 23.8% of the 4-coastal county 3-year average, and 10.5% of the 3-year state average). In 1993, the LTBR and other beach expenditures for the four coastal counties totaled about $2.0 billion; gambling expenditures at Atlantic City totaled $3.2 billion. Thus, beach-related tourism and recreation plus gambling accounted for more than half of the $9.7 billion of tourism expenditures in the four coastal counties in 1993. These values are estimates from the data reported in the Longwoods study and represent the approximate role of beach recreation and tourism in New Jersey. Further effort should be directed to incorporate beach-related information in future Longwoods studies.

SHORE PROTECTION POLICY-ORIENTED STUDIES

The Cost-Benefit Analysis (CBA) performed in the New Jersey Shore Protection Master Plan (NJSPMP) is basically static, although some attempt was made to incorporate changes that occur over time, namely estimates of future beach use and estimates of future property lost or damaged. No attempt was made to incorporate any other dynamic elements nor the risk associated with the expected outcome of the projects, where one could introduce uncertainty into the derivation of net benefits (benefits less costs). A dynamic analysis would compare and contrast the monetary value of a projects' outcome if completely certain versus that with the presence of uncertainty. In the case of beach protection, possible risk factors could involve such effects as erosion and storm damage that could cause any project from not being 100% completed, uncertainty over available funds to ensure 100% completion of any project over the planning period, and uncertainty over the estimated number of future beach users, and the value of estimated future property structures lost versus protected. Probably the most serious fault is the problem of downward bias in both the cost and benefit estimates which would tend to introduce either an upward bias or a downward bias in the magnitude of the B/C ratio, respectively, distorting the B/C ratio. The net effect is ambiguous, but places concern over the validity and accuracy of the CBA in the NJSPMP.

Policy findings of the ICF (1989) study were the following: 1) "new" development in coastal floodplains was found to be a net cost to governments, "existing" development in many cases was worth protecting; 2) the "best" policy response was found to depend on the following factors a) the existing level of development, b) costs from damage, and c) magnitude of revenues gained; 2.a) in areas that are relatively less-developed, beach nourishment was found to be a viable policy; 2.b) in areas with high levels of development, protection via dikes was found to be a viable policy where large amounts of property could be damaged and where dike building could be coupled with a policy of halting further development; 3) optimal policies differed over time; and 4) the use of subsidies, e.g., NFIP, was found to have important consequences on development (in the promotion of development).

Policy recommendations offered by ICF (1989) were for two categories, 1) future development, and 2) existing development. Concerning future development, ICF recommended that: 1) continued large-scale development would be a net cost to governments (costs greater than revenues); 2) NFIP should tighten the availability of flood insurance to discourage future development (such action would have an effect similar to one where property owners are charged the full costs of flood insurance); 3) policies should be implemented whereby property owners are charged the full costs of cleanup and repairs; 4) policies should be designed to prohibit reconstruction of structures and land should be rezoned following significant storm damage (e.g., when 50% or more of a structure is damaged); and 5) governments should establish future policies on shore protection and announce these to the public (the idea is that if governments pre-commit to a policy of no provision of shore protection in areas facing "new" development, this will create disincentives for future development and cause property owners to internalize and bear the full costs of damage and cleanup).

Regarding existing development, ICF admits that policy choice "is not an easy answer," (ICF 19887:60). Recommended policy options were found to depend on development levels; ~~in~~ areas with high levels of development is was recommended that policies protect existing structures, whereas in areas with low levels of development, policies of protection were not recommended, but recommendations of property acquisition, rezoning, tightening of insurance, and having owners assume the full costs of damage and cleanup and accept losses of capital investment in buildings and from losses of the tax base were.

RECOMMENDATIONS FOR IMPROVING ECONOMIC ANALYSES

A variety of economic techniques such as CBA, Input-Output models, simulation models, risk-return models, and other relevant economic approaches needs to be explored to determine their relative importance and usefulness in policy-oriented studies of shore protection and in their assessment of tradeoffs among the policy options to determine whether or not all economic techniques provide similar policy recommendations (there is a possibility that different policy outcomes could result from different techniques because the techniques emphasize the different criteria and information).

The building of pertinent databases, which involve the collection and development of appropriate data necessary to specific economic approaches will be dependent on the specific approach and can be a very lengthy process. Some of these data can be gathered from the respective USACOE districts (especially for inventory surveys of physical structures), some will involve statistics and data generated from the state government.

The ICF (1989) study demonstrates the complexity of the issues involved in public policy tradeoffs. However, this is the tip of the iceberg; an analysis should be intertemporal rather than static; performing an analysis that is intertemporal and involves many cost and benefit components is an extremely tedious and complex task; resources of time and funding must match the complexity of the problem;

The analysis must incorporate the elements and effects of uncertainty in benefit and cost estimates since these depend on the probability of storm occurrence as well as the magnitude of the storm; hence cost and benefit items are stochastic in nature and vary according to storm severity, time and sea-level rise.

The analysis must also incorporate the element of risk associated with project failure and outcome.

ICF (1989) demonstrates that there are many more elements to consider regarding policy tradeoffs (level of development, future vs. existing development, level of erosion, storm events, availability of flood insurance, who should bear the burden of flood insurance and that of cleanup and repair costs, land rezoning issues, reconstruction policies, and future shore protection policy stances); future analysis must be designed to incorporate these numerous and varied elements.

MITIGATION

RATIONALE

The main objective of the mitigation is to reduce damage and loss from natural hazards and to improve public safety. An important part of the 1996 Coastal Hazard Management Plan is to emphasize mitigation as a tool to reduce exposure for people to the risks of living near the shoreline. Many emerging trends on a local and national level show that mitigation is developing as part of a response to managing existing hazards as well as helping to cope with those which will continue to happen in the future. Not only do we have to contend with major hazards - storms and hurricanes, but we must also take into account other factors such as sea level rise which, although a slower process, increases the extent of storm effects and flood levels, and exacerbates.

It has been realized that many approaches that were thought to be appropriate in the past are not so anymore. Past management had addressed the shoreline as if it were static, whereas the system is extremely dynamic, requiring special attention and considerations. These static approaches have proved to be futile in some cases and detrimental in others. An alternative approach to successfully handle these natural hazard issues is to mitigate their effects in the first place, or to at least try to lessen them.

As part of the 1996 Coastal Hazard Management Plan, hazard mitigation is only one of the many components. However it is one of the most important, and seeks to provide the best approach to protect human life and reduce risk for those living near the New Jersey shoreline. Natural hazard mitigation will become the means by which coastal planning is handled and disasters can be averted.

Mitigation is both a philosophy and an approach. It builds on the understanding that it is impossible to defend against all of the forces that are causing change at the shore. It derives from an emphasis of reducing the risk to people rather than protecting things. However, mitigation requires a regional approach to be applied most effectively. It requires an interactive approach reaching across the several levels of government and merging the objectives of the several levels.

Details about the application of mitigation are presented in the next section on 'Approaches" There are many strategies that qualify as mitigation, just as there are many degrees of exposure and risk at the shore. Indeed, the variety of coastal conditions requires the consideration of a multi-faceted program to risk reduction and public safety in New Jersey. .

SHORE PROTECTION STRUCTURES

A wide range of shore protection approaches have been implemented to adjust to coastal erosion processes. Both engineered (including shore parallel and shore perpendicular techniques) and non-engineered approaches (including beach augmentation and stabilization techniques) have long been utilized by the state to mitigate the natural loss of beach sand from shorefront property. Since the turn of the century, beach erosion control methods have concentrated on the construction of permanent structures such as jetties, groins, seawalls, and breakwaters to protect the shore recreation industry. Coastal protection structures have been built along 102.66 miles or 80.8 % of the total New Jersey beach front. Protective structures are located in 41 of the 45 shorefront communities. The following section provides an inventory of engineered shore protection approaches currently utilized along the New Jersey shore. Each approach is discussed in greater detail in terms of the (1) short-term/long-term positive and negative impacts (2) the associated costs and benefits, and (3) the life expectancy of the method in the white paper *New Jersey Shoreline Future: A Review of Shore Protection Approaches and Strategies Utilized in New Jersey* (See Appendix).

SHORE PERPENDICULAR STRUCTURES / INTERCEPTING SHORELINE TRANSPORT

Groins

A groin is a stone, concrete, steel or timber structure placed perpendicular to the shoreline. It is designed to slow the rate of littoral drift of sand and to capture sand along the updrift side causing accretion of sand. Groins are built at varying lengths and with a range of profile shapes (e.g., constant top-elevation or sloping top-elevation - low profile groin). There are 368 groins within the four New Jersey coastal counties. Most NJ groins were built between 1942 and 1967.

Jetties

Jetties are constructed at inlets and are used primarily to confine tidal flow and to prevent littoral drift from shoaling the channel. Jetties are often constructed in pairs and are designed to help stabilize the depth and location of channels. There are 24 jetties within the four coastal counties, built between 1908 and 1967.

Breakwaters

Breakwaters are offshore structures constructed of stone and/or concrete armor units (CAU). They are designed to protect shore areas from direct wave action and to create littoral sand traps. Breakwaters may be attached or detached from the mainland. According to the Inventory, there is only 1 attached breakwater in Ocean City, NJ. This breakwater was built in 1965.

Wavebreakers are closely associated with breakwaters and groins. They are described as rows of closely-spaced pilings in the beach connected by tie rods to a timber bulkhead on the inshore face (**Fig. XX**). There are 5 wavebreakers (2 in Long Beach, 1 in Ventnor, and 2 in Strathmere) recorded in the *Inventory of NJ Coastal Structures*. The construction date for wavebreakers in largely unknown, with the exception of the Ventnor construction which was built in 1920.

Artificial Reefs

The artificial reef is the only major addition to the suite of shore protection approaches currently implemented along the NJ shore. In 1993-94 three artificial reefs were installed along the Atlantic shoreline of Avalon, Cape May Point, and Belmar/Spring Lake, New Jersey. The reefs, designed by Breakwaters International, in Flemington, NJ, are composed of interlocking concrete units and measure approximately 1000 ft. in length. As pictured in **Figure X**, the structure consists of a ribbed seaward face and a more steeply sloping landward face leading to a slotted opening that runs along the slightly curved crest of the reef. These units were engineered to theoretically reduce the offshore loss of sand during storm events through (1) the reduction of the incident wave height, and (2) the creation of a vertical current (through the deflection of bottom flow upwards through the slotted openings at the crest).

Each reef installation varies greatly in its configuration and conditions. Both the Avalon and Belmar/Spring Lake projects included nourishment of the landward beach. The Avalon reef was constructed immediately adjacent to an inlet (Townshend Inlet) and was the only structure to have an open end. Both the Belmar/Spring Lake and the Cape May Point installations involved a complete spanning of groin compartments. In all cases the reefs were connected to the groins or jetty with additional stone placed at the junction with the reef structure. All reefs were placed with different top elevations (i.e., depth of water at mean low water). The Cape May reef was placed in the most shallow water, followed by the Belmar/Spring Lake, and the Avalon reef. Geotextile fabric or mattresses were placed beneath each unit to provide scour protection.

The Beachsaver Reefs were evaluated through a State-sponsored monitoring project conducted by engineers from the Davidson Laboratory at Stevens Institute of Technology in Hoboken, NJ. The monitoring effort included beach surveys, offshore bathemetric surveys, wave and current measurements, dye release studies, and visual (scuba) inspections of the structures. Each of the three reefs varied in success.

The Avalon Reef was considered a qualified success in limiting the loss of the renourished beach. The northern portion of the project site seemingly insulates the area from the strong tidal currents in the Townshends Inlet channel. The reef has not, however, provided the same degree of protection in the southern portion of the installation. This area has experienced the same rate of erosion as the unprotected area to the south, and has exhibited a local scour zone just landward of the southern end of the structure. This loss of sediment is thought to be caused by the *open end* at the southern limit of the installation. Because the area is not sheltered by a groin installation, Stevens engineers think the reef causes an enhanced wind/ wave-induced set up in the area immediately shoreward of the structure thus causing a loss of sediment.

Both the Belmar/Spring Lake and the Cape May installations have experienced accretion landward of the reef. Of some concern, however, is the presence of local scour zones immediately landward of the reef in enclosed situations. These scour zones do not appear to extend any great distance landward. This feature is thought to be caused by the deflection of the bottom flow by the reef thereby causing locally intense bottom shear stress and sediment removal.

The Belmar/Spring Lake installation has experienced a redistribution of sand to the offshore bar. The severe berm erosion and bar formation was the result of several major storm events associated with a very active hurricane season in 1995.

Stevens engineers conclude the artificial Beachsaver reef lose their effectiveness in the vicinity of an open end, and should therefore either be employed only in the protection of natural or man-made (e.g., groins) cells, or should be re-designed to minimize the end effects. Research has indicated there is no evidence of reef impact on adjacent beaches. The reefs do not impede nearshore water exchange and become productive bottom habitats.

SHORE PARALLEL APPROACHES / SAND RETAINING AND STABILIZING APPROACHES

Revetments

Revetments are placed on the seaward face of a slope and are designed to stabilize an eroding shoreline in areas of light wave action. These structures are often composed of interlocking concrete blocks or stones called rip-rap. There are only 5 revetments in NJ built between 1952 and 1962.

Bulkhead

Bulkheads are vertical walls constructed of steel or concrete sheet piling, creosote treated lumber, aluminum, plastic, or timber. These structures extend from below low water to above high tide and usually do not experience direct wave action except during storms or other high water events. There are 82 bulkheads along the New Jersey shore, built between 1905-1989.

Seawall

Seawalls are constructed of stone or concrete and are sometimes built with a curved face to dissipate wave energy and prevent undermining. They are designed to sustain the full force of wave action, and are often used in conjunction with other structures. Seawalls as well as bulkheads, are designed to only protect the land immediately behind them. There are 14 seawalls built between 1898 (at Sandy Hook) to 1980 (Avalon).

Sediment Filled Fabric Tubes

Elongate fabric tubes have been used as a barrier to coastal processes. They have a diameter of 2-8 ft and are usually filled with local sediments in place. The tube envelope is made of a soil tight geotextile fabric and is hydraulically filled with a soil-water mixture. The tubes have been used at locations of severe erosion in New Jersey in the past as a form of elongate sand-bag revetment. More recently, they have been used in New Jersey in two different situations. In Atlantic City, they have been placed on the upper beach in front of the boardwalk, filled with sand pumped from the beach, and covered with sand to create a dune **(Fig. XX)**. In Avalon, they have been placed at the low tide line at the inlet to form a type of low revetment **(Fig. XX)**. In both cases the use of filled fabric tubes is to encapsulate some of the local sediments and form a barrier to the sediment transporting processes, a type of wall. In areas of modest erosion, they will protect the areas to their inland side. In locations of high erosion, they will be undermined and shift seaward. Although they are resistant to ripping and tearing, if they are torn, the sediment will wash out.

APPLICATION OF STRUCTURES

Shore structures, although abundant throughout the state, are directed toward local erosion or stabilization problems. Generally, they attempt to restrict the movement of sediment either by slowing its rate of passage through an area, or to keep sediment out of an area. The structures do not create any new sediment so that they do not change the balance of sediment availability to a region. They do locally redistribute existing sedimen supplies. Most structures have downdrift effects because of the local interference of sediment transport. If they are used, they should be part of a regional program for sediment and shoreline management. Walls and barriers are frequently the last resort in attempting shoreline stabilization.

Beach Nourishment

The history of shore protection in New Jersey is a long narrative of attempts to defend a shoreline position. Reports produced by the New Jersey Beach Erosion Commission describe and illustrate the continuing construction of barriers to reduce wave energy or to retain sand in the beach (1930; 1950). More recent publications by the Corps of Engineers chronicle the construction of groins, jetties, and bulkheads in New Jersey in a photographic record of the placement of these structures (1964; 1990). It is an impressive collection of continuing efforts at shoreline stabilization by structural means. The photos from both the State reports and the Corps publications illustrate the central problem identified earlier in this document: that is, at the present time there is an absence of sediment input to the coastal zone to build beaches and to buffer the effects of the incident waves. Therefore, the result is a continual erosion of the beach and a stranding of structures in the sea in various states of disrepair and function.

As stated in the 1981 SPMP (Vol. I, Chapt II) and in the beach policies of the New Jersey Coastal Management Program of 1980 and revisions, the preferred approach to managing shoreline erosion was non-structural, such as beach nourishment, although some structural approaches may be conditionally acceptable. The rationale proposed for favoring beach nourishment as the non-structural approach at that time was that it was the approach preferred at the Federal level, although it was noted that beach nourishment was an expensive approach to countering erosion. Further, beach nourishment was viewed as interacting with the natural dynamics of the beach and moving away from the static approaches of the past. An important consideration introduced was the provision of a recreational beach associated with beach nourishment and that consideration merged with the anticipated additional need for a beach capacity to meet the demands of a projected recreational requirement (SCORP, 1977). Thus, the direction established by the policy at the time attempted to restrict any further construction of hard structures because of a long history of localized interference with sediment transport in the beach zone. Instead, the policy stressed support of existing beaches on a regional basis and discouraged any actions that would interfere with the processes of sediment transport and accumulation in the existing beach system.

A major advantage to the beach nourishment approach to shoreline stabilization is that it addresses the basic problem of insufficient sediment availability in the coastal zone. This approach replaces the losses and rebuilds the beach to some previous position. In concept, beach nourishment should contribute to the maintenance of the beach, the offshore zone, and the foredune. The new sediment will be lost in time, but that is the intended scenario. The addition of sediment provides some period of time before the beach is eroded to its pre-nourishment position. According to the 1981 SPMP, beach nourishment should be planned to address the concerns of an entire reach and not an isolated erosional problem. There should be an opportunity for the emplaced sediment to move downdrift and buffer other beaches in the reach. Further, it is stated that the application of beach nourishment should be not be used to address an emergency erosional condition.

HISTORY OF BEACH NOURISHMENT

Beach nourishment projects are usually directed to broaden and heighten the beach surface, producing a berm which is 10 ft above mean low water and is 100 ft wide. The offshore slope of the berm usually has a ratio of about 1:30 down to the intercept with the pre-existing surface. Sometimes, a design dune is incorporated at the inner margin of the berm.

Past beach nourishment has seen sand placed on the beach by various means and from various sources. Small amounts of sand (thousands of cubic yards) are frequently transported by truck and dumped on the beach where severe local erosion may be penetrating inland to endanger property or infrastructure **(Fig. 1)**. Larger amounts (hundreds of thousands to millions of cubic yards) are usually pumped to the beach site by pipeline **(Fig. 2)**. The sand is derived from the offshore or inlet initially by dredging and then transferred directly or with some intermediate handling to the beach. Because of the large volumes involved with pumping, the emplacement usually combines building the beach at a selected position with placing sand in an updrift location (feeder beach) so that some sediment is being released downdrift to further buffer the effects of

Figure 1.
Beach Nourishment in small section of shoreline, emplaced by truck and earth moving equipment.
Brant Beach

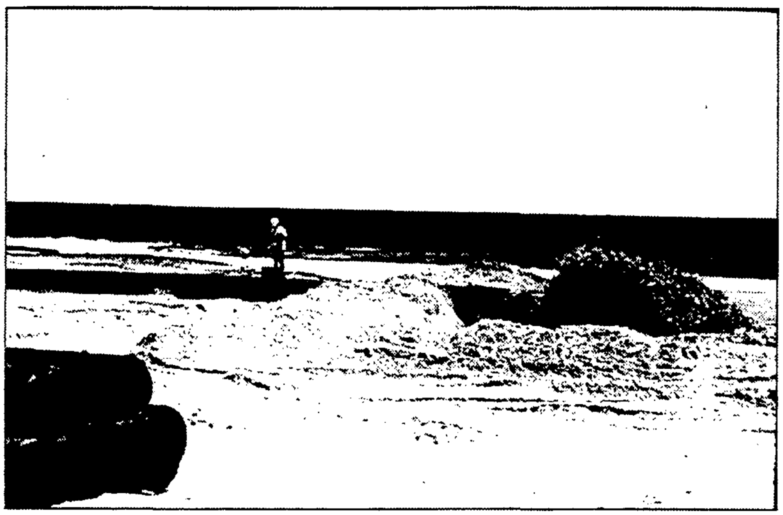

Figure 2.
Pumping of sand onto beach via pipeline.
Ocean City

erosion. The feeder beach concept is a sort of stockpiling of sediment to be released over some time period to downdrift locations of a reach. It fosters the application of sediment management throughout a reach rather than a single location of erosion.

Large scale beach nourishment was applied to the New Jersey beaches following the March 1962 storm that caused great damage and erosion. In 1962 and 1963, sand was pumped onto the beaches in quantities reaching approximately 7,500,000 cubic yards and 4,650,000 cubic yards, respectively (USACOE, 1990, augmented by data in the NJDEP files). Each of the coastal counties had some sand transferred to the beach to rebuild the beaches and dunes. Most of the subsequent projects were small, local episodes, except for a few projects in either Atlantic City or Ocean City. The costs of the projects were a significant constraint. For most of the small shore communities, the high cost of pumping sand was beyond their financial capabilities, and even the larger cities necessitated substantial state aid. The 1980s demonstrate an increasing amount of sand emplacement on the beaches of New Jersey (Fig. 3), sometimes in response to storm erosion (1984, 1993) or as parts of a longer-term program. There were several very large beach nourishment projects during this time, including an extensive project at Sandy Hook in 1983 and 1984, repeated in 1989 (Federally-supported), plus efforts at Ocean City and Atlantic City (largely state-supported) (Fig. 4). Beach fill in the 1990s continued to increase with ongoing efforts at Ocean City, Cape May City, Monmouth Beach, and Sea Bright. A strong catalyst for beach nourishment was the creation of a stable funding source for beach protection approved by the State Legislature in 1992. The pool of $15 million annually for the Shore Protection Fund to provide most of the non-Federal share (35%) in the post-1992 period is an important factor in supporting the new emphasis on pumping sand onto the beaches.

POLICY AND ENDORSEMENT

Support for beach nourishment exists in the 1981 SPMP, but with several important qualifications. Initially, the plan suggests that beach nourishment be used to maintain existing recreational beaches and further indicates that this approach should not be applied as an emergency measure, primarily because it then be contrary to the original intent of strengthening

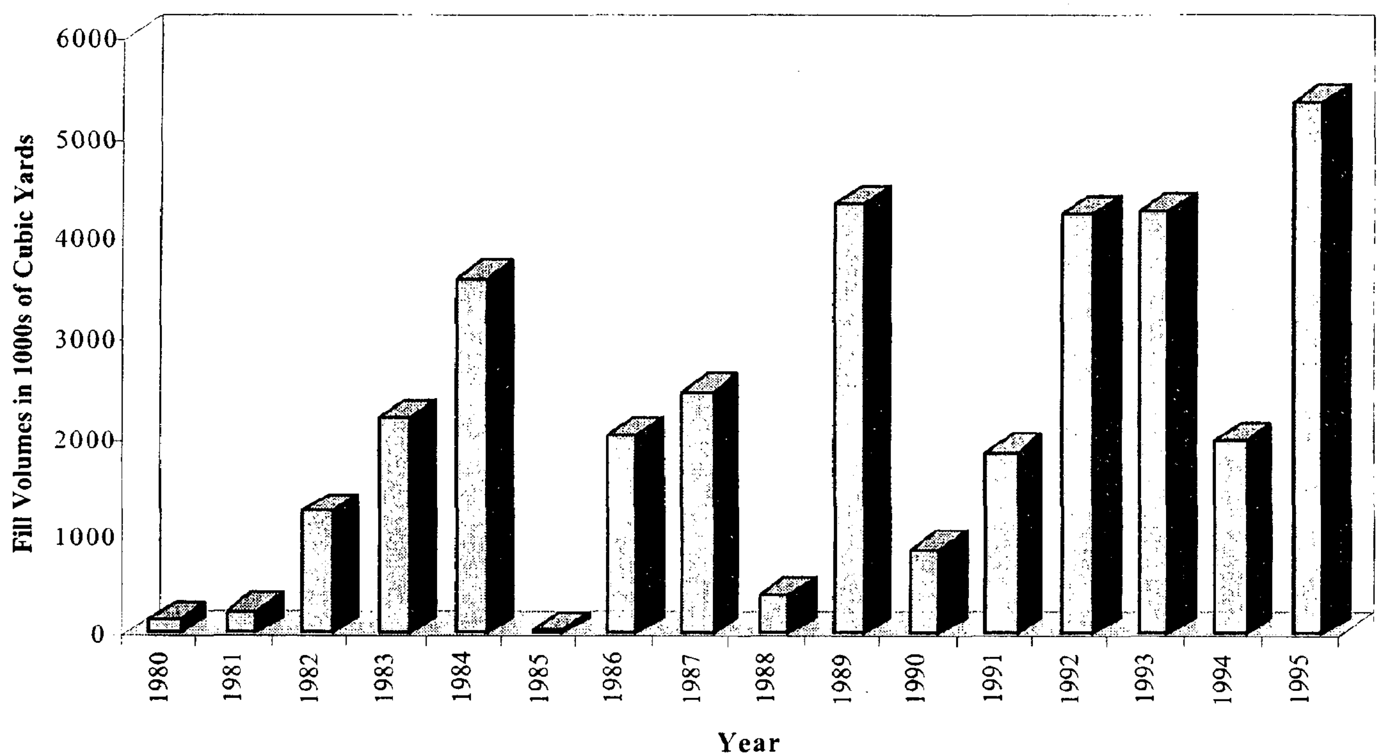

Figure 3. Beachfill, by Year, along Coastal New Jersey. Sources: Uptegrove, J., et al, 1995; USACOE, 1990; USACOE, 1995 NJDEP Files.

Figure 4. Listing of Beachfill Projects, New Jersey, 1980-1995. Sources: Uptegrove, J., et al, 1995; USACOE, 1990; USACOE, 1995, NJDEP Files.

Project No.	Location	Dates	Amount of fill cubic yards	Site	cost	Other Information
NJDEP	Allenhurst	1985	35-40,000 yd			
174a	Atlantic City	1/83-6/83	75,000 yd	Mass Ave to	$358,250	trucked
575	Atlantic City	9/86-2/87	1,000,000 yd		$7,000,000	
576	Avalon	1987	1,300,000 yd	8th to 30th St.	$2,400,000	
1219	Avalon	12/87-1988	158,945 yd		$2,873,940	
NJDEP	Avalon	1989	60,000 yd			
	Avalon	1990	330,000 yd			
NJDEP	Avalon	1992	350,000 yd			
567	Avon	1981	136,000 yd		$352,240	
NJDEP	Barnegat Light	1991	75,000 yd	Dredged from Barnegat Inlet		
171	Cape May	12/22/81	36,000 yd		$93,000	
583	Cape May	1991	770,000 yd		$1,017,501	
578	Cape May, U.S. Coast Guard	1989	465,000 yd		$1,334,059	100% USCG
583/584	Cape May City	1991	900,000 yd		$3,690,000	
587/fed	Cape May City	April, 1993	415,000 yd		$2,370,000	storm rehab
587	Cape May City	1992	500,00 yd			
fed	Cape May City	Sept,1993	300,000 yd		$2,135,000	1st nour cycle
fed	Cape May City	9/94-2/95	330,000 yd		$2,605,000	2nd nour cycle
NJDEP	Cape May Point	1992	42,000 yd	Dredged from Cape May Canal		
1217	Cape May State Park	1/85 -86	15,000 yd	sand dune construction	$272,618	

176	Cape May State Park	6/14/92	200,000 yd		$261,905	
581	Harvey Cedars	1990	27,300 yd		$34,957	
2092	Harvey Cedars	1/1/92	110,000 yd	between 85th and 82nd		
2092						
4005 NJDEP	Harvey Cedars Long Beach Twp.	2/10/94 6/15/09	485,000 yd 175,000 yd	Dredged from Barnegat	$3,700,000	trucked
				Inlet; placed on section 1		
582	Longport	1990	250,000 yd	dreged from Great Egg Inlet	$949,000	
NJDEP	Lower Township	1986	87000 yd	Dredged from Cape May Canal		
fed	Monmouth Beach	1994 1995	800,000 yd 3,600,000 yd	3.1 miles	$19,600,000	
2086	North Wildwood	1989	190,000 yd	dredged Herford Inlet	$875,000	
566	Ocean City	1980	150,025 yd		$647,147	
1062	Ocean City	1982	1,149,683 yd	Morningside Rd	$4,885,000	
172	Ocean City	7/82-12/82	1,217,647 yd	Morningside Rd. to 13th street	$5,285,000	
1235	Ocean City	5/87-1988	Dunes, 190,000 yd		$2,847,086	
			fill, 40,000 yd			
579	Ocean City	1989	250,000 yd		$717,236	
1250	Ocean City	1990	256,000 yd Emergency fill		1207250	
585	Ocean City	1991	100,000 yd		$130,840	
586	Ocean City	1992	2,617,000 yd		$10,915,970	

fed	Ocean City	1993	2,700,000 yd		$14,571,908	
fed	Ocean City	1993	845,000 yd		$2,915,132	
fed	Ocean City	1994	607,000 yd		$3,217,825	
fed	Ocean City	1995	1,411,000 yd		$5,746,992	
571	Sandy Hook	1983	2,370,000 yd		$10,236,161	
572	Sandy Hook	1984	598,000 yd		$3,968,965	
1228	Sandy Hook	1989	3,200,000 yd		$1,350,000	
1055	Sea Isle City	1981	20,880 yd		$54,080	
NJDEP	Sea Isle City	1992	375,000 yd	between 77th and 82nd		
577	Sea Isle City	1987	150,000 yd	South of 78th St.	$528,244	
569	Sea Isle City	1983	45,000 yd		$194,294	
1061	Sea Isle City	1984	800,000 yd		$3,652,500	
1614	Sea Isle City	3/12/92	20,000 yd	between 2nd and 10th		
4009	Spring Lake/ Belmar	1/6/94	70,000 yd	between 19th Ave. and Pitney Rd.	$486,000	
568	Strathmere	1982	45,000 yd		$90,000	
1080	Strathmere	1984	450,000 yd		$2,986,679	
574	Strathmere (upper)	1984	592,000 yd		$3,929,142	
1201	Upper Township	1984	120,000 yd		$2,453,600	
NJDEP	Upper Township	1992	23,000 yd	Whale Beach		
1056	Upper Township	Dec-81	36,000 yd		$93,240	
573	Upper Township	1984	1,600,000 yd			

an existing beach. Further, the plan indicates that the use of beach nourishment should be a reachwide activity, suggesting that the benefits must be applied to the reach concept and not to some smaller locality. This is an important consideration that appears to be neglected in the applications of beach nourishment in the past decade, except for part of the design in the Sea Bright to Barnegat Inlet project. Significantly, all of the projects that are currently listed as either in the reconnaissance or feasibility phase at this time are applied to entire reaches.

Public concern about the appropriateness of protecting the shoreline and the techniques used in the process has generated considerable interest and exchange of views. Some see the emplacement of sand on the beaches as an expensive attempt to stabilize a very dynamic system. A system that has changed greatly in the past and will continue to do so. Others see the beach nourishment as necessary to provide stability to the economic development at the shore. A further issue is the matter of assigning the cost of the project. At present, approved beach nourishment projects are cost-shared with the Federal government paying 65% of the total and the non-Federal share being divided among the State, County, and local governments.

Because beach nourishment must be repeated at some time interval to replace the lost sediment and rebuild the shoreline, all projects are designed to incorporate re-nourishment or maintenance over a 50-year period. This is an ongoing cost that is included in the financial analysis of the project. Obviously, the commitment for 50 years of maintenance should be driven by state policy that endorses the expenditures for this purpose in a particular reach. The cost of maintenance is shared between the Federal Government and the State on a 65% - 35% basis. Usually, the funding for maintenance is several times the amount of the initial project cost. Generally, re-nourishment occurs on a three-to-five year cycle, with storm rehabilitation an additional expense. An example of the scale of the project is gleaned from the Sandy Hook to Manasquan Inlet beach nourishment plan which extends for 21 miles and incorporates $190 million in initial construction costs and $1.452 billion in maintenance for a 50-year period (Fig. 5). If the project were completed according to the design plan, the state's share of the cost would be about $52 million of the initial construction cost and an average of about $10 million per year for the duration of the maintenance period, plus episodes of storm rehabilitation.

Beach nourishment is an expensive approach to defending the shoreline as seen in the above commitments of funds for the initial costs of construction and for the maintenance over the 50-year period (Fig. 5). Portions of Sections I and II of the Sandy Hook to Manasquan Inlet project are not funded at present and represent potential reductions in the total costs for those portions of the shoreline as well as reductions for the 50-years of maintenance. However, the four ongoing beach nourishment projects, if fully-funded, incorporate a non-federal commitment of over $14 million annually averaged over the project lifetime, in addition to the cost of the initial construction, thereby committing a large share of the $15 million Shore Protection Fund.

Figure 5. Initial Costs and Maintenance Costs for Authorized and Proposed Projects in New Jersey

	Initial Cost Total Project	Initial Cost non-Fed share	Maintenance non-Fed share 50 years	Maintenance per year, 50 years non-Fed
Sandy Hook to Manasquan Inlet				
Section. I Sea Bright to Ocean Township*	$133,000,000	$32,550,000	$297,885,000	$5,957,700
Section II Asbury Park to Manasquan Inlet**	$57,000,000	$19,950,000	$210,560,000	$4,211,200
Cape May City	$10,526,000	$2,149,000	$10,600,000	$212,000
Ocean City	$33,195,000	$10,482,000	$201,518,000	$4,030,360
Brigantine***	$8,558,000		$12,728,800	$254,576
Long Beach Island***	$35,794,000		$60,055,450	$1.201,109

*Contract 3, in Section I, not included in FY 97 Federal budget
**Contract 2, in Section II, not included in FY 97 Federal budget
***proposed but not budgeted

AN EVALUATION OF BEACH NOURISHMENT

Because of the very vocal public debate about use and effectiveness of beach nourishment in treating the problems of an eroding shoreline, The U. S. National Research Council, through its Marine Board, established a Committee on Beach Nourishment and Protection to review multiple aspects of beach nourishment. It sought to:

> "... conduct a multidisiplinary assessment of the engineering environmental, economic, and public policy aspects of beach nourishment to provide an improved technical basis of judging the use of beach nourishment and protection technology in shoreline stabilization, erosion control, recreational beach creation, dredged material placement, construction of coastal storm barriers, and protection of natural resources." (Seymour, 1995)

Among the conclusions of the Committee were that beach nourishment is an appropriate technique for erosion protection storm damage reduction. However, it is not a panacea. Projects should be designed for specific areas, with a sound foundation in science and engineering. Areas of high erosion rates may not be good locations for the application of beach nourishment. Futher, beach nourishment is effective in human time scales (decades, not centuries). It should be applied in concert with established goals and a method of quantifying measures of success. It is important that maintenance be part of the original plan and that sources of sediment for re-nourishment be identified at the origination of the project. Beach nourishment is not inexpensive. There are no inexpensive.technologies nor approaches to protect the beaches.

A brief followup to the NRC report recently appeared that offers a small caveat to the endorsement of beach nourishment as an appropriate means for shore protection (Seymour, 1996). The Chair of the Committee relates that the public policy toward beach nourishment shifted as the report was in its final stages. There was a slowing of the availability of Federal funding and a modification of the partnership that had hitherto been the basis for an economic assessment. This changing policy was reason for concern about aspects of the report. However, it was decided that most of the report was a valid review of the application of beach nourishment and was of value independent of any new partnerships. Further, because states and local governments may have to be increasingly responsible for the planning, financing, and execution of beach nourishment projects, it was decided that the assessment information became more valuable.

POLICY CHANGES

With a general economic belt-tightening and a heightened concern for financial constraints on public expenditures and more economic accountability, there are fewer Federal funds available to support beach nourishment projects. In FY95 and FY96, all support for beach nourishment projects in the US Army Corps of Engineers budget was removed. Some funds were restored by special appropriation, but the message coming from the Executive Office was that general Federal support for beach nourishment was disappearing. This is in contrast to the situation of the previous years when the federal funding of beach nourishment was mover available and it was extremely difficult to generate the non-Federal share of the project costs. Certainly, those states which are most affected by the loss of Federal funds in support of beach nourishment will attempt to have the funds restored either as a continuing item in the Public Works budget or as special appropriations for specific projects.

CONTINUING ISSUES

As identified in the NRC report (Seymour, 1995), the application of beach nourishment addresses the symptoms of the problem but does not address the basic conditions responsible for the erosion of the coast; sea-level rise and the natural meager supply of sediment present at the shore. Indeed, beach nourishment focuses on the ocean front shoreline and defends the location of the line. In the case of barrier islands, as sea level rises the entire island is being submerged and the placement of sand on the shoreface does not reduce the rate of inundation and narrowing of the island. Nor does it change the decreasing elevations of the islands and the increasing exposure to storm damage as the common storms are able to penetrate inland to positions that were once protected by virtue of their height above water level. Sea-level rise is a continuing process and it is changing the conditions of exposure and modification due to storms. The cause of sediment deficits is another issue that is not directly addressed by beach nourishment. The deficiencies continue to persist. Beach nourishment is a temporary respite in the landward displacement of the shoreline. Longevity of the life of the fill is largely related to the magnitude of the sediment deficit, but it is also related to location, exposure, other protection structures, and to the weather events. Importantly, beach nourishment is a program supported by public funds and it is likely that the State will be called on to fund a larger proportion of the total costs, if not the entire cost. Beach nourishment should be part of a longer-term program than just responding to the post-storm needs and it should relate to the regional shore management plan and to the State objectives for the coastal zone. The expenditure of state-level public funds should directly relate to the strategies employed to meet State objectives for long-term management of the shore.

REFERENCES

New Jersey Board of Commerce and Navigation, 1930. Report on the Erosion and Protection of the New Jersey Beaches. Trenton, NJ, 129 p.

New Jersey Dept. of Environmental Protection, 1977. Statewide Comprehensive Outdoor Recreation Plan (SCORP). Office of Green Acres. 398 p.

New Jersey Department of Environmental. Protection, 1980. New Jersev Coastal Management Program,

New Jersey State Beach Erosion Commission, 1930. Annual Report on the Protection and Preservation of the New Jersey Beaches and Shorefront. Trenton, NJ, 17 p.

Seymour, R. J., 1995. Beach Nourishment and Protection. National Research Council, National Academy Press, Washington, D. C., 334 pp.

Seymour, R. J., 1996. An introduction to the Marine Board study on beach nourishment and protection, Shore and Beach, 64: 3.

U. S. Army Corps of Engineers, 1964. A Pictorial History of Selected Structures Along the New Jersey Coast, Miscellaneous Paper No. 5-64. Coastal Engineering Research Center, Fort Belvoir, Virginia, 99 pp.

U. S. Army Corps of Engineers, 1990. Report of Limited Reconnaissance Study, Philadelphia District, 217 pp. plus appendices.

U. S. Army Corps of Engineers, 1995. Barnegat Inlet to Little Egg Harbor Reconnaissance Study. Philadelphia District,

Uptegrove, J., Mullikin, L. G., Waldner, J. S., Ashley, G., Sheridan, R. E., Hall, D. W., Gilroy, J. T., and Farrell, S. C., 1995. Characterization of Offshore Sediments in Federal Waters as Potential Sources of Beach Replenishment Sand --Phase 1, New Jersey Geological Survey

Open-File Report OFR 95-1. New Jersey Department of Environmental Protection, Trenton, NJ, 148 p.

Coastal Dunes

Coastal dunes are natural features of the coastal landscape. They exist in conjunction with the beach and are part of the sand sharing system that actively exchanges sand between the dune, the beach, and the offshore bars. In areas of adequate sand supply, the coastal dunes achieve their full form; however, if sand supply is limited, the dunes may be small, narrow features that are frequently overwashed. In areas of very meager sand supply, the dunes will not exist.

In developed coastal zones, coastal dunes continue to perform their natural function as sand storage, but also provide an additional role of forming a natural barrier to storm surge and flooding. Thus, dunes are valued by the coastal communities because they offer a natural, esthetic, and protective component of the coastal landscape. Although dunes have been recognized as a form of coastal protection since the early 1930's, it was not until 1984 that coastal communities and the State took an active role in restoring, repairing, and maintaining the dunes. Through these efforts, the public value of the coastal foredune as a barrier against coastal storm surges and waves has been established and continues to increase.*

Attributes of Coastal Dunes

Understanding the processes that influence the creation of coastal dunes is an important aspect of their management. Coastal dunes are part of the natural beach system. Dunes in the coastal zone are molded by waves and wind. In a beach profile, the coastal dune forms a ridge of sand that accumulates above the high tide line and inland of the extremely mobile, bare sand beach surface. The active coastal dune, often referred to as the foredune to distinguish it from other and older dune forms, is located immediately inland of the bare sand beach. Other, older dunes may exist inland from the foredune. They are usually referred to as secondary dunes whereas the active foredune is the primary dune. It is the coastal foredune that is the subject of most of the remainder of this discussion. Unless otherwise noted, reference to the dune means the foredune, the primary dune in the beach/dune interactive system.

The principal attributes of natural coastal foredunes are that they are sites of sediment accumulation and storage. They exist because more sand is deposited in their locations than is removed. As a result, they become a physical form with height, width, and mass. The foredune is in dynamic interaction with the beach and the processes that move sand in the beach, including waves, currents, and winds. As long as sufficient sand is present, the dunes will exist at the inland margin of the beach. However, if the erosion is too severe, or there is no space for the dune to shift inland as the shoreline erodes, the dunes will not persist.

Certain types of vegetation can tolerate the harsh conditions of heat, aridity, high

* The attributes, management, creation, and maintenance of coastal dunes is further discussed in the white paper *Coastal Dunes: Dune Building Processes, A Primer for Dune Development and Management* (see Appendix)

salinity, and low nutrient availability found at the shore. These plants are referred to as pioneer plants and comprise the dune grasses and other plants that colonize the seaward face or crest of the foredunes. Coastal dunes exists in the zone where pioneer vegetation traps sand transported inland from the beach primarily by wind action, and forms an accumulation in the shape of a coast parallel sand ridge. As the sand accumulates around the primary vegetation, roots and rhizomes spread from which new plants grow. This dense vegetation anchors the dune below the surface and stabilizes sediment on the surface providing a natural barrier to incoming waves. Without the presence of dune vegetation, dunes become extremely vulnerable to the forces that create them.

Although the coastal foredune accumulates sand blown across the beach into the pioneer vegetation, it also loses sand when wave action erodes the beach and attacks or scarps the foredune. Scarping by waves is the process by which the sand held in storage in the foredune is returned to the beach for subsequent transfers offshore, alongshore, or to its original location in the dune profile. The dune will obviously lose dimension if the amount of sand removed is greater than the amount replaced. Conversely, the dune will gain in dimension if the amount of sand replaced is greater than was originally removed by the scarping process.

Natural coastal foredune development occurs inland of the frequent storm tide position where it is beyond the part of the beach that is constantly changing with the tides and wave variation. Foredune development also occurs in this zone because it is the area where vegetation can persist. On accreting shorelines, the pioneer vegetation extends seaward from the dune face and eventually establishes a new line of sand accumulation. However, most of New Jersey's beaches are eroding, and the seaward edge of the foredune is located extremely close to the storm water line and is frequently attacked by waves.

The foredune is a ridge, higher than the beach surface, forming a natural barrier to the inland penetration of high water from storm surges. By functioning as a barrier, dunes restrict the effects of storm waves and currents to the beach and the foredune face. While buffering the effects of these forces, sand stored in the dune is released by the mobilizing processes of waves and flowing water. Because the amount of protection is related to the mass of the dunes, higher and wider dunes will provide more buffering than lower and narrower dunes. However, the buffering effect of the coastal dune is obviously diminished when the dune crest is overtopped and eroded. Overwash may sometimes be so severe as to completely remove the dune form and transport much of the sand inland.

Rationale

In 1930, the New Jersey Board of Commerce and Navigation produced a Report on the Erosion and Protection of the New Jersey Beaches. Whereas the report emphasized the continuation of structural solutions to reduce beach erosion, it noted that coastal dunes should be given more consideration for their protective qualities. It was not until 1972 that the attributes of coastal dunes were recognized by the passage of the Coastal Zone Management Act. Among the basic tenets that formed the foundation of the Act was the desire to protect dunes as a natural protective feature (P.L. 91-583, 1972). Under the Act, states could receive federal funding to develop and to implement the Act's objectives. For the first time, there was a national impetus for coastal states to promote dune restoration and maintenance. However it was not until after the March 1984 storm, which destroyed much of New Jersey's dunes, that the State utilized these funds to implement the Federal Emergency Dune Restoration Program. With the availability of this federal funding, New Jersey coastal management strategy began to emphasis dunes as a preferred form of coastal protection through technical and financial support to communities for restoring. NJDEP and the New Jersey Office of Emergency Management (NJOEM), have continued to encourage community restoration, improvement, and maintenance of dunes through technical and financial support.

As New Jersey's coastal management strategies shift from protection of property to the enhancement of public safety, coastal dune maintenance can easily be incorporated into these efforts. As previously stated, coastal dunes buffer the effects of storm surges and prevent subsequent damage. Therefore, the utilization of coastal dunes is consistent with both federal and state mitigation objectives. If the Federal government continues to decrease monetary support for beach nourishment projects as a type of coastal protection, the buffering abilities of coastal dunes may become the primary means of protection. Further, through dune maintenance programs such as annual beachgrass plantings, many municipalities can bring various community resources together for a common cause, creating a feeling of community "togetherness".

Determining Objectives

If coastal dunes are employed to protect communities from the effects of coastal storms, communities must determine the level of protection they wish to achieve from anticipated storm water levels prior to constructing the dunes. When determining their objectives, communities must balance the level of protection desired with the amount of space they will need to achieve their goals. The spatial dimensions of a foredune that would protect against a 1 in 5 year storm water level, for example, differ from the dimensions required to buffer a 1 in 50 year storm. Although a municipality may wish to provide protection from water levels of a 1 in 50 year storm, the dune/beach area may only provide adequate space for a foredune that can buffer a 1 in 20 year storm water level. If communities desire to develop dunes that will protect against higher magnitude storms, but do not have the desired space, they should consider rezoning the beach front areas. This zoning would allow communities to develop or expand existing dunes as space becomes available. Unless a community is willing to designate adjacent landward property as part of the dune area, limited space leads to smaller dunes that offer a lower level of protection.

Something communities should consider when forming their objectives is the temporal component of dune preservation. Through time, the ability of coastal dunes to buffer storms is compromised by an eroding shoreline and rising sea levels. As the shoreline erodes, unless coastal dunes are able to shift inland in relation to these changes, they will be subject to scarping and to overwash, and may eventually be completely eroded. When determining a dune's level of protection, municipalities may want to incorporate a buffering area that will permit a coastal dunes' position to be translated landward in response to the dynamic nature of the coastline.

Building a Coastal Dune

Once municipalities have established their objectives and have determined that there is adequate space to achieve these goals, the next step is to implement the construction of dunes. There are several different techniques available to create coastal dunes. Dunes can be built by mechanical manipulation, planting appropriate dune vegetation, erecting sand fences, or a combination of these methods.

Mechanical Manipulation: A simple but relatively expensive method of creating a coastal dune is by bulldozing sand into the dimensions of a dune. An advantage to this method is that dunes and their protective qualities are instantly achieved. Sources of sand for creating a dune using this technique include transferring sand from the beach or obtaining sand from an outside source. Although it may be more expensive to transport sand into the system, an advantage to this method is that additional sand will be added to an already depleted system. It should be noted that the sediments comprising mechanically-made dunes are unstable because they are not bound together. Therefore, once the proper dimensions of a dune are established, vegetation and appropriate fencing should be planted and maintained to stabilize the dune.

Dune Vegetation: One of the simplest and least expensive methods used to create a dune is to plant 'Cape' American beachgrass, (*Ammophila breviligulata*) or other primary dune vegetation at adequate distances inland from the MHT. Unlike bulldozed dunes, this method takes some time before optimal dune dimensions are achieved. Maintaining dense, healthy dune vegetation is one of the best means to stabilize a dune and to minimize mobilization and erosion. Once established, beachgrass accumulates sand to form a dune and its extensive root system helps to bind the sand in place.

Sand Fences: Sand fencing is also an effective method for trapping sand. Whereas sand fencing (or snow fence material) builds dunes much faster than vegetation alone, it is still a fairly slow process and more expensive than vegetation alone. However, sand fencing is much cheaper than mechanical manipulation; costing as little as a $1 a foot. Sand fencing accumulates sand in the same manner as dune vegetation. As wind borne sand travels from the beach to the backbeach area, sand is deposited and accumulates to the lee of the fence line. As the sand accumulates, additional fencing can be placed over the filled areas until the dune reaches a desired level of protection or height. When building a dune just using fencing, planting should begin when the sand elevation approaches the top of the fence. These plants are necessary to hold the sand in place and bind the particles together.

Combination of Sand Fence Plus Vegetation: A combination of sand fencing and beachgrass should be more effective at building a dune than either of the two alone. As the fence traps the sand, the beachgrass roots secure the dune, thus trapping more windblown sand then either could alone. As the fences are covered by the sand, additional fencing can be erected to increase the elevation of the dune (Hammer *et al*, 1992).

Coastal Dune Restoration and Maintenance

The continuation of the coherent foredune requires a rigorous maintenance program. Even the best-vegetated dune will need attention to support a good vegetated cover and to retain the integrity of the sand ridge. Beachgrass needs to be fertilized, planted, pathways need to be maintained, and broken fencing needs to be replaced on a continuing program. Additionally, any blowouts or scarping of the dunes will need to be stabilized.

Conclusion

Communities benefit from the preservation and enhancement of coastal dunes, which are an important component of the natural coastal system. Although dunes are valued for their function as a natural barrier, there are many other roles and functions of dunes. By acting as a natural sand storage area for the sand sharing system, coastal dunes actively exchange sand within this system. Additionally, coastal dunes provide a habitat for diverse plant life and offer various esthetic qualities.

Standardized procedures that assist in the general maintenance and enhancement of coastal dunes can be developed on a community level. Dune protection ordinances provide a legal mechanism for communities to develop programs that maximize the function and effectiveness of dunes. It is important that these ordinances reflect the objectives of the community's dune preservation's efforts.

Whereas there is considerable interest in the creation of coastal dunes as part of a community effort, it must be stressed that dunes do not prevent erosion and they do not reverse an erosional trend. They do offer protection from storm surge and they do contribute sand to buffer the rates of shoreline displacement. Thus, dunes act as a barrier to communities and reduce storm-related damage. However, the dunes have a finite capacity to provide protection and buffering. They may be eroded and overwhelmed by waves and winds. They may be topped by very high storm surges. Although communities can extend the protective capabilities and other qualities of dunes through maintenance programs, it is likely that dunes should be considered as a short-term protective strategy that is within the capabilities of the community to perform and that will have to be repeated at some time interval.

MITIGATION - AN APPROACH TO COASTAL HAZARD MANAGEMENT

I. Philosophical Basis for Mitigation in the State Coastal Hazard Management Plan

The coastal areas in our Nation are under great pressure from population and related development because almost one-half of our total population live in these areas (NOAA, 1990). These development pressures in turn, have disrupted the coastal systems and are occurring in addition to fundamental changes in the functioning and characterization of our coastal systems (NOAA, 1990). Accompanying the increased development pressures in the coastal zone are natural processes that are eroding the shorelines and further altering the remaining systems. As these cultural and natural processes reconfigure the coastal zone, there is an increased awareness and need for appropriate management to safeguard the people and the resources of these dynamic areas.

In the past, management approaches have addressed the coastal area as if it were static, but the New Jersey coastal zone is a highly dynamic system requiring special attention and management consideration. There are natural and cultural forces that are placing some of the coastal resources at risk and requiring an effective stewardship of the natural and cultural resources present in the coastal zone.

Through a combination of long-term sea-level rise and sediment loss, intertwined with coastal erosion, the shoreline has become an area of increasing exposure to the effects of storms, which will only escalate through time. One possible approach to managing these risks with emphasis on public safety is by creating safer communities through natural hazard mitigation. Hazard mitigation involves recognizing and adapting to natural forces and it is defined as any sustained action taken to reduce long-term risk to human life and property (FEMA, 1995). In helping to create these safer communities, it is an important part of the Plan to emphasize mitigation as a tool to reduce exposure of people to the risks of living near the shoreline. Many emerging trends on a local and national level show that mitigation is developing as a part of a response to managing existing hazards as well as helping to cope with those which will continue to happen in the future.

Whereas emphasis on pre-storm mitigation is important to the Plan, the need for post-storm planning and recovery is especially important. Actions at the community level can be and have been successful in mitigating the effects of small storm events. The effects of major storms, however, require preparedness to provide for increased public safety as a product of the post-storm recovery process. Areas of high risk from natural hazards should be identified and plans developed to reduce exposure in these areas. Preparedness and post-storm recovery programs are basic to the Coastal Hazard Management Plan.

The demand for public safety is an important driving force and a major objective for managing the hazards associated with living near the shoreline. Because the coast is largely developed, it becomes necessary to create plans and strategies with which to enhance public safety and to reduce the amount of damage that can result from natural disasters. Preparedness for these natural disasters is key in the protection of the public and a necessary component of any hazard mitigation plan.

Educating and increasing the awareness of the public to the dangers of living near the shoreline is another objective of the plan that will assist with preparedness. The process of public involvement in the planning and developing stages will allow for the means by which to implement management strategies for reducing risk along the shoreline.

Also important for management considerations are the many natural and cultural resources along the New Jersey shoreline. The diversity of resources in New Jersey make this state unique and alluring. The wide variety of attributes along the coastline include such parks as Sandy Hook, and Island Beach State Park; highly developed recreational coastal towns such as Atlantic City; and structures such as boardwalks, ocean piers, and the Barnegat Bay Lighthouse. These and other valued resources along the shoreline warrant preservation or stewardship from the citizens and officials of the state of New Jersey. It is this stewardship, this balancing of the system, that is important to the natural and cultural future of the New Jersey shoreline.

The continual need to update the information concerning the shoreline is another important component of the system. This dynamic environment needs to be monitored regularly and the information collected to be shared with those involved in its study. The need for a strong data base and the ways and means by which to carry this out are paramount if we are to continue to manage hazardous situations. We also need to consider using a regional instead of a piecemeal approach to the problems and issues surrounding the shoreline in order to manage them effectively. There is a need to foster partnerships among municipalities, counties, etc. in order to deal with these issues of shoreline management and public safety in a successful manner across the board.

II. Background

II.A. New Directions and Objectives

II.A.1. Federal Policies & Directions

An important Federal policy that continues to influence our shoreline is the Coastal Zone Management Act of 1972. Until the late 1960's, decisions affecting coastal resources were made without coordination among federal, state, and local governments. Increased demand for recreational, economical and other uses of the coastal zone led to conflicts among the diverse groups involved. In response, Congress enacted the Coastal Zone Management Act (CZMA) in 1972, with the objective of which was to preserve, protect, develop, and where possible, to restore and enhance the resources of the nation's coastal zone for this and succeeding generations.

The CZMA created a partnership among federal, state, and local governments to seek collective solutions to problems caused by competing coastal pressures. All activities within the coastal zone, and those activities outside this area that affect resources inside the coastal zone, are now subject to the multiple use management regime established by the CZMA. Among the basic tenets which form the foundation of this legislation are several that directly relate to shore protection issues:

- Reduce the risk to life and property from coastal storms and erosion by directing coastal development away from hazardous areas; and

- Protect the dunes as a natural barrier to coastal storms.

More than 95% of the nation's shoreline is managed under the CZMA through a network of 30 states, including New Jersey. To entice coastal states to join this voluntary program, the federal government provided them with two incentives: financial assistance to develop and implement state coastal management plans, and federal consistency authority, a tool which enables states to address the adverse effects of federal activities on coastal resources.

Since the establishment of the 1981 Shore Protection Master Plan, much has occurred within the Federal government with regards to hazard mitigation, especially concerning floods and flood-related disasters. An important program that continues to this day is the National Flood Insurance Program (NFIP). The NFIP was established by the National Flood Insurance Act of 1968 and was defined even further by the Flood Disaster Protection Act of 1973. The Act allowed for the availability of flood insurance within communities willing to adopt floodplain management programs to mitigate future flood losses. The identification of all floodplain areas within the United States and the establishment of flood risk zones within these areas was also required in the Act. Coastal communities also qualified to participate in the program because it was identified that they face unique flood hazards from storm surges and wave action from large open bodies of water. Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRMs) for flood-prone communities are vital documents that foster the goals of the NFIP. These studies provide the technical information to communities that enables them to adopt floodplain management measures required for NFIP participation (FEMA, 1995).

In 1995, Congress mandated that there be a 30-day waiting period before coverage under a new contract for flood insurance or any modification to coverage under an existing flood insurance contract becomes effective, with two exceptions. The express intent of Congress in mandating a 30-day waiting period was to prevent the purchase of flood insurance at times of imminent flood loss (FEMA, 1995). One exception to the required waiting period involves the initial purchase of flood insurance in connection with the making, increasing, extension, or renewal of a loan. The second involves the initial purchase of flood insurance within one year of a map revision.

Another important development for the NFIP was passage of the Upton-Jones Amendment to the Housing and Urban Development Act of 1987. Under the Act, for the first time, Congress authorized payments from the National Flood Insurance Fund (funded by NFIP premiums) for certain costs of demolishing or relocating insured structures imminently threatened with collapse from erosion (Platt, et al., 1992). The intent of Upton-Jones was to encourage voluntary action by owners to remove their threatened structures. Prior to Upton-Jones, the NFIP only paid claims on insured buildings that had sustained physical damage as a result of flooding or flood-related erosion. The amendment allowed for payment of a claim prior to actual damage for the purpose of relocating or demolishing the structure (NRC, 1990).

Upton-Jones was intended to encourage the removal of erosion-prone structures prior to their collapse to avoid higher NFIP costs and to reduce public safety hazards. The intentions of Upton-Jones were good with regards towards mitigation, but the implementation of Upton-Jones was very successful because eligibility was too narrowly defined and few claims were ever filed. Few property owners took advantage of the benefits, and when they did, they opted for demolition over relocation (Platt et al., 1992). Upton-Jones was eliminated from the NFIP in September of 1995 in the National Flood Insurance Reform Act of 1994, Title V of the Reigle Community Development and Regulatory Act of 1994 (P.L. 103-325).

In its place, a National Flood Mitigation Fund was created that allows for funds to be used for mitigation activities such as relocation and acquisition of repetitive loss structures (P.L. 103-325, 1994). Money for this fund is to come from surcharges placed on existing flood insurance policies. Selection of projects for support from the fund will be based on those that reduce payments from the Flood Insurance Fund. While this fund is still in the authorization stage, it does represent a future mitigation opportunity.

An important mitigation development occurred when the Disaster Relief and Emergency Assistance Act of 1974 was renamed by the Disaster Relief and Emergency Assistance Amendments: Great Lakes Planning Assistance Act of November 23, 1988. These amendments changed the name to the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (P.L. 93-288 as amended by P.L. 100-707), and added requirements for disaster preparedness plans and programs. Under the Stafford Act, the President must declare a disaster emergency prior to the authorization of any federal assistance. The Act provides up to 75% of the cost of hazard mitigation measures that the President has determined to be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster (P.L. 93-288, as amended, 1988). The Stafford Act also created the Hazard Mitigation Program which provides matching Federal funds for state and local mitigation projects. These grant funds are also tied to disaster declarations.

Along with new opportunities for mitigation activities, there is a new direction as proposed by the Federal Emergency Management Agency (FEMA). In 1995, FEMA announced its new and emerging National Mitigation Strategy, "Partnerships for Building Safer Communities," that raises hazard risk reduction to the level of a national priority and places mitigation as the cornerstone for creating these communities (FEMA, 1995). The Strategy is intended to generate a fundamental change in the general public's perception about hazard risk and mitigation of that risk and to demonstrate that mitigation is often the most cost-effective and environmentally-sound approach to reducing losses. It is this national lead that New Jersey can follow in establishing its own strategy for creating safer communities and in mitigating the effects of natural disasters that pose a threat to some of the resources at the shore.

II.A.2. State Policies & Directions

II.A.2.a. Coastal Development, Redevelopment, and Planning

Coastal storms often result in extensive damage to property and infrastructure. After such a disaster, reconstruction and repairs have typically been completed in such a manner as to restore damaged property to its pre-disaster condition without consideration for the natural hazards present. Although this type of restoration does return a community to some form of normalcy rather quickly, the replication of pre-disaster conditions often results in a cycle of repetitive damage and reconstruction (FEMA, 1990). Continued coastal development in this manner will undoubtedly result in future property damage and the increased need for costly shore protection measures.

In an effort to break this cycle, communities and state governments have begun to adopt storm hazard mitigation strategies. In 1984, the New Jersey State Office of Emergency Management (NJOEM) produced a plan that incorporated mitigation strategies. The State Hazard Mitigation Plan was updated in 1993 as a result of a presidential disaster declaration for the January 1992 Coastal Storm (DR-936-NJ). The most recent revision of the Plan was completed in May of 1994. In the current revision, the Plan provides an outline for a system of risk reduction in New Jersey and serves to aid State and local emergency management officials in developing a hazard management program. In addition to New Jersey's individual state efforts, FEMA is in the process of developing hazard mitigation plans that can be adopted on state, county, and municipality level.

Typically, storm hazard mitigation plans are developed for post-disaster situations; however, post-storm mitigation plans are essentially a pre-disaster plan for the next disaster. Post-disaster relief and planning can be accomplished through strategies such as identifying hazardous areas, educating people about hazard mitigation, and changing land-use management, construction practices, and shore protection techniques. Improving land-use management can be accomplished through steps such as acquiring land in hazardous areas (i.e. the Coastal Blue Acres program), transferring development rights, re-zoning (i.e. setback limits and dune protection ordinances), relocating public roads and other public necessities away from hazardous locations, and exchanging land in high hazard areas for safer property locations. By requiring new construction and damaged property to meet stringent flood hazard area standards, severe damage to property can be reduced.

Building and reconstruction moratoriums can also be imposed in identified hazardous areas. Redefining shore protection measures entails establishing and maintaining non-structural coastal protection devices such as coastal dunes and beach nourishment projects in appropriate locations. Hazardous areas need to be identified through a systematic program and continuously monitored for changes in vulnerability. Finally, educational programs can be developed to educate people about natural coastal hazards and ways in which hazard mitigation can strive to reduce associated coastal threats

II.A.2.b. Need for Regional (Partnership) Approach

The coastal managers of New Jersey are challenged by the population demands placed on shoreline use. High population density and its accompanying infrastructure is continually juxtaposed against the functioning of the natural processes that determine stability and change along our shoreline. One of the traditional approaches for managing shoreline systems in developed settings has been to deal with it on a piecemeal basis. This approach does not take into account the downstream or cascading effects of a management action in one part of the shoreline system on other parts of the coast. For example, installation of a groin in one municipality may trap sand that is naturally transported to a neighboring municipality.

As demand for use of the shoreline continues to grow, there is a concomitant need for better information and creative management strategies to support continued resource use and stewardship. If present and future coastal managers are going to successfully balance these stresses on the shoreline in a manner that fosters access, mitigates coastal hazards, and preserves the ecological integrity of the shoreline system, New Jersey's integrated coastal management approach must be addressed on a regional basis. Specifically, coastal managers must look at the overall current wave actions, sand transportation, existence of shore protection structures, and erosion rates that effect the entire shoreline. Partnerships that transcend community boundaries are desirable and necessary to achieve this aim. Therefore, coastal management must be integrated at least at the reach levels. In addition, programs should be identified that function at the regional level and committees should be supported to "fit" into the larger program objectives.

II.A.2.c. Creating an Informed Public & Public Involvement

The process of developing an informed public goes beyond simply providing information to the coastal communities. An informed public results from the development of communication goals and the establishment of a communication plan or process. Establishment of a mechanism for community involvement and participation is critical to instituting a successful partnership.

All viewpoints and opinions from the community must be acknowledged and validated.

Decisions on how to encourage and incorporate the input from the community is an important component of a successful public participation process. Citizen meetings, questionnaires, and information hotlines are a few examples of what can be done to involve the public.

It is important for resource managers to clearly define the community role in the project as well as to mutually agree with the community itself on the level of their input into the project. Involving communities from the onset is the best way to deal with both the technical aspects of the project and the community concerns.

Involving an informed public in the implementation of a management strategy requires creating a productive dialogue between resource managers and the community. The development of an effective communication strategy includes producing communication goals, defining the audience, deciding how the communication goals will be implemented, and how the resource mangers will respond to the community.

III. National Mitigation Strategy

The reorganization of the Federal Emergency Management Agency (FEMA) on November 28, 1993 brought about the creation of the Mitigation Directorate. Mitigation, which involves reducing the impact of natural hazards, became one of the key elements in FEMA's reinvented organizational structure (FEMA, 1994). Director James Lee Witt raised FEMA's mitigation efforts from a low-level office to one of its four main branches. FEMA has recently announced its National Mitigation Strategy "Partnerships for Building Safer Communities," which raises hazard risk reduction to the level of a national priority and makes mitigation the cornerstone for creating these communities (FEMA, 1995). Development of this strategy is a major redirection of national policy for high-risk, natural hazard areas. Also of major importance is the most recent (February, 1996) appointment of FEMA to the Presidential cabinet giving FEMA and its endeavors higher priority than it had previously. FEMA's present new focus is removing people from hazards, providing support for public safety, reducing the costs of recovery following damage from natural hazards, and reducing payouts from the National Flood Insurance Program by 50% by the year 2010.

The Strategy is intended to generate a fundamental change in the general public's perception about hazard risk and mitigation of that risk and to demonstrate that mitigation is often the most cost-effective and environmentally sound approach to reducing losses. The long-term goal of the Strategy is to increase public awareness of natural hazard risk and, within 15 years, to reduce the risk of loss of life, injuries, economic costs, and disruption of families and communities caused by natural hazards. There are five objectives that FEMA has developed to meet this National Mitigation Goal:

- Conduct studies to identify hazards and assess the risks associated with those hazards for communities throughout the nation;
- Encourage applied research that will develop the latest technology in response to natural hazards risks and promote the transfer of that technology to users - State and local government, the private sector, and individual citizens;
- Create a broad-based public awareness and understanding of natural hazard risks that lead to public support for actions to mitigate those risks;
- Provide incentives and encourage mitigation activities and redirect resources from both the public and private sectors to support all elements of the Strategy; and
- Provide national leadership in the achievement of the National Mitigation Goal, provide coordination among Federal agencies to promote hazard mitigation throughout all Federal programs and policies, and provide coordination with other levels of government and the private sector (FEMA, 1995).

IV. The Development and Application of Mitigation in New Jersey

IV.A. New Jersey's State Hazard Mitigation Plan

Since the 1981 Shore Master Plan was produced, federal and state governments have been shifting away from post-disaster assistance and moving towards the use of mitigation measures to alleviate or to avert damages prior to a disaster. Although, the federal government has been discussing the use of mitigation to reduce risks from disasters for a number of years, little had been done to implement a mitigation strategy on a national level until 1995. Thus, prior to this time, implementation of a successful mitigation strategy was the primary responsibility of state governments. In 1985, the NJDEP, in cooperation with NJOEM and other State emergency management agencies, developed a hazard reduction mitigation plan for the state, called the NJ State Hazard Mitigation Plan: Section 406 (HMP). As a result of a presidential disaster declaration in 1992, the HMP (DR-936-NJ) was updated, and subsequently revised again in 1994 (DR-973-NJ).

The HMP strives to reduce or to eliminate loss of life and property from natural disasters by providing an outline for a system of mitigation measures for the State. The HMP also serves as an aid to local and State emergency officials by developing a hazard mitigation plan and establishing the framework for coordination between FEMA and the State Interagency Hazard Mitigation Team (SHMT) (NJDEP, 1995). Although the HMP recommends mitigation activities for both coastal and riverine areas, only those measures appropriate to the coastal area are discussed herein.

IV.A.1. History of the New Jersey Hazard Mitigation Plan

IV.A.1.a. 1985 New Jersey Hazard Mitigation Plan: Section 406

From March 28 to 29, 1984, an intense northeaster tracked slowly along the New Jersey shore. The storm surge caused flooding, damage to shore protection structures, and severe beach and dune erosion (NJDEP, 1985). A second nor'easter followed this storm from April 4 to 5, 1984 which produced extensive riverine flooding along the Passaic River and its major tributaries (NJDEP, 1985). On April 12, President Reagan declared the four coastal counties disaster areas (FEMA-701-DR). Following the presidentially-declared disaster, New Jersey applied for disaster relief funds available under Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974 (P.L. 93-288 as amended, 1988). Under the Act, the federal government may contribute up to 75% of the cost of hazard mitigation measures that are determined to be cost-effective and substantially reduce the future risk of damage, hardship, loss, or suffering (P.L. 93-288 as amended, 1988). In order to receive disaster relief funding, New Jersey had to evaluate and mitigate against natural hazards, which lead to the production of the HMP.

The 1985 New Jersey Hazard Mitigation Plan: Section 406 is a comprehensive document that describes damages from the riverine flooding and coastal storm of 1984. It also summarizes existing state mitigation measures and proposes mitigation measures to reduce future risks. The mitigation team recommended 23 short- and long-term mitigation activities to assist the affected coastal regions recover from the disaster. These "work elements" consisted of mitigation actions for specific sites, as well as actions for the entire coastal area.

Short-term recommended measures include: revisions to the computations of storm surges at the Atlantic City Steel Pier, technical assistance to communities to implement the HMP recommendations, structural fortification, a grant to study Long Beach Island's evacuation and warning systems, and the endorsement of changes to Building Officials and Code Administrators (BOCA). Long-term mitigation measures include: dune enhancement and restoration projects, the continuation of shoreline profiling, implementation of acquisition/relocation projects, and the restriction of development seaward of Ocean Avenue in Sea Bright and Monmouth Beach until sand is provided.

On September 27, 1985, while the NJDEP and NJOEM were preparing the HMP, Hurricane Gloria passed along the New Jersey coast. Although the sustained damages were less than those received by the 1984 storms, additional long- and short-term mitigation measures were developed as a result of a declared disaster (FEMA-749-DR). Highlights of the short term recommended measures include: amendments to CAFRA such as prohibiting development in V-zones, instituting a 50-foot setback from shore parallel structures, and supporting changes to BOCA for wind speed. Long term mitigation measures include: the continuation of NJDEP regulatory jurisdiction of the coastal area, the continuation of the U.S. Army Corps of Engineer's (USACOE) NJ Hurricane Evacuation Study, the establishment of dunes seaward of boardwalks in Monmouth County, and a proposed acquisition project for Whale Beach, Cape May County.

IV.A.1.b. Coastal-Storm 1992 (FEMA-936-DR-NJ) Interagency Hazard Mitigation Team Report

Between 1985 and 1992, the State handled approximately 18 storm-related flooding emergencies (NJDEP, 1993). Each of these events were managed by local, County, or State funding and NJOEM's mitigation efforts. On March 3, 1992, all four coastal counties were declared major disaster areas by the President due to the January 4, 1994 storm that devastated the coast. The storm produced coastal flooding and the further erosion of beaches that were already weakened by a similar storm in October of 1991 (NJDEP, 1993). Although the HMP had been updated as necessary during 1985-1992, the HMP was revised to included mitigation measures developed as a result of the 1992 storm in order for the State to qualify for disaster assistance funding.

The SHMT made formal mitigation recommendations in the 1993 Coastal-Storm 1992 (FEMA-936-DR-NJ) Interagency Hazard Mitigation Team Report. These recommendations were placed into either mitigation, public awareness/alert warning, coastal issues, hazard identification, or social services categories. Each recommendation, when implemented, would serve to prevent or reduce losses in the event of a similar coastal disaster (NJDEP, 1993). The first recommendation of the HMP was the permanent creation of a State Interagency Hazard Mitigation Team (SHMT). During the production of the 1985 HMP, a temporary State Interagency Hazard Mitigation Team (SHMT) had been created to assist NJDEP and NJOEM identify an interagency approach to hazard mitigation that supported the goals and objectives of mitigation (NJDEP, 1993). Following the 1993 HMP, the SHMT was formally established by Executive Order. The NJOEM was established as the lead agency to establish and coordinate a State interagency hazard mitigation team. Support agencies include NJDEP, the Department of Transportation, Department of Community Affairs, Office of Statewide Planning, USACOE, and other agencies involved with the State's mitigation efforts.

The Public Awareness section of the SHMT recommended the installation of remote sensors in the bay areas to forecast flooding, and a training program be established for local media, public officials, and educators on emergency preparedness and public warnings. Coastal Issues mitigation measures include: technical guidance for communities to implement FEMA's beach policy, and the development of the Shore Protection Fund. Some recommended mitigation measures for hazard identification include: communities, which rely on coastal dunes for protection, adopt FEMA's definition of "Coastal High Hazard Areas" and "primary frontal dunes" in their flood prevention ordinances to provide immediate protection of the entire dune; all coastal flood insurance rate maps be revised to include the assumption that all dunes would be lost during a 100-year storm; and a schedule for conducting wave height analyses for municipalities be created. Lastly, the SHMT recommended that State, County, and local emergency management and human service officials develop an emergency social services capability to produce a social services resource network.

IV.A.1.c. State of New Jersey Office of Emergency Management DR-973-NJ Hazard Mitigation Plan

In December 1992, New Jersey experienced its second Presidential Disaster Declaration since 1985. Between December 11-17, 1992, a severe nor'easter storm caused widespread coastal damage from flooding and high velocity winds. The State of New Jersey Office of Emergency Management Hazard Mitigation Plan, the State's current HMP, is a revision of DR-936-NJ State Hazard Mitigation Plan that reflects new hazard mitigation needs, and re-prioritizes existing mitigation recommendations. The SHMT coastal area recommendations for 973-DR-NJ consists of six categories:

- *Beach and Dune Areas*:
  Recommendations included a re-emphasis for the continuation of dune restoration and maintenance; a priority list of shore protection projects be created; the replacement of bulkheads not in compliance with the Federal Flood Insurance criteria for shore protection devices; the revision of ordinances prior to emergency work in communities with repetitively damaged beaches; an acquisition program be developed for post-disaster assistance; and an update of beach/dune topographic mapping.

- *Flood Warnings*:
  The SHMT recommended that both offshore data collection and the installation of backbay flooding remote sensors continue.

- *Regulations*:

The SHMT recommended the passage of regulations for permits for the installation and/or repair of retaining walls. They also recommended that NJOEM develop procedures and policies to regulate the collection and disposal of debris and implement a disaster debris management plan.

- *Specific coastal areas*:
  The SHMT recommended that the South Cape May Meadows area be studied to assess the erosion problem and develop some alternatives to emergency dune management. A comprehensive plan utilizing floodproofing, relocation. zoning, and setback measures for the north end of Atlantic City was also recommended in the Plan.

- *Flood Insurance*:
  The SHMT recommended that ordinances be adopted requiring landlords of rental properties within high hazard areas to provide flood insurance information for their tenants.

- *Planning*:
  The SHMT reinforced the continuation of the SHMT, and recommended that HUD and DCA advise municipalities of the availability of Community Block Grant and Small City Block Grant Programs for emergency response and risk reduction funding.

IV.A.2. Accomplishments of the State Hazard Mitigation Plan

Following the creation of the HMP, the NJOEM has been involved in the State's coastal hazard mitigation efforts. In Section VI of the most recent HMP (1994), NJOEM lists the accomplishments, to date, of the Hazard Mitigation Plan. Specific implemented hazard mitigation measures include:

1) Technical assistance from NJDEP has been provided to implement the HMP's recommendations;

2) The Shore Protection Fund was implemented;

3) In 1986, the Division of Water Resources, Bureau of Flood Plain Management completed a study of Long Beach Island;

4) NJDEP was granted an increase in regulatory jurisdiction in the coastal area through the revision of CAFRA;

5) Development was permanently restricted seaward of Ocean Avenue in Sea Bright and Monmouth Beach;

6) NJDEP continues long-term monitoring of beaches and dunes;

7) NJDEP continues to pursue the proposed park plan for Whale Beach, Sea Isle City;

8) In 1984, the Assessment of Dune and Shorefront Protection Ordinances was published;

9) NJDEP received a $2 million grant for dune restoration for the 1984 storm damages;

10) Shore Protection Rules were revised to require adherence to coastal program regulations as a condition of State shore protection expenditures to municipalities;

11) NJDEP completed storm vulnerability studies and site specific storm hazard mitigation studies for the barrier islands in 1985;

12) All jurisdictions in the State are in compliance with the National Flood Insurance Program due to aggressive efforts by the state flood plain management officials;

13) In 1992, the New Jersey Hurricane Evacuation Study, 1992 was produced and is being used to increase the State's level of preparedness levels;

14) The State initiated the investigation of several mitigation measures including studying the use of submerged concrete breakwaters as means to stabilize ocean-front beaches;

15) NJDEP supported further recommendations to BOCA.

IV.A.3. Recommendations to Improve the State's Hazard Mitigation Efforts

Since the inception of the HMP, the SHMT has recommended and implemented many mitigation measures in the coastal area. Whereas the HMP has had a measure of success, there is still a need to redefine and to improve the State's mitigation measures and incorporate new strategies into the HMP to continue to reduce the public's exposure to coastal hazards. There are several mitigation measures that can be executed through the HMP to further prevent storm damage:

- Promote the continuation of dune enhancement and maintenance programs;
- Identify high hazard areas in the coastal area and periodically update the list to reflect any changes;

- Continue public awareness and education programs;
- Once FEMA's national guidelines have been established, assist local municipalities to develop their mitigation plans;
- Prohibit development in high hazard zones;
- Promote the acquisition of structures in identified high hazard areas;
- Incorporate evolving wind-load reduction into the State's building codes;
- Provide technical assistance and incentives to communities to participate in mitigation efforts;
- Shore protection efforts should be made contingent on local efforts to implement mitigation strategies;
- Utilize FEMA's Hazard Mitigation Grant Program funds to implement mitigation activities;
- Continue to develop mitigation strategies on a regional approach instead of on a piece-meal basis.

V. Integrating NJ's Hazard Mitigation Efforts With FEMA's National Mitigation Strategy

V.A. Consistency of Direction and Philosophy of State and Federal Efforts in Mitigation

The 1981 Shore Protection Master Plan addresses mitigation in a section titled, "Disaster Mitigation and Recovery," under the Federal Programs and Policies portion of the Policy Review. The Plan states there are Federal disaster relief programs designed to provide assistance to states, local governments, individuals, and owners of selected non-profit facilities to alleviate suffering and damage which result from natural disasters (SMP, 1981). It also notes that these programs assist in the reconstruction and rehabilitation of devastated areas including those located in hazardous areas on barrier islands. The programs the SMP refers to are specifically those of the United States Army Corps of Engineers (USACOE), and the Federal Disaster Assistance

Administration's (FDAA), now known as the Federal Emergency Management Agency (FEMA), administering of the Federal Disaster Relief Act of 1974.

It was advised in the 1981 Plan that Federal disaster mitigation and recovery programs be redirected to ensure that the programs do not invite past mistakes by encouraging or subsidizing reconstruction or restoration of storm damaged structures in high hazard areas (SMP, 1981). They listed several options for both moderate-level and high-level protection. One of the options concerning moderate-level protection was strengthening the role of the U.S. Army Corps of Engineers in coastal protection by emphasizing the natural protective capabilities of beaches and dunes and the need to preserve them. Also, it should be recommended that the U.S. Army Corps of Engineers shift from increasingly expensive structural control of erosion and flooding to cooperative land management (SMP, 1981). The U.S. Army Corps of Engineers has indeed shifted from structural control measures of erosion to softer approaches such as beach replenishment and nourishment projects, but their newer measures are not less expensive. Much controversy surrounds the beach nourishment projects because they exhibit high costs. Another moderate-level recommendation was that FEMA and the Small Business Administration (SBA) should consider developing regulations that would base receipt of pre-disaster planning and post-disaster loans or grants on established state disaster recovery plans that would: 1) incorporate the state's disaster legislation and require its full implementation; 2) that it provide for a recognition that barrier islands are especially vulnerable to disaster; and 3) that the regulations should also be adequate to protect human life by discouraging development of high hazard areas; and 4) require state preparation of "contingency redevelopment plans" to encourage reconstruction away from barrier islands (SMP, 1981).

With regards to high-level protection options, the Plan recommended some options that would establish mechanisms for identifying and delineating areas and types of facilities in coastal high hazard areas which, when severely damaged by storms, would not be eligible for Federal assistance to reconstruct or restore in the same location (SMP, 1981). There would be available relocation assistance; however, to aid individuals and businesses move from the high hazard areas.

One of these options was that the Federal Flood Disaster Protection Act of 1973 (P.L. 93-234) be amended to restrict disaster assistance from being used for reconstruction in high hazard areas and instead used for providing relocation assistance for businesses and residents who voluntarily elect to move to safer areas.

Another option in the 1981 SMP was that the Disaster Relief Act of 1974 be amended to require disaster preparedness plans and programs, and that post-disaster recovery assistance would be contingent upon the inclusion of such plans and programs. The Act should also authorize the establishment of Recovery Planning Councils prior to a major disaster to assist in developing and gaining approval of pre-disaster contingency plans for barrier islands (SMP, 1981).

There are provisions in the Disaster Act, renamed the Stafford Act in 1988, for revising and broadening the scope of existing relief programs; encouraging the development of comprehensive disaster preparedness and assistance programs by the States and by local governments; encouraging hazard mitigation measures to reduce losses from disasters; and providing Federal assistance programs for both public and private losses resulting from disasters (P.L. 93-288, as amended 1988).

Since the 1981 Shore Master Plan was developed, there has been much discussion regarding mitigation on a federal level as a means of alleviating or averting disasters, but little with regards to successful implementation of such means. Thus, the issue of implementing successful mitigation strategies becomes an important task for the State.

The New Jersey Office of Emergency Management (NJOEM) has had a plan that incorporates mitigation strategies in existence since 1984. The NJ State Hazard Mitigation Plan was updated in 1993 as a result of a presidential disaster declaration for the January 1992 Coastal Storm (DR-936-NJ). The most recent revision of the Plan was completed in May of 1994.

In the current revision, the Plan provides an outline for a system of risk reduction in New Jersey and serves to aid State and local emergency management officials in developing a hazard management program. The Plan also lays the groundwork for the coordination between FEMA and the State Hazard Mitigation Team (SHMT) which would coordinate review of hazard mitigation plans and facilitate specific projects (Hazard Mitigation Plan, 1994). The SHMT is overseen by the NJOEM, which is responsible for hazard mitigation efforts.

The Plan also suggests that a positive relationship between government and the private sector be developed as a means of persuading the public of the viability of hazard mitigation (Hazard Mitigation Plan, 1994). In addition, the use and activities of various nonprofit groups to influence the public could serve as valuable resources. Overall, the NJ State Hazard Mitigation Plan does provide for the means by which to carry out mitigation activities, but it is limited in available funds from both State and Federal levels. Therefore, the need for methods of getting these funds from the State and Federal government becomes an important task for NJOEM.

VI. Formulating the State Hazard Mitigation Plan in Terms of the National Mitigation Strategy

It is important to identify programs or processes in New Jersey hazard mitigation that are demonstrative of the five national objectives associated with the National Mitigation Strategy. It is important to establish state objectives in natural hazard management and to take the national lead and develop existing programs even further and create new programs that will work towards the mitigation goal. Emphasis will be placed on development of procedures to translate the National Strategy into useful strategies for state and local government, the private sector, and the public. Even greater emphasis should be placed on the provision of public safety and the mitigation strategies best suited for supporting that objective.

It is important for the state Coastal Hazard Management Plan to identify some of the high hazard risk areas associated with the New Jersey shoreline and to educate the public of their existence. The need to know of these areas and the dangers that they possess is vital to the safety of the public and to the success of this new plan. The new plan needs to bring about a change in the public's attitude toward the shoreline by stressing the issue of safety, to provide incentives to vacate hazardous areas, and to also provide disincentives for staying in these hazardous shoreline areas.

New Jersey is in the position to utilize existing HMP mitigation strategies to easily incorporate the State's mitigation efforts into FEMA's new initiatives. NJ's 1994 HMP recommendations could be embodied in FEMA's five initiatives in the following manner:

- *Hazard Identification and Risk Assessment*

  -A coordinated governmental program of dune creation, restoration, maintenance and expansion for emergency recovery and long-term protection should be developed.
  -NJDEP should develop beach/dune topographic mapping that reflects post-storm conditions and submit these maps to FEMA for use in Flood Insurance Administration reviews.
  -The National Weather Service should explore alternate methods for obtaining further offshore data in the voids left by removing the Large Navigational Buoys (LNB).
  -Remote sensors in the backbay areas should be installed to monitor bay side inundation.

- *Applied Research and Technology Transfer*

  -NJDEP should develop a prioritized list of coastal municipalities that require revised wave height analyses based on FEMA's current sand dune evaluation mapping criteria or flood insurance map revisions.
  - An analysis of appropriate long-term and short-term strategies for enhancing public safety should be conducted.
  - Coastal dune development assistance should be provided and standards developed for protection levels available with specific dune dimensions.
  -FEMA should revise the emergency work eligibility criteria for beaches with repetitive damage to include local adoption of beach and dune system management ordinances in conformity with the Aug. 20, 1990 edition of the NJ Rules on Coastal Zone Management.
  -FEMA should require that the State have an acquisition plan as a condition for future disaster assistance after coastal storms.
  -A study should be conducted on the South Cape May Meadows area to assess the erosion problem and examine alternatives to continued emergency dune management.
  -Atlantic City should develop a comprehensive plan utilizing floodproofing, relocation, zoning and setback measures in the north end of Atlantic City
  -State regulations requiring permits for installation and/or repair of retaining walls should be implemented for waterfront bulkheads and related construction.
  - Setback regulations should be developed that are directed toward the establishment of variable width buffers and setbacks that can shift in high rate erosion zones.
  -NJOEM should develop standardized policies and procedures to regulate the collection and disposal of debris and to implement a disaster debris management plan.

- *Public Awareness, Training, and Education*

-When remote sensors are installed in the backbays, NWS should use these to accurately forecast and warn communities of emergency situations.
-Municipalities should be encouraged to develop ordinances that require landlords or rental properties within high hazard areas to provide flood hazard information at the time of the rental.

- *Incentives and Resources*

-Dune creation programs should be established that create procedures and funding of emergency recovery and long-term and short-term protection.
-Once a stable funding source is in place, the State should establish a policy for the expenditure of these public funds. Objectives should be determined and funds expended in pursuit of those objectives. All projects should be in support of the Coastal Hazard Management Plan.
-Legislation should be introduced to modify Public Assistance Cost-sharing (406) to 40% federal and 60% non-federal and make the difference available under section 404 for property acquisition.
-Municipalities should be advised by HUD and DCA of the availability of Community Block Grant and Small City Block Grant Programs for emergency response and risk reduction funding.

- *Leadership and Coordination*

- Policies should be created that establish long-term objectives for management of the coastal zone.
- Strategies that work towards achieving the short-term and the long term objectives should be developed.
- The State should assist communities in achieving the steps required to be consistent with the objectives.
-Communities should be assisted by the State to complete tasks/recommendations of the HMP.
-The SHMT should act as a coordinator between community and FEMA and State NFIP.
-NJDEP should develop standards in accordance with NJ Rules on Coastal Zone Management which would apply to all development within the coastal zone as defined by CAFRA.
-A Hazard Mitigation Executive Order should be developed that establishes a permanent state hazard mitigation team.

VII. Mitigation and Shoreline Management Options

Through experience, it has been realized that many shore stabilization approaches that were once thought to be appropriate, are not so anymore. Past management practices attempted to maintain a static shoreline position, when in reality the coastal system is very dynamic, requiring special attention and consideration. These static approaches have proven to be futile in some cases and detrimental in others. An emerging approach is to manage the coastline in a manner that is more compatible with the natural system. That approach is mitigation.

As part of the 1996 Coastal Hazard Management Plan, hazard mitigation is one of several components. However it is one of the most important, and seeks to provide the best approach to minimize potential loss of life and damage. Natural hazard mitigation will become the concepts by which coastal planning is developed and the effects of major coastal hazards can be lessened. Mitigation offers flexible strategies that strive to work in conjunction with a dynamic coastal zone rather against it.

There are several different management approaches to hazard mitigation that can be incorporated into New Jersey coastal management efforts, they include: 1) structural approaches; 2) non-structural approaches; and 3) land use management. An important component of most of these approaches is their ability to lessen or alleviate the effects of coastal natural hazards. Each option attempts to mitigate against the effects of hazards before they occur. Application of specific approaches should be conditioned by the characteristics of the site, by the regional setting, and by the appropriateness within the objectives for the site and region.

VII.A. Background

Numerous reports (National Research Council, 1995; Platt et al. 1992) have pointed out that the stabilization of eroding shorelines has shifted from "hard" engineered approaches to those of "soft" management strategies. Federal policies had been found to be more reactive to natural disasters than proactive to temper the conditions that foster and acerbate the magnitude of natural disasters. Federal policy had also only addressed short-term erosion, that resulting from storms, and paid little attention to long-term erosion resulting from things such as relative sea-level rise

States like North Carolina, have moved decisively regarding eroding shorelines by adopting a retreat strategy in the form of minimum setback requirements for shoreline construction (Platt et al., 1992). Conversely, New Jersey is found to be limited in the extent of state intervention in coastal development as a result of inadequate standards for rebuilding after a disaster. There are few successful examples of the application of setbacks to accommodate inland shift of the shore zone and the concept of retreat is still very much socially unacceptable. Because of the enormous value of shorefront property, it is suggested that arguments to prevent coastal development or to convert developed areas to natural environments hold little weight (Nordstrom, 1995) and not many want to listen. Although there do exist some encouraging signs in some states such as North Carolina, retreat as a general strategy in response to coastal erosion has not yet been widely applied.

There needs to be much in the way of education and public awareness of the dangers of living near the shoreline if the concept of retreat is to be considered seriously by the people of the New Jersey shoreline. Identification and knowledge of the high hazard areas can help to foster the education and public awareness objective for the risks associated with the shoreline and the need for some mitigation strategies can then be seriously considered.

In 1988, the National Research Council (NRC) established the Committee on Coastal Erosion Zone Management in response to a request from FEMA and the FIA. The committee was asked to provide advice on appropriate erosion management strategies, supporting data needs, and the methodologies with which to administer these strategies through the NFIP. In 1990, the NRC published Managing Coastal Erosion, the result of a study which emphasized how the coastal population has increased and the increasing pressures that have resulted from it. The report also discussed the very complex physical process of coastal erosion, involving many natural and human induced factors, and it is these factors that are putting stress on the coastal zone. A followup publication on the use of beach nourishment, Beach Nourishment and Protection (1995), addressed the positives and negatives of the technique.

The goal of the NRC was to create a balance in approaches to erosion and provide opportunity for science and engineering to be used effectively in the planning and management processes (NRC, 1990, 1995). The books describe the causes, effects, and distribution of coastal erosion; management and approaches; the NFIP; various state programs; project design and life; environmental issues; and a discussion of future shoreline changes and recommendations for continued review and monitoring. Studies like these serve as aides in identifying the hazardous nature of being along the shoreline and provide a perspective on some mitigation strategies designed to reduce exposure to natural hazards.

VII.B. Shoreline Mitigation Options

VII.B.1 Structural Approach

A former emphasis on structures to confront shore erosion attempted to address the symptoms of sediment losses at the shoreline by erecting barriers to the penetration of storms and high waves. These hard structures were developed over decades and their remains are seen in many portions of the coast, in the water. There are structures erected parallel to the coast which involve sand retention and stabilization features such as revetments, bulkheads, and seawalls. There are also structures erected perpendicular to the coast to intercept shoreline transport, such as groins and jetties.

Whereas coastal structures are an effective means of preventing inland penetration of storm waters, they do not work in conjunction with the natural system. Instead, they form a barrier and anything seaward of these structures are sacrificed. Thus, the beaches and coastal dunes, which symbolize and attract people to the coastal area are eventually destroyed.

VII.B.2. Non-Structural Approach

VII.B.2.a. Dune Maintenance and Nourishment

Dune maintenance and nourishment, and in cases where dunes do not exist, the artificial creation of dunes are a quasi-natural form of mitigation. Dunes serve as a protective buffer that exchanges sand with the beach to reduce rates of shoreline displacement, and act as a barrier to storm surges and high water levels. Therefore, coastal dunes have proven to be an acceptable means by which to hold off some of a storm's negative impacts. Dunes, artificial or natural, can be stabilized and enhanced through vegetation which is affordable and can be long-lasting. Dunes should be built or maintained to achieve certain dimensions on the beach profile. These dimensions relate to a pre-determined level of protection against storm surge and erosion. While they are not the panacea for shoreline protection and provide limited buffering, dunes are certainly worth the effort as a mitigation option. Many New Jersey communities have already established dunes and have dune ordinances in place, while others are striving towards that goal.

VII.B.2.b. Beach Replenishment and Nourishment

Another non-structural approach is that of beach replenishment and nourishment. Beach nourishment involves replacing sand on an eroded beach, which requires transporting sand from an outside source, and placing it in the sediment starved area. This process is time consuming and expensive. Beyond these factors, there are several other factors that need to be taken into consideration when undertaking a beach nourishment project, such as the rate of loss of beach in the region; the availability of beach material to be used; methods used for the process; and the suitability of the beach material. It is important that the beach fill material closely resemble that of the original beach. Further, beach nourishment is a short-term approach that does not prevent erosion, it only prolongs shoreline displacement. Thus, this approach requires continuing financial commitment, which can become an expensive proposition. Importantly, beach nourishment should be practiced regionally, and consistent with the objectives for the region.

VII.B.3. Land Use Management

VII.B.3.a. Zoning

Zoning is the primary means for local governments to regulate land use (e.g. residential, industrial, or commercial) as well as their integrity (bulk, height, setbacks) (Beatley, et al, 1994). Although, many coastal communities in New Jersey have adopted mitigation ordinances to protect their dunes and to regulate development, there are several other mitigation strategies that can be incorporated into their ordinances to further enhance public safety. Some of the mitigation measures that could be embodied into zoning ordinances are the designation of high hazard zones, and the establishment of maximum density development.

If coastal communities were to clearly define and establish a high hazard zone, ordinances could be adopted to prohibit or to restrict development in these areas thereby reducing the public's exposure to hazards. High hazard zones should include, but not be limited to, areas of dune fields, frequent washover, rapid erosion, or island breaching. These zones should also include areas which, under normal conditions, would have dunes even if no dunes are present at the time (NJDEP, 1984). By delineating these high hazard areas, communities will also be able to create buffer areas and promote dune/beach interaction. Ideally, high hazard zones should be periodically re-delineated to account for the dynamic nature of the coastline and move inland as the coastline changes.

Once these high hazard areas have been delineated, certain structures may become non-conforming uses in order to achieve mitigation objectives. Under the Municipal Land Use Law (N.J.S.A. 40:55D-1), non-conforming uses can only be restored or repaired after a disaster if the damages are not substantial (NJDEP, 1984). Although communities may otherwise define "substantial damage", this is generally taken to be less than 50% loss (NJDEP, 1984). Therefore, non-conforming structures damaged by more than 50% should not be permitted to rebuild unless they comply with existing mitigation ordinances.

Another mitigation land-use strategy municipalities can use to reduce hazard risks is to impose maximum density development. By lowering the development density of a community, the amount of population and property exposed to coastal storm events will greatly be reduced; thereby averting potential damage and loss of life. Restricting density development will also ensure that during times of emergencies, the population will not exceed the caring capacity of the community (e.g. road capacities, water supply, medical assistance, sewerage, and land area).

In the 1984, Coastal Storm Hazard Mitigation Handbook, NJDEP recommends ordinances should be passed that prohibit construction of high-rises or multi-family structures in high hazard areas (NJDEP, 1984). By preventing the construction of these types of structures in high hazard areas, the amount of population exposed to coastal storms can be substantially reduced. An additional benefit to this type of zoning is that single-family dwellings will also be easier to relocate than larger structures as the shoreline erodes (NJDEP, 1984).

The application of zoning is the primary means for municipalities to regulate land-use development and should be used to enforce hazard mitigation strategies. By designating high hazard coastal areas, communities may limit the type of development (single-family verse multi-family dwellings), and the density of the area. Ordinances can also be used to create buffer areas and preserve beach/dune systems. Zoning is an effective means of reducing both human and structural exposure to coastal hazards.

VII.B.3.b. Construction Setbacks

Setback lines, an extension of zoning, is an extremely effective mitigation strategy. Either established by State or local regulations, setback lines prohibit any development other than water dependent uses or shore protection measures seaward of the line. In high hazard coastal areas, setback lines can also be used to create a buffer zone from the impacts of coastal storms. These buffer zones minimize the impacts of development on beach and dune systems, reduce people's exposure to the effects of coastal storms, and provide an area for natural dune migration.

Setback lines may be established on the basis of a combination of factors such as erosion rates, wave run-ups, V-zone boundaries, presence of dunes, vegetation line, shore protection structures, distance from shorelines, or elevation (NJDEP, 1984). One of the strictest setback lines is employed by North Carolina. For small-scale development in beachfront areas, all new development must be setback a distance of 30 times the average annual erosion rate for that particular stretch of coastline, measured from the first stable vegetation line (Platt, et al, 1992). Development must also be landward of the crest of the "primary dune", and the toe of the "frontal dune" (Platt, et al, 1992). Conversely, New Jersey, employs a "fixed" line to determine the State's coastal high hazard setback line. The NJ Administrative Code (NJAC) 7:7E-3.18(d) (1995) requires permanent structures must be setback from oceanfront shore protection structures, typically including bulkheads, revetments, and seawalls at a minimum of 25 feet. This setback line is an important mitigation effort in preventing potential structural damage from storm wave run-up and penetration.

Although the setback line reduces potential damage to buildings behind these shore protection structures, New Jersey has not adopted setback lines to protect the continuation of coastal dunes. Rather, most coastal communities rely on dune ordinances to establish a static dune protection area. In the 1984 assessment of dune ordinances, NJDEP found most dune ordinances only describe a fixed and static defined line, such as a building line or dune area that does not account for future beach erosion or dune migration landward past this fixed line. A consequence of this fixed line is that the ordinances do not prevent construction in natural dune areas which are landward of the building line (1984).

There exists the opportunity to create dune protection zones and setback lines in the State's emerging mitigation strategy. These zones should include a description of the dune's location and should be marked on a map with appropriate definitions provided. Landward of this zone, a setback line should be established that would provide adequate space for an extension of the natural beach/dune process. These setback lines will allow dunes to extend landward naturally as wind and overwash accumulates sand in this area.

In order for setback lines to be effective, the location of the line must be able to move as conditions change; therefore the boundaries of the zone must be periodically reviewed and adjusted to account for the natural shoreline changes over time. Ordinances should be revised to include language that provides for review and re-designation of dune zones and setback lines every 2 -10 years. These changes should be cited on topographic maps as well.

In summary, setback lines are an effective method of addressing coastal hazard reduction. By requiring development to locate certain distances landward from coastal dunes, a buffer area for mitigation is created. This area protects dunes as well as reduces the public's direct exposure to the effects of coastal storms. In order for dune protection zones or buffer areas to be most effective, dunes dynamics need to be accommodated. Thus, setback lines can not be a static fixed line. Language must be incorporated into ordinances that requires setback lines and dune areas be reviewed and re-delineated as the coastline changes.

VII.B.3.c. Elevation of Structures

Elevating structures above estimated storm water levels is another mitigation land use option. This option involves the elevation of structures above an established base flood elevation. By elevating structures in areas prone to flooding, this strategy will reduce the amount of structural damage associated with storm surge and flooding.

The elevation of structures is a damage reduction requirement for all communities participating in the NFIP. The NFIP, administered by FEMA, requires participating communities to adopt regulations that will protect any new construction from inundation by a 100-year flood. Base Flood Elevations (BFE's) and Flood Insurance Rate Maps (FIRMs) have been developed by FEMA to assist communities depict the 100-year coastal flood plain and the elevations of the 100-year flood. The 100-year coastal floodplain is divided into the velocity zone (V-Zone) and A-Zone.

The V-Zone (velocity zone) is the portion of the 100-year floodplain that would be inundated by tidal surges with velocity wave action, and is the inland extent of a 3 foot breaking wave, where the still water depth during the 100-year flood decreases to less than 4 feet. Additionally, the FIRMs for coastal communities take into account BFE's that incorporate wave heights or wave run up associated with the 100-year flood. Although erosion is taken into consideration when determining V-Zones, It is often difficult to project erosion into the future because the erosion rate is non-linear, and it is also related to episodes of human manipulation of the sediment budget. The A-Zone is defined as the portion of the 100-year floodplain not subject to wave action; however, residual forward momentum of the breaking waves is present in this zone (FEMA, 1986).

Whereas these zones are adjacent to each other, construction requirements in the V-Zone and A-Zone differ from each other. In coastal V-Zones, any new construction and substantial improvements (greater than 50%) to existing buildings or structures must be elevated on anchored pilings or columns so that the bottom of the lowest horizontal structural members of the lowest floor (excluding the pilings and columns) is at or above the BFE (FEMA, 1986). A registered professional engineer or architect must certify that the structure is securely fastened to anchored pilings or columns to withstand velocity waters and hurricane wave wash forces. In addition, it is required that no fill be used for structural support of new or substantially improved structures in V-Zones, and that sand dunes not be altered so as to increase the potential for flood damage. In coastal A-Zones, new construction or substantial improvements must be elevated so that the lowest floor (including basements) is at or above the BFE. However, the use of fill raised foundations or piles and columns may be used to attain this elevation (FEMA, 1986). Figure 1 demonstrates the different construction requirements associated with V- and A-zones.

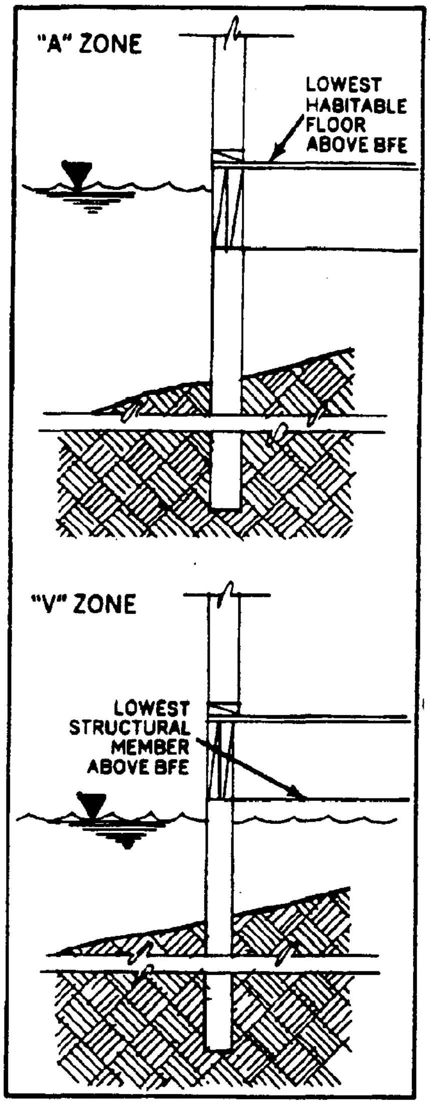

Figure 1. Comparison of construction requirements in ' A-Zone' and 'V-Zone' Source: FEMA (1986).

VII.B.3.d. Building Codes

Building codes provide a mechanism for the construction of structures that can better withstand hurricane force winds, waves, and surges; thereby reducing the amount of structural damage from a coastal disaster. By specifying the standards for the design, material, and construction practices for all new construction and substantial improvements, model codes assure these buildings will withstand storm waters and winds.

Building codes can be mandated on either national, state, or local levels, and can vary substantially in their stringency. Whereas some standards have been produced on a national level, most model building codes are developed on a regional basis to reflect the different building environments and are incorporated at the state and local levels (FEMA -209, 1991). Due to these different environmental factors, four major model code organizations have been created: Building Officials and Code Administrators (BOCA), the Southern Building Code Congress International (SBCCI), the International Council of Building Officials (ICBO), and the Council of American Building Officials (CABO) take the form of either performance standards or construction specifications. New Jersey and most of eastern and midwestern States have adopted BOCA's model codes, which for the most part, are performance standards (NJDEP, 1984).

VII.B.3.d.1 New Jersey and BOCA

In New Jersey, BOCA's National Building Code has been adopted as the Uniform Construction Code (N.J.S.A. 52:27D-1 et seq.) and must be used by all municipalities (NJDEP, 1984). Under this legislation, municipalities are required to use the BOCA codes as their only construction standards and are not currently permitted to supplement them with more stringent standards. The New Jersey Department of Community Affairs administers and enforces these codes at the local level. Since the passage of the 1981 Shore Master Plan, the Uniform Construction Code has continued to be updated to reflect BOCA's new recommendations to further reduce property damage from water-related damages.

In 1984, floodproofing codes were adopted for the first time nationally and have subsequently been revised (NJDEP, 1984). In the 1993 BOCA codes, Section 3107.0 refers to flood-resistant construction. The code applies to all buildings and structures under construction in areas prone to flooding and to all buildings undergoing alterations and repairs greater than 50% of the cost of the building (BOCA, 1993). Flood prone areas are determined using the 100-year flood elevation from Flood Insurance Rate Maps (FIRM). This elevation is used as the base flood level. Any building or structure located within the flood prone area must have the lowest floor elevated at or above the base flood elevation. Structures located in the V-zone must also have all structural members supporting the lowest floor located at or above the base flood elevation as well. The code also requires the structural systems of all buildings and structures in the flood prone areas be designed and anchored to resist flotation, collapse, or permanent lateral movement due to structural loads and stresses from flooding (BOCA, 1993).

VII.B.3.d.2 FEMA

One aspect of FEMA's mitigation efforts to reduce the public's risk from hazards is to promote the adoption of State and local loss reduction standards for all new construction, as well as for renovations and substantial improvements on older structures (FEMA-209, 1991). In their 1991 brochure Reducing Losses of Life and Property through Model Codes (FEMA-209, 1991), FEMA emphasized the adoption of model codes as a primary tool for reducing the Nation's exposure to risks from natural and man-made hazards. FEMA has striven to incorporate floodproofing standards into the model building codes by working closely with the four national building code organizations. Due to FEMA's efforts, most of the organizations, including BOCA, have adopted a majority of the National Flood Insurance Program (NFIP) building regulations (FEMA-209, 1991).

In order for communities to participate in FEMA's NFIP, communities must meet FEMA's minimum floodplain management standards. To aid communities meet these standards, FEMA has produced manuals and guidelines for the design and construction of buildings in areas subject to coastal storms and flooding. In 1986, FEMA distributed the Coastal Construction Manual, the second edition of these guidelines (FEMA-55, 1986). The manual is meant to assist builders, designers, communities, and home owners to comply with the performance standards of the National Flood Insurance Program. FEMA stresses that the manual is not intended to encourage construction in hazardous areas, but it is meant rather to ensure that construction in these areas are designed and erected in such a manner as to minimize potential wind and flood damage (FEMA-55, 1986). The Coastal Construction Manual (FEMA-55, 1986) developed and expanded guidelines on some of the following information: construction materials, foundations, fastenings, anchorings, bracing, shapes of houses, and wind and water loads. The second edition (1986) made several changes including design guidance for breakaway wall enclosures, maintenance recommendations, and revisions of design procedures to reflect the American Society of Civil Engineers standards and other design information. Overall, the manual continued FEMA's direction to elevate, floodproof, and securely stabilize structures in high hazard coastal areas to avoid potential damage.

VII.B.3.d.3 Wind-load Reduction Standards

After a succession of severe coastal storms in the 1990s, emphasis is being placed on developing structures that will withstand hurricane force winds as well as flooding. Although wind standards had been adopted, Hurricane Andrew proved homes that were constructed to survive 120 mph winds speeds were not strong enough. One reason for this severe damage was the inadequate enforcement of existing codes (FEMA-261, 1995). A solution to this problem is the enforcement of prescriptive codes rather than the present performance codes (FEMA-209, 1991). While performance codes determine how a building should perform, a prescriptive code indicates the design and construction of a building, such as the size and material of the structure. Prescriptive codes are beginning to be incorporated into the model building codes which provide specific building designs against wind damage.

VII.B.3.d.4. Leadership at the State Level

Whereas building codes are a proven method for reducing coastal community risks from coastal hazards, they need to be amended on a national and state level. For the most part, New Jersey coastal construction has withstood storm waves and winds fairly well due to the adoption of model codes. However, most of these structures have not been tested by hurricane force winds or water. Hurricane Andrew proved the adoption of performance standards was not enough, and that there is a need for better code enforcement on a national level. If New Jersey is to avoid a similar disaster as Florida, prescriptive codes should be incorporated into the Uniform Construction Code. Because coastal communities are unable to mandate new building codes, either BOCA or the state must develop prescriptive codes to enforce building compliance and enforcement. Alternatively, new legislation could be introduced which enables communities to supplement BOCA's codes with more stringent floodproofing controls. Lastly, as the insurance industry continues to develop wind-reduction incentive programs, grading systems, and other programs, New Jersey should support their efforts.

VII.B.3.e Relocation

Relocation of existing structures from eroding and/or flood prone shorelines is another mitigation option the State and coastal communities can incorporate into their efforts. By relocating structures away from high-hazard areas, the potential for loss of life and structural damage is reduced. Relocation of smaller structures such as one- and two-story residential buildings is a more economically feasible and easier than the relocation of larger structures.

There are however, a number of institutional and economic impediments associated with relocation. If space is not available on the same lot for the structure to be moved, an alternative site must be acquired and prepared (NRC, 1990). Further, the problems continue if the alternative site lacks the view and/or direct access that are often the reasons for shoreline property ownership in the first place. If relocation is to become a realistic mitigation option, there need to be much in the way of education and public awareness of the dangers of living near the shoreline. The identification of high hazard areas can assist to foster the education and public awareness objective for the risks associated with the shoreline.

VII.B.3.f Acquisition

By acquiring high hazard lands, coastal communities and the state can reduce the loss of life, injuries to people, and damages to property caused by coastal storms. Acquisition of hazardous areas can also reduce the subsequent potential storm-related losses and vulnerability to coastal communities by creating the opportunity for natural coastal protection areas (buffer zones) and the development of coastal dunes. Beyond protecting the public's safety through an enhanced buffer zone, there are other associated benefits to coastal land acquisition such as an increase in public access, recreational opportunities, and conservation areas.

Acquisition of coastal land has several drawbacks, primarily the high cost of acquiring developed property and the loss of tax ratable to a community. However, if the acquired property were to provide public access for recreational opportunities, the loss of property tax revenue may be partially offset by an increase in revenue derived from beach fees and other resulting tax revenues (NJDEP, 1984). By acquiring high hazard property and reducing related storm damage, land acquisition programs could potentially save communities expenditures for post-storm clean-up and repairs.

High hazard coastal areas can be acquired either through voluntary means or condemnation for a fee simple or less-than-fee simple purchase. Acquisition of fee simple property is the most desirable type of acquisition because the ownership and property rights are transferred completely (Clayton, 1987). Less-than-fee simple purchases can also be a useful acquisition strategy. Examples of less-than-fee simple acquisitions include easements, leases, transfer of development rights, and donations. Whereas less-than-fee simple acquisitions cost less than fee simple purchases, they do not provide total ownership and control of the acquired land.

Land acquisition programs can either be implemented as pre- or post-storm programs. Pre-storm acquisitions are preferable to post-storm because the exposure of people to coastal hazards is minimized prior to any disaster (NJDEP, 1984). However, many property owners in high hazard areas are reluctant to move willingly until their property has been substantially damaged by a storm; thus if the community condemns the property, the cost of pre-storm acquisitions can become quite expensive. In the 1981 Shore Master Plan, post-storm acquisitions were preferred to pre-storm under the rationale that expected damages to structures during a disaster could reduce the cost of post-storm buyouts (NJDEP, 1981). However this approach to post-storm acquisition has changed. In recent years, as an incentive to property owners, states with successful post-disaster acquisition programs have offered to purchase the property at the fair market value as it existed immediately prior to a disaster (McCain, 1996). New Jersey's own coastal Blue Acres program will also be using this concept to determine fair market value for post-storm acquisition.

VII.B.3.f.1 Coastal Blue Acres Program

In 1995, New Jersey established coastal Blue Acres, a $15 million bond program to assist coastal communities acquire, from willing sellers, coastal lands most susceptible to storm damage and erosion. With the establishment of Blue Acres, acquisition of high hazard property has become a more viable mitigation strategy for New Jersey. Beyond serving as buffer areas within the coastal communities, all Blue Acres parcels will be utilized as conservation and/or recreational sites as well. Administered by the NJDEP's Green Acres Office, Coastal Blue Acres is divided into two specific types of purchases: pre- and post-storm acquisitions. Post-storm acquisition involves the purchase of properties damaged by a storm and pre-storm acquisitions involve the planned acquisition of open, undeveloped, or largely-undeveloped parcels.

Under the post-storm program, $9 million will be available for coastal communities to purchase lands in the coastal area that have been damaged for up to a 50 percent grant/50 percent loan basis (P.L. 1995, c.204). In order for storm-damaged property to qualify for the coastal Blue Acres program, the value of the improvements on the property must be reduced by at least 50% due to damages caused by a storm or storm-related flooding (P.L. 1995, c. 204). In an effort to expedite post-storm buyouts and provide emergency relief, post-storm purchases only need the approval of the Legislature's Joint Budget Oversight Committee. Not only will a quick response provide the community with a unique opportunity to relocate citizens away from hazardous areas, it may also help victims stabilize their lives as quickly as possible (Patton, 1993).

The remaining $6 million is available to coastal communities for up to a 75% grant/25% loan to assist them to acquire lands in the coastal area that may be prone to incurring damage caused by storms or storm-related flooding, or that may buffer or protect other lands from such damage, or that support recreation and/or conservation, among other criteria (P.L. 1995, c.204). Because this type of purchase is planned rather than on an emergency basis, pre-storm acquisition projects must first be approved by the State Legislature.

It is imperative that Blue Acres limited funds be used to purchase property that only promotes the expansion of public safety and natural coastal protection. Before any Blue Acres parcels are acquired, the Green Acres staff must determine an acquisition strategy for the Blue Acres program to ensure that the parcels purchased promote the Act's objectives. By creating and applying an acquisition plan, the Blue Acres program can reduce the continuous community and state investments to repair and reconstruct structures in known highly exposed and vulnerable areas, as well as promote further coastal protection. In order to achieve a reduction of the public's exposure and associated long-term risks from coastal hazards, these highly hazardous coastal areas need to be characterized and identified. Once these areas have been designated, an advisory committee could assist the Green Acres staff identify potential specific parcels or areas.

VII.B.3.g Funding Sources in Support of Acquisition

As the coastal zone of New Jersey continues to be developed, property values will probably also continue to increase making acquisition an expensive option. Therefore, the amount of funding available for acquisition is a critical aspect of the program's success. Several Federal, State, and private sources of funding exist which can be potential sources of additional funding. Utilization of these sources will increase the amount of money available under the Blue Acres program. The following section presents various sources of funding for New Jersey coastal acquisition:

VII.B.3.g.1. Green Acres Program:

New Jersey's successful Green Acres program provides funding for up to 50% of the total cost of an acquisition project (P.L. 1995, c.204). Whereas coastal Blue Acres pertains to just the coastal area, the Green Acres program grants funds for acquisition projects across the state, including coastal areas. Therefore, Green Acres is another potential funding source for coastal acquisition of hazardous areas. Under the program, land with unique natural features, water frontage or water resources, and/or other characteristics can be acquired for conservation and recreational purposes (P.L. 1995, c.204). Unlike the coastal Blue Acres program which only allocates funds to local governments, non-profit and private groups can qualify for matching funds up to 50% of the cost of the project under the Green Acres program (P.L. 1995, c.204).

VII.B.3.g.2. Non-profit Sector:

Because many nonprofit groups can qualify for matching Green Acres funds under the Green Acres program, several nonprofit groups in New Jersey have actively participated in acquisition projects. Besides grants from the Green Acres program, these groups also receive funding through personal and private land and monetary donations. Whereas most nonprofit groups acquire undeveloped lands to preserve and protect the biodiversity of unique habitats, some acquisitions are used to promote the expansion of public recreational areas as well. The Trust for Public Land, the Nature Conservancy, the New Jersey Conservation Foundation, and the New Jersey Audubon Society are a few examples of non-profit groups which have participated in land acquisition projects before and could be potential funding sources for the non-state share of coastal land acquisition projects.

VII.B.3.g.3. Private Sector:

Private corporate or personal donations could also be potential contributors to the non-state's share of a project's costs. Large companies or businesses benefiting from the shore area and related tourism could make tax-deductible contributions towards the coastal Blue Acres program. Private personal donations of land or money could also be a large source of funding for the non-state share of the Blue Acres program as well (NJDEP, 1984). For any property being acquired, encouragement for some donation as part of non-state funding.

VII.B.3.g.4 NJ Shore Protection Fund:

P.L. 1992, c.148 created the "Shore Protection Fund" to finance shore protection projects. The Shore Protection Fund receives $15 million annually from New Jersey's realty-transfer tax which is allocated towards shore protection projects. This fund could also be a potential funding source for coastal acquisition projects as a type of shore protection.

VII.B.3.g.5 FEMA's Hazard Mitigation Grant Program:

Under Section 406 of the 1993 Stafford Act, the Federal Emergency Management Agency may contribute up to 50% of the cost of funding for approved hazard mitigation measures. After a declared disaster, the State and local governments can apply through the Office of Emergency Management for funding for acquisition and relocation projects that result in the protection of public or private property (P.L. 100-707, 1993). Many states affected by the 1993 Mid-West flooding have used these funds to successfully relocate people and buildings, and acquire substantially-damaged property (FEMA, 1995). These Hazard Mitigation Grant funds can be a valuable source of funding for communities acquiring parcels through the Blue Acres post-disaster grant/loan program.

VII.B.3.g.6 HUD-Community Development Block Grants:

Each year, states and small cities (under 50,000 in population) may apply for Community Development Block Grants (Non-Entitlement) to assist them promote sound community development. Under the program, the grants may be used towards such projects as acquisition of real property, as long as no less than 70% of the funds are used for activities that benefit low- or moderate-income persons (HUD, 1996). The Department of Housing and Urban Development also offers loans to communities to finance property acquisition under Section 108 of the Community Development Block Grants. These loans are granted for projects that either principally benefit low- or moderate-income people, or assist community development needs that present a serious and immediate threat to the health and welfare of the community, i.e. a coastal storm disaster (HUD, 1996). Either of these Community Development Block Grants could be a source of funding for the community's share of an acquisition project.

VII.B.3.g.7 Small Business Administration Disaster Loan:

Small Business Administration (SBA) Disaster Loans, granted after declared disasters, are administered by FEMA. The SBA offers low interest loans to repair or replace damaged property and personal belongings not covered by state, or local programs, or private insurance (FEMA, 1994). Under the SBA loan, homeowners are eligible for loans up to $200,000 for repair or replacement of real estate and it may be increased by up to 20% for mitigating devices for damaged real property. Businesses may receive up to 100% of the uninsured, SBA-verified disaster losses and that also be increased by up to 20% for mitigation devices for damaged real property. SBA loans could be used in conjunction with other disaster benefits an owner has received to lower the overall cost of post-disaster acquisition projects.

VII.B.3.g.8 National Flood Mitigation Fund:

Replacing the National Flood Insurance Program's Upton-Jones Amendment, the National Flood Mitigation Fund was created in 1994. The fund will be used for mitigation activities such as relocation and acquisition of repetitive loss structures (P.L. 103-325, 1994).

Funding for this program will come from surcharges on flood insurance policies. (Lesser, 1996 Personal Communication). The National Flood Mitigation Fund can also be a source of coastal land acquisition funding.

VII.B.3.g.9 Individual and Family Grant Program:

Homeowners who do not qualify for a SBA loan or do not have other financial or insurance resources can apply for an Individual and Family Grant Program. Individual Grant Program loans are another supplementary recovery loan available to assist individuals or families recover from a disaster. Under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (P.L. 93-288), an individual or family may receive a grant for up to $10,000 for disaster assistance; 75% of which the Federal government will fund. The remaining 25% of the cost is paid to the family or individual from funds made available by the State (FEMA-229(4), 1995). Similarly to SBA loans, Individual Grant Program loans could also be used in conjunction with other disaster benefits an owner receives to lower the overall cost of post-disaster acquisition projects.

In summary, acquisition of property in high hazard areas is a mitigation method for local and State governments to reduce the public's exposure to coastal hazards. With the inception of the State's Blue Acres program, acquisition of coastal property in high hazard areas has become a viable mitigation strategy for the State. Because only $15 million is available under Blue Acres, the number of acquisition projects are limited. Therefore, the State and coastal municipalities need to take advantage of existing complementary acquisition funding sources to expand the utilization of this mitigation strategy. Further, acquisition should be part of local or regional mitigation program to reduce loss or exposure.

VII.B.4. Other Mitigation Options

VII.B.4.a Insurance

Owners of property being financed that is situated in identified high hazardous areas must obtain flood insurance. Because almost the entire coastal zone of New Jersey is considered a high hazard area, insurance premiums along the New Jersey shore have increased over the past few years saturating the market (Defendorf, 1996 Personal Communication). The rates for flood insurance premiums are mandated by the Federal government and when they increase, they do so across the board Thus, every property owner located in a state affected by flood insurance sees an increase. Special areas or particular zones, such as the coastal zone, are not targeted for a higher premium associated with higher risk.

VII.B.4.a.1 Wind-load Reduction Incentives

An emerging trend in the realm of the insurance industry is the companies who are targeting coastal areas as sites of unacceptable losses with regards to homeowners insurance. Whereas FEMA has provided technical guidance on the NFIP wind requirements, it is the private insurance industry which has taken an aggressive approach on reducing wind-load related losses. Following Hurricane Andrew, which caused $16 million in private insurance losses, the insurance industry was unable to receive reinsurance and was forced to find ways to cut its losses (Moore, 1996). In an attempt to avoid a similar disaster, the insurance industry has taken an aggressive approach on reducing wind-load related losses. The insurance industry has begun to implement building standard changes to include incentives for reducing wind-associated damages (FEMA-261, 1995). Prior to Hurricane Andrew, the insurance industry created Wind-Rite, a credit/debit system which allows for a more precise and accurate rating system (FEMA-261, 1995). Depending on what is being done to reduce wind hazards, premiums and/or deductibles will go up or down under the program (FEMA-261, 1995). Also prior to Hurricane Andrew, the insurance industry began implementing a program to improve construction practices by developing a code grading system for rating enforcement, the training of personnel, and the operations of building code development (FEMA-261, 1995).

The insurance industry has also begun promoting research for building wind resistant homes in the hope that it will create consumer demand for stronger, safer homes (Moore, 1996). In North Carolina, a pilot project named Blue Sky is in the process of developing houses that resist hurricane force winds as a result of this new direction (Ross, 1995). The aim of Blue Sky and other programs is to reduce property loss, create a safer community, and offset insurance costs and other tax benefits to homeowners.

VII.B.4.a.2 Mitigation Incentives

As part of their mitigation efforts, FEMA has initiated the community rating system (CRS). The CRS seeks to reward communities with a rebate for additional activities they undertake, beyond the minimum requirements of the NFIP, in which they practice good floodplain management and try to minimize flood damages. Participation in the CRS is voluntary and it is the responsibility of local governments to submit the documentation that shows implementation of the different creditable activities (Beatley, et al., 1994). The insurance premiums are reduced for those property owners within these communities and, in turn, they receive a rebate on their insurance premiums.

There are four categories under the CRS program, with eighteen mitigation activities, that the CRS will credit. The four categories are: public information; mapping and regulation; flood damage reduction; and flood preparedness. A certain number of points are assigned for these activities depending on the extent to which the community has successfully achieved the CRS objectives (Table I). The points accumulated from each individual measure are tallied together to determine the community's total points, whereby the premium reduction is calculated. Premium reductions range from 5% to 45% for property within SFHAs (Table II). There is a maximum 5% reduction allowed for property that is outside of SFHAs because premiums are already low in these areas and because means by which credits are given are based on the zones assigned to the 100-year flood level (Beatley, et al, 1994).

Although the CRS rating system was designed with good intentions, it is basically impossible to achieve the highest rating. Presently, in order for a community to receive a high CRS rating, they would basically have to remove everyone from the floodplain. As a result, communities that are credited with initiating many mitigation activities, such as Ocean City, are only a Class 8 Community (Defendorf, Personal Communication).

Table I. Eighteen Mitigation Activities in the CRS Program

ACTIVITY	MAXIMUM POINTS	AVERAGE POINTS	APPLICANTS (%)
300 Public Information			
310 Elevation Certificates	137	73	100
320 Map Determinations	140	140	92
330 Outreach Projects	175	59	53
340 Hazard Disclosure	81	39	40
350 Flood Protection Library	25	20	77
360 Flood Protection Assistance	66	51	45
400 Mapping and Regulatory			
410 Additional Flood Data	360	60	20
420 Open Space Preservation	450	115	42
430 Higher Regulatory Standards	785	101	59
440 Flood Data Maintenance	120	41	41
450 Stormwater Management	380	121	37
500 Flood Damage Reduction			
510 Repetitive Loss Projects	441	41	11
520 Acquisition and Relocation	1,600	97	13
530 Retrofitting	1,400	23	3
540 Drainage System Maintenance	330	226	82
600 Flood Preparedness			
610 Flood Warning Program	200	173	5
620 Safety	900	0	0
630 Dam Safety	120	64	45

Source: Beatley, et al. (1994)

Eighteen CRS Mitigation Factors

COMMUNITY TOTAL POINTS	CLASS	SFHA CREDIT (%)	NON-SFHA CREDIT (%)
4,500	1	45	5
4,000 - 4,499	2	40	5
3,500 - 3,999	3	35	5
3,000 - 3,499	4	30	5
2,500 - 2,999	5	25	5
2,000 - 2,499	6	20	5
1,500 - 1,999	7	15	5
1,000 - 1,499	8	10	5
500 - 999	9	5	5
0 - 499	10	0	0

Source: Beatley, et al. (1994)

VII.B.4.b Post-Storm Recovery Plans

Post-storm recovery plans should be developed to serve as an aide in reducing future losses in high hazard areas. These plans can provide guidelines for a more idealized distribution of land-uses, avoiding development in problem areas and utilizing the environmental, economic, and cultural resources of the area. In most of the coastal zone, the post-storm period is the only opportunity to alter existing land-uses and to move toward a long-term objective. The post-storm recovery period would be an appropriate time to apply incentives toward reducing vulnerability and increasing public access (Psuty, 1993). Although the concept is to develop post-storm plans, these plans, in turn, evolve into mitigation approaches for the next storm and future conditions.

The development of post-storm plans should incorporate the interests of the several levels of government. Objectives may largely coincide among these levels but there may be differences as well. Some of the communities may have moved forward in the creation of storm hazard mitigation plans and post-storm recovery plans. Others may have only general concepts and very little strategy developed in the pursuit of the long-term objectives. However, there will be a need to blend the local plans into a regional plan which is in concert with the long-term objectives of coastal management for the state. Leadership will be required at the higher levels to enunciate the long-term objectives and to establish the direction for coastal management. Local authorities must be informed about the regional goals and how they are components of the larger system. Throughout the process, there should be assistance in the form of information about the long-term objectives, about coastal dynamics, about the application of mitigation strategies, about the opportunities for financial support in the pre-storm period and in the recovery period. An important product of the recovery plan would be the identification of measures which communities may use to conform to the long-term objectives and to quality for federal and/or state funds. This information can serve as a tool for state and local decision-makers when faced with incorporating mitigation strategies into the post-storm recovery and subsequent hazard reduction plans.

VIII. Future of Mitigation in Shoreline Management

As a result of FEMA's new direction and other institutional and economic policies, subsidies that once existed for coastal development and rebuilding will no longer be readily available. With this absence comes the need to utilize coastal planning to redirect and to redevelop the coastal zone. Instead of the previous focus, which has always been on "defending the line," the new focus will be directed towards "coastal hazard management." More emphasis will be placed on public safety issues and protecting the public and managing public funds rather than on protecting property. Furthermore, the goal will be to integrate coastal natural hazard mitigation at the several jurisdictional levels with the availability of public funds. That is, as the redevelopment or recovery plans are in phase with the regional and state long-term objectives, there will be more opportunity to qualify for public funds in support of local programs. Conversely, those local activities that do not contribute toward the long-term objectives to enhance public safety and to reduce damage will not qualify for public funds beyond the community level. In theory, the coastal hazard mitigation plans should originate at the local level;

they are blended at the county level to achieve a regional approach; and they are integrated into a statewide Coastal Hazard Mitigation Plan for funding and implementation. State leadership is a key ingredient in establishing the long-term objectives and in securing the public funds to drive the regional mitigation programs.

RECOMMENDATIONS

ORGANIZATION - State Coordination

New Jerseyans are challenged by the population demands placed on shoreline use. High population density continually jeopardizes the natural processes governing stability and change along our shoreline. One of the traditional approaches for managing shoreline systems in developed settings is to implement strategies on a municipality by municipality basis. This is certainly true in New Jersey where home rule has fostered a piecemeal approach to shoreline management. That is, New Jersey's plan is comprised of a multitude of statutes. Although these statutes seek to achieve the same end--informed management of the coastal zone--no overarching administrative framework exists to ensure that the coastal zone is managed on a consistent basis in a fair and reasonable manner.

As demand for use of the shoreline continues to grow, better information and more creative management strategies are needed to support continued resource use and stewardship. How can we assist coastal managers and train students to manage this natural resource in a manner that fosters access, mitigates the risk associated with coastal hazards, and preserves the ecological integrity of shoreline systems? An integrated, coordinated, management approach has been used by other coastal states to address shoreline processes which occur at regional scales (e.g., currents, sand transport) and are more effectively managed at these scales. Partnerships that transcend juridical boundaries are desirable and necessary to achieve this aim.

The adoption of a comprehensive planning approach--such as that used in North Carolina--arguably would provide the necessary oversight as well as a mechanism for consistent (integrated) coastal policy thereby ensuring safe and effective coastal management. The review of this approach suggests that a regional or holistic approach to coastal management is the most effective and reasonable method by which to manage our coast. Accordingly, as discussed previously, a regional approach provides the best means through which an integrated system of coastal hazard mitigation can be implemented.

An administrative framework should be developed under a simple, yet effective comprehensive planning statute. A single state entity should be charged with the sole responsibility of managing the New Jersey coast. Consolidation of coastal hazard management efforts within state government is supported by a recent review of the state's coastal management program conducted by the National Oceanic and Atmospheric Administration. Presently, coastal management efforts are divided among several divisions at NJDEP (Office of Environmental Planning, Bureau of Coastal Engineering, and the coastal permit group housed in the Office of Land Use Regulation) and the Office of Emergency Management and Preparedness of the N.J. State Police. This somewhat diverse organization on coastal management in New

Jersey needs to be reorganized to manage and service a new regional approach that functions in close cooperation with county and local planning entities. Reorganization should include the establishment of well-defined objectives that are coordinated through a single office. Establishment of one state entity for this responsibility could reside at what is now known as the Office of Environmental Planning. This office currently manages federal funds allocated for coastal zone management and possesses a great deal of expertise on coastal issues. In addition to shifting regulatory and mitigation responsibilities to this office, a liaison must be established with the State Planning Office to ensure that coastal management policy is incorporated into the N.J. Development and Redevelopment planning effort. Consolidation will simplify and enhance coordination of state management efforts.

This state "division" should establish the existing citizen advisory committees as a means to receive local input on coastal issues relevant to their respective regions. The state coastal "division" would interact with the citizen advisory committees to integrate local and regional coastal policy goals with coastal hazard management strategies. That is, the state would acknowledge that although coastal policy is formulated at the state level (based on input from each region), each region has its own authority to address its particular coastal issues at a local level within the statutory framework. In other words, the program must ensure that there is a partnership between state and local governments regarding development of coastal management policies, and there are opportunities to blend the objectives of the several authorities and there will opportunities to the contrary. However, when the accomplishment of the goals is in agreement at the several levels, that is the opportunity to use public funds in support of the regional program. Individual local programs will be supported only at the local level.

The "division" should also manage a coastal lands acquisition program (such as the recently enacted Blue Acres program) which sets guidelines for land acquisition and establishes a "priority" list for land acquisition. This is particularly important since many opportunities for acquisition occur after a storm event. Finally, the "division" should establish and maintain a public information/outreach program pertaining to coastal issues. Specific elements of such a program are presented in the Education Section of Part 2.

Within this general framework, coastal hazard mitigation measures could be implemented effectively on both state and local levels. The "division" could implement a comprehensive coastal planning requirement, particularly with regard to the dune/beach systems and coastal erosion on both a state and local level. Also, a statewide coastal land acquisition program would ensure that high hazard erosion areas, which are in mitigation programs at the local and regional level, are placed on a state "priority" list. Further, as in Delaware, a program could be implemented which provides incentives (such as density bonuses and credits) which encourage coastal landowners and developers to refrain from building in high hazard areas. Simply put, a single state entity would seek to ensure that coastal development and the preservation of coastal areas are conducted in the public interest on the basis of a strong public participation process.

For this approach to be effective, there must be a clearly defined role in the decision-making process for citizens and government to solve problems together. Responsibilities should include citizen oversight and monitoring, meetings called jointly by government and citizen groups, and funding to hire technical consultants and/or to implement projects.

Policy

Long-term shoreline management objectives need to be developed by the State to provide leadership in directing the management of the shore.

- Long-term mitigation strategies are needed that support the State's coastal management objectives into the year 2050*. What should the coast look like in 2050? Will there be dunes, a beach, the same land-use, the same densities, or same infrastructure?
- When determining the objectives, the State should incorporate sea-level rise and a modified coastal zone in planning for the future. Mitigation objectives and strategies should be developed on anticipated water levels, erosion, and the degree of protection sought from coastal storms.
- The objectives and strategies should to be created in a manner that recognizes that the coastal system is dynamic in nature and the means to interact with a changing system should also be dynamic.
- These objectives should incorporate back bay systems and other low-lying shoreline areas into regional mitigation efforts aimed at storms, flooding, and sea-level rise.

Once the State's objectives are developed, coastal management strategies need to be created to achieve these objectives.

- In keeping with Federal and State mitigation strategies, these strategies should incorporate goals that enhance public safety and reduce the public's exposure to coastal hazards.
- There is a need to continuously review and assess these strategies and actions taken to ensure that they are fulfilling the State's long-term objectives as the coastal zone changes.
- The State should incorporate the various mitigation approaches and techniques as described in the *New Jersey Hazard Mitigation Plan.* As this plan is periodically updated, the State should continue to incorporate their recommendations into the State's long-term management strategies.
- The State should assist communities in meeting the mitigation goals of the NJHMP and the

* A shoreline future should be projected for planning and management purposes. 2050 is selected because of its similarity to the USACOE 50-year maitenance agreement. Further, all of the recommendations are approproiate considerations when reviewing the 50-year time frame.

FEMA National Mitigation Strategey. Not only will this reduce the public's risks, but these efforts may increase community CRS ratings.

The State should apply strategies on a regional basis not at the local jurisdictional level.

- Regional planning efforts should be conducted in a manner that recognizes the natural processes operating in a reach, and that promote informed land-use decisions in the coastal zone that are based on hazard mitigation strategies.
- The State management plan should be created so that it incorportes local input to address the effects of regional coastal processes.
- Regional planning should be used to establish appropriate land uses, land-use densities, and long term strategies.
- State and Federal funding should be linked to the consistency of local programs with state and regional objectives. Those programs that agree with the State's objectives of reduction of risk and improvement of public safety should be given funding priority.
- If local communities develop programs that are not consistent with the State's objectives, then the community should carry these out at their own expense.
- Public funding for projects that support development in high hazard areas should be eliminated.

High hazard coastal areas need to be identified. These areas need to become a focus of State and community mitigation efforts.

- The characteristics of high hazard areas should be identified and applied to the coastal region. Identification of high hazard areas can assist to foster the education and public awareness objective of the risks at the shoreline.
- These areas should be prioritized according to the degree of risk to the public, and should be periodically updated or revised, particularly following storm events.
- Of especial importance are the low-lying areas that are flooded from minor storm occurrences, including the bay side communities.
- Coastal Blue Acres funding should be used to purchase property in identified high hazard areas. If a potential Blue Acres parcel complements the objectives of the State's mitigation strategies, then the State's portion of the purchase should be increased.
- The proportionality of Blue Acres funding for purchases in high hazard areas should be a 50/50 cost share ratio if the purchase meets the local mitigation objectives. However, the ratio of State share should increase to 100% where regional/State mitigation objectives are also achieved.

Approaches

The State and coastal communities should continue to utilize coastal dunes as a natural

barrier to coastal storms and associated risks.

- A coordinated governmental program of dune creation, restoration, maintenance, and expansion for emergency recovery and long-term protection should be developed.
- Communities need to determine their dune preservation objectives. Once established, municipalities should adopt and enforce effective dune protection ordinances and maintenance programs to promote dune creation and enhancement.
- The boundaries of dune areas should be scientifically defined and flexible, which acknowledge the migration of dunes by natural forces. These boundaries need to be periodically reviewed, particularly after a storm event.
- Where possible, communities should establish a formal dune buffer area inland of the built dune to permit the inland extension of the dune processes.
- The other attributes of coastal dunes, such as their sand storage abilities, should be incorporated into municipal dune preservation efforts.

Develop a Coastal Hazard Management Plan that provides a blueprint to guide long-term management of the shoreline and that targets high hazard areas for post-disaster land use change. Planning efforts should focus on mitigation of the risk to public safety and not on the defense of property. This plan can provide guidelines for a more idealized distribution of land-uses, to avoid development in high hazard areas and utilize the environmental, economic, and cultural resources of the area. These plans should:

- Enact building moratoria as an element of post-disaster plans until an accurate assessment of damages has been completed in the context of long-term mitigation objectives and alternatives.
- Incorporate post-disaster land-use changes in identified high hazard areas such as prohibiting development, acquiring damaged property, and relocating people in these areas.
- Develop community based emergency evacuation plans. The plans should include an analysis of existing evacuation routes, alternative routes or the construction of new routes, population density, and availability of support facilities.
- Construction of new infrastructure should be relocated away from erosion and flood prone areas. Funding for disaster repairs should be used to relocate infrastructure, such as roads and sanitary sewer lines away from hazardous areas.
- Enact zoning ordinances to limit the type of development in high hazard areas, to create buffer areas, and to preserve dune/beach systems.
- Identify property in high hazard areas for post-storm acquisition with coastal Blue Acres funding. The State and coastal municipalities should to take advantage of existing complementary acquisition funding sources to expand the use of this mitigation strategy.
- Develop prescriptive codes to enforce building compliance or introduce enabling legislation to supplement BOCA codes with more stringent flood proofing controls.

Establish setback lines that create a buffer area between coastal dunes and development.

This area protects dunes and reduces the public's direct exposure to the effects of coastal storms.

- Setback lines can not be a static fixed line if dune duffer areas are to be effective. Language should be incorporated into ordinances that require setback lines and buffer zones, and should be revised periodically, particularly after a storm event.

Structural solutions can be conditionally employed as a barrier to the effects of coastal storms, but they may cause loss of beach and dunes. They should be used in conjunction with regional approaches to shoreline management.

Beach nourishment can be used to reconstruct the protective and recreational features of beaches; however it is an expensive short-term strategy that should be part of a regional shoreline management program. Beach nourishment projects should not be conducted in high erosion rate areas.

Mitigation approaches should be developed specifically for low-lying areas, such as the back bay systems, which are affected by even minor stormwater elevations.

Out Reach/Education

Foster informed planning and community response to coastal hazards through awareness and education.

- Maintain the Citizen Advisory Committees as a vehicle to raise awareness of shore protection issues, to solicit local input on the development of regional strategies to mitigation, to implement the State's mitigation objectives, and to facilitate dissemination of information.
- Maintain and continue to update the CHMP bibliography, homepage, and background documents on coastal hazard issues.
- Establish and coordinate volunteer mitigation and monitoring efforts.
- Provide local resource managers with easy access to information on management strategies that mitigate the effects of severe storms and coastal erosion.
- Foster awareness of coastal hazards through the formal and informal education communities.
- Develop programs to raise public awareness on their vulnerability to coastal hazard, the potential costs associated with these hazards, and the means to mitigate these hazards.

Scientific and Technical Assistance

Any and all public expenditure of funds in the coastal zone should be monitored through an evaluation program.

- This will assure that the technical methods used are credible, replicable, cost-effective, and grounded in scientific research.

- The continuation and results of applied research on coastal system dynamics and associated natural hazards should be transferred to coastal decision makers. This information will expand their knowledge and enable them to make sound decisions and anticipate the outcomes of future decisions.
- An evaluation of projects supported by public funds will also justify the continuation of successful programs.

The State should encourage the collection, analysis, and dissemination of data on shoreline change and coastal processes.

- Regular monitoring will enable the maintenance of a consistent, uniform data base for future decision making.
- The monitoring of the shoreline through dune/beach profiling should continue to assess the natural dynamics of the coastal zone.
- The current effort to investigate dune response to varying magnitude storms should be periodically updated to reflect any changes.
- The installation of self recording instruments to gather data on waves and currents is also essential to sound decision making.
- There is a need to investigate and understand coastal processes better, as well as the effects of sea-level rise on these processes. Areas that should be investigated include sediment dynamics, dune and beach dynamics.
- Studies should be developed on the dynamics of estuaries and wetland loss.

Programs should to be established which collect appropriate data to measure the economic importance of the coastal economy on a local, regional, and State basis.

- Future economic studies should be based on accepted research approaches and designs, and use appropriate statistical data, otherwise results will be of little use and will only cloud the issue of the relative economic importance of coastal tourism vis a vis investment in shore protection.
- Economic techniques, such as Cost-Benefit Analysis, need to be explored to determine their relative importance and usefulness in policy-oriented studies of shore protection.
- A pertinent database should be established and maintained to manage the appropriate data necessary for specific economic approaches. This will allow for a more accurate economic assessment of management approaches and improve regional management strategies.
- Studies should be conducted on a seasonal basis that would isolate and identify economic activity dependent on the coastal zone and/or on specific beach nourishment projects. Such studies may require data on economic activity and tourism expenditures that are location specific, in terms of the relative proximity to the shoreline, and to beach nourishment projects.

- Analysis should incorporate the elements and effects of uncertainty in benefit and cost estimates, as well as the element of risk associated with project failure and outcome. Future economic analyses could also incorporate other elements regarded as policy tradeoffs, such as level of development, level of erosion, and storm occurrences.