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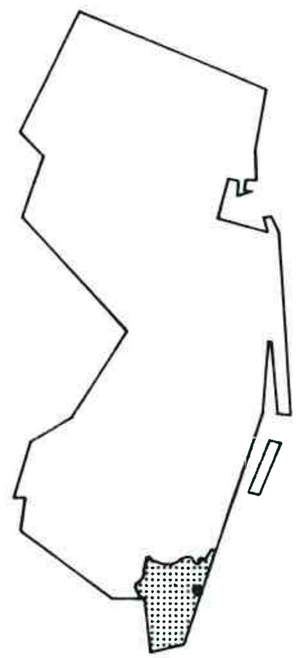
FLOOD INSURANCE STUDY

WAVE HEIGHT ANALYSIS

CITY OF SEA ISLE CITY, NEW JERSEY
CAPE MAY COUNTY



JULY, 1982

Federal Emergency Management Agency

COMMUNITY NUMBER - **345318**

ANALYSIS OF WAVE HEIGHTS
FOR
THE CITY OF SEA ISLE CITY, CAPE MAY COUNTY, NEW JERSEY

FEDERAL EMERGENCY MANAGEMENT AGENCY

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1.0 INTRODUCTION

1.1 Background and Purpose

The Federal Emergency Management Agency recently adopted recommendations by the National Academy of Sciences to include prediction of wave heights in Flood Insurance Studies for coastal communities subject to storm surge flooding, and to report the estimated wave crest elevations as the base flood elevations on Flood Insurance Rate Maps (FIRMs).

Previously, FIRMs were produced showing only the stillwater storm surge elevations due to the lack of a suitable and generally applicable methodology for estimating the wave crest elevations associated with storm surges. These stillwater elevations were subsequently stipulated in community flood plain management ordinances as the minimum elevation of the first floor of new construction. Communities and individuals had to consider the additional hazards of velocity waters and wave action on an ad hoc basis. Because there has been a pronounced tendency for buildings to be constructed only to meet minimum standards, without consideration of the additional hazard due to wave height, increasing numbers of people could unknowingly be accepting a high degree of flood-related personal and property risk in coastal areas subject to wave action. Therefore, the Federal Emergency Management Agency has pursued the development of a suitable methodology for estimating the wave crest elevations associated with storm surges. The recent development of such a methodology by the National Academy of Sciences (Reference 1) has led to the adoption of wave crest elevations for use as the base flood elevations in coastal communities.

Historically, the Ludlam Beach barrier island on which Sea Isle City is located has experienced few direct hit hurricanes. The Hurricane of September, 1944 passed approximately 30 miles east of Sea Isle City and resulted in tidal heights of 7.5 to 8.0 feet above mean sea level and caused extensive property damage. Another storm of extreme intensity was the Great Atlantic Storm of March, 1962, during which portions of the barrier island were breached due to prolonged high tide elevations and wave action. Hurricane "Donna" of September, 1960 also caused severe damage as it passed approximately 80 to 100 miles off New Jersey's Atlantic coast. Strong winds and intense precipitation accompanied the Storm of November, 1950 and Hurricane "Belle" of August, 1976 (References 2 and 3).

The purpose of this study is to revise the FIRM for the City of Sea Isle City to include the effects of wave action for the following flooding source: Atlantic Ocean (Ludlam Beach).

2.0 INVESTIGATIONS

2.1 Previous Studies

In 1968, the Phildadelphia District of the U.S. Army Corps of Engineers prepared a Flood Plain Information report in which tidal stillwater elevations for Cape May County were published (Reference 2). This report proposed a 100-year stillwater elevation of 10.0 feet mean sea level (msl) for the open coast, and 9.2 feet (msl) for the back bay areas within Cape May County, however, these elevations had been derived as estimates extrapolated from high water marks.

More recently, the Corps of Engineers has compiled a design memorandum (Reference 4) in which a joint probability method was used in conjunction with actual recorded flood elevations to construct a high tide frequency curve with over 60 years of record. The coastal stillwater elevations presented in this high tide frequency curve were: 6.3 feet (msl) for the 10-year frequency, 8.5 feet (msl) for the 50-year frequency, 9.8 feet (msl) for the 100-year frequency, and 13.1 feet (msl) for the 500-year frequency. These elevations constitute the best data available and supercede those published in the earlier Flood Plain Information report. As a result, they have been adopted for use in this wave height analysis. Because no technical analysis has been performed on the back bay areas, and no valid surge elevations are available, the coastal stillwater elevations have been adopted for use in the back bay areas.

The previous FIRM for the city of Sea Isle City was based on a 100-year stillwater elevation of 10 feet (msl), with no surge change in the back bay areaas. The information presented in this wave height analysis supercedes the previous FIRM dated December, 1975.

2.2 Data Collection and Review

All available source data applicable for the wave height analysis were collected and reviewed. Because wave height calculations are based on such parameters as the size and density of vegetation, natural barriers (sand dunes), buildings, and other manmade structures, it was necessary to obtain detailed information on the physical and cultural features of the study area.

Attempts were made to obtain information from the following sources: the Cape May County Planning Board, the U.S. Army Corps of Engineers (Philadelphia District), the New Jersey Department of Environmental Protection, Keystone Aerial Survey, Walker, Previti, Totten and Holmes (city engineers for Sea Isle City), the U.S. Geological Survey, and the New Jersey Office of Shore Protection.

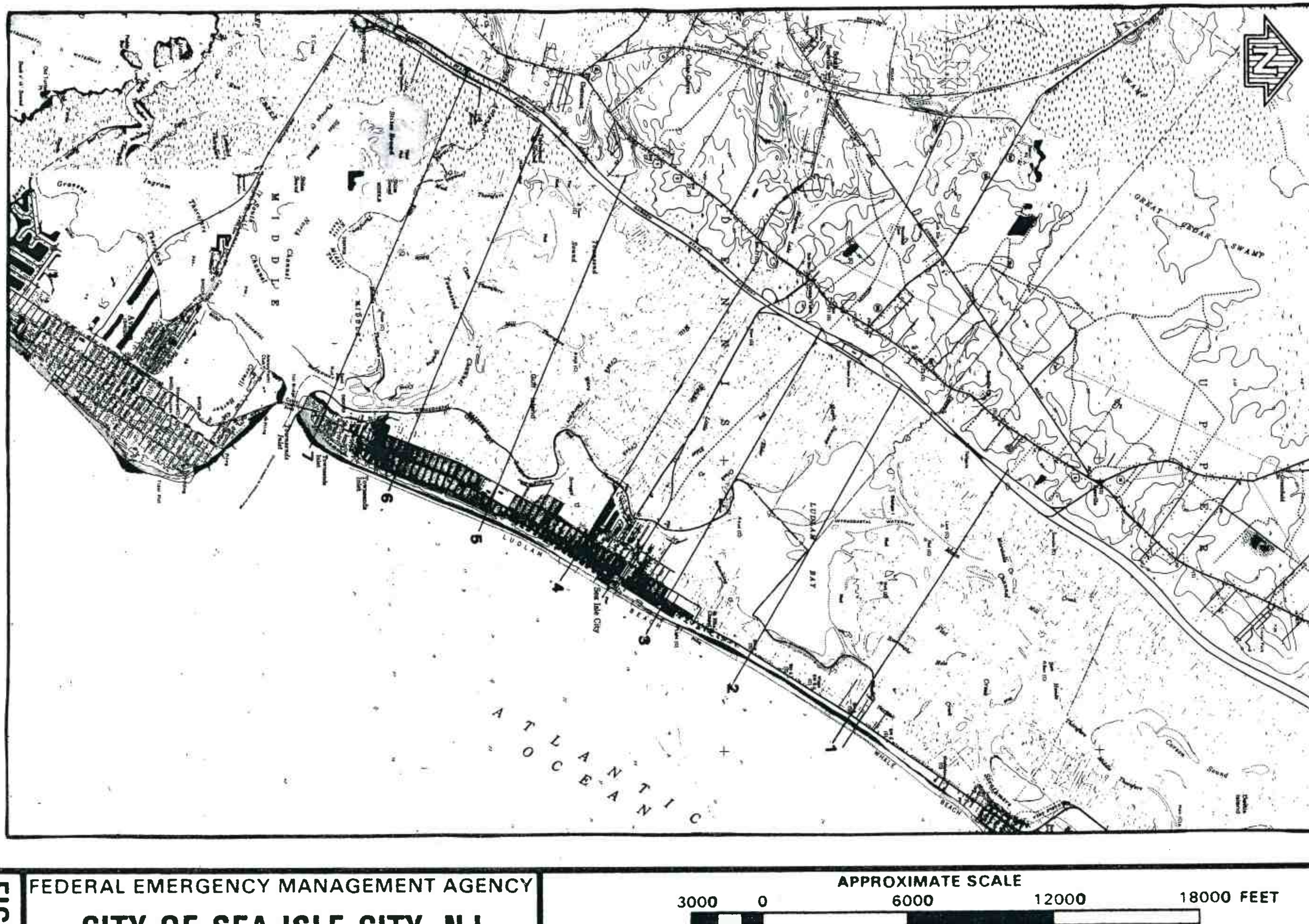
The principal source materials used for the wave height analysis are described below. The stillwater elevations for the flooding sources, and general information refering to past flooding events were obtained from the reports prepared by the U.S. Army Corps of Engineers (Reference 2 and 4). Walker, Previti, Totten and Holmes (the city engineers) contributed detailed topographic mapping for the beach area which provided beach, dune, seawall and road elevations, as well as some structural information (Reference 5). Aerial photographs of Sea Isle City, obtained from Keystone Aerial Survey (Reference 6), were used to locate structures, to calculate structural density ratios and to determine vegetation patterns. Inland spot elevations and road names were taken from the Curb Grade Maps prepared by the city engineers (Reference 7). U.S. Geological Survey topographic maps (References 8 and 9) were used to create a base map, and supplied supplemental topographic information for inland areas. Publications prepared by the National Oceanic and Atmospheric Administration provided historic information pertaining to the severity and extent of hurricanes and storm events (References 3, 10, 11, 12 and 13).

2.3 Wave Height Analysis

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 1). This method is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in Reference 1. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 1, in accordance with the Users Manual for Wave Heights Analysis (Reference 14). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended inland to a point where wave action ceased. Along each transect, wave height and elevations were computed considering the combined effects of



FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF SEA ISLE CITY, NJ

(CAPE MAY CO.)

TRANSECT LOCATIONS MAP

FIGURE 1

changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect. Table 1 provides a listing of the transect locations and stillwater starting elevations, as well as initial wave crest elevations.

Sea Isle City's beachfront area is protected by a series of dune formations in conjunction with a seawall, which contributes to the dissipation of wave energy. For the purposes of this analysis, the seawall was assumed to be stable, thus allowing its protective features to be considered. The dunes, which span the length of Sea Isle City's shoreline, were not considered stable for this analysis, although they would offer an initial contribution to inhibiting wave transmission. The fairly dense structural development, especially on the central and southern portions of the city, also contributes to impede wave action.

Figure 2 is a profile for a typical transect illustrating the effects of energy dissipation and regeneration on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Actual wave conditions in the City of Sea Isle City may not necessarily include all the situations illustrated in Figure 2.

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including the topographic mapping, aerial photographs and engineering judgement. Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

2.4 Results

Computed wave heights and elevations associated with the 100-year storm surge are summarized below for various reaches in the study area. As a result of the flat ground surface, the lack of extensive structural development, the absence of flood protection structures, and the relative instability of the dunes, the Atlantic coastal zone would completely inundate the city north of 29th Street. Although the dunes in this area would not prevent the intrusion of waves, the wave heights would slightly decrease in elevation as the waves moved inland across increasing ground elevations. From 29th Street south to 57th Street, the seawall (which runs the length of the asphalt promenade and has an average elevation of 12 feet mean sea level), in conjunction with higher ground elevations and denser structural development act to inhibit

Table 1.
Transect Locations, Stillwater Starting Elevations, and Maximum Wave Crest Elevations

		Elevation (Feet NGVD)	
Transect	Location	Stillwater	Wave Crest
1	perpendicular to the shoreline, beginning approximately 450 feet southwest of the northern corporate limit boundary continuing inland across Whale Creek, Burroughs Hole, Flat Creek and Main Channel, and terminating at the Garden State Parkway.	9.8	15.15
2	perpendicular to the shoreline, beginning approximately 650 feet northeast of 22nd Street, continuing inland across Ludlam Bay, and terminating at the Garden State Parkway.	9.8	15.15
3	perpendicular to the shoreline, running parallel to 34th Street, inland across the Ludlam Thorofare and Big Elder Creek, and terminating at the Garden State Parkway.	9.8	15.15
4	perpendicular to the shoreline, running parallel to 48th Street, inland across Ludlam Thorofare and Sunks Creek, and terminating at the Garden State Parkway.	9.8	15.15
5	perpendicular to the shoreline, running parallel to, and midway between 62nd and 63rd Streets, inland across Ludlam Thorofare, Mill Thorofare and Townsend Sound, and terminating at the Garden State Parkway.	9.8	15.15
6	perpendicular to the shoreline, running parallel to 78th Street inland across the Intracoastal Waterway and Townsend Channel, and terminating at the Garden State Parkway.	9.8	15.15
7	perpendicular to the shoreline, running parallel to 92nd Street inland across the Intracoastal Waterway and Middle Thorofare, and terminating at the Garden State Parkway.	9.8	15.15

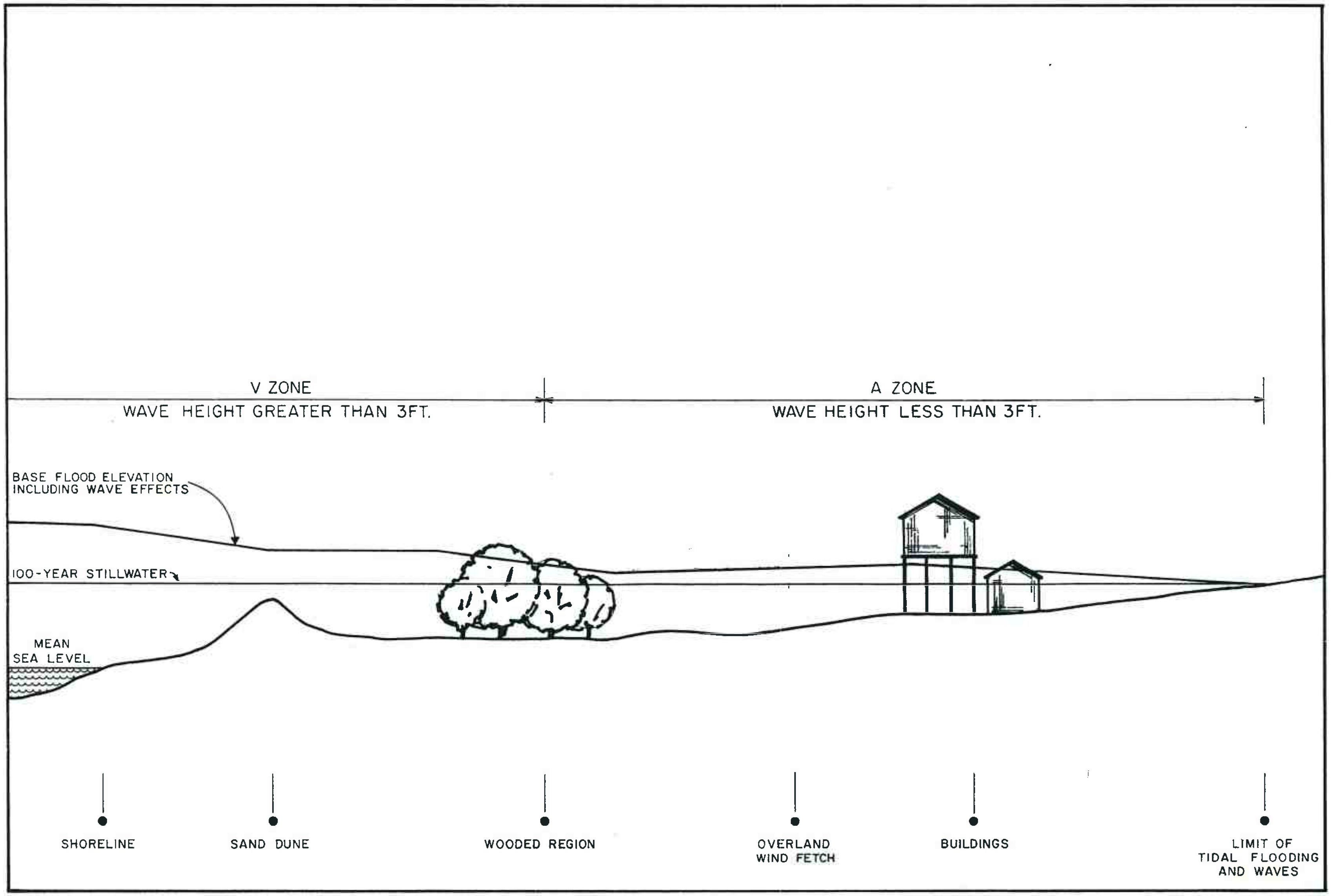


FIGURE 2
TYPICAL TRANSECT SCHEMATIC

the transmission of waves inland. South of 57th Street, the V zone would terminate at Pleasure Avenue where increased structural density and higher ground elevations combine to reduce wave heights.

Beyond the limit of the V zone, the ground surface would be inundated by the 100-year flood with an average elevation of 11 feet (msl). Within this zone, minimal wave heights would exist. This zone is widest where less obstacles and flat ground elevations exist, and minimal interference with wave transmission occurs. The remainder of the city would be inundated by the 100-year flood with an average elevation of 10 feet (msl). Within this zone, no wave heights would exist.

3.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage local governments to adopt sound flood plain management program designed to reduce future flood losses. The FIRM for the City of Sea Isle City has been revised to incorporate the latest available information, including wave height data, to assist these communities in developing the most appropriate and effective flood plain management measures.

3.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency as the base flood for purposes of flood plain management. This flood has a 1 percent chance of being equalled or exceeded each year and is expected to be exceeded once on the average during any 100-year period. The risk of having a flood of this magnitude or greater increases when periods longer than 1 year are considered. For example, over a 30-year period, there is a 26 percent chance of experiencing a flood equal to or greater than the 100-year flood. The 500-year flood plain is also shown on the FIRM to indicate areas of moderate flood hazards.

Areas inundated by the 100-year flood are shown as A and V Zones on the community's FIRM. It is in these areas that the Federal Emergency Management Agency requires local communities to exercise flood plain management measures as a condition for participation in the National Flood Insurance Program.

3.2 Base Flood Elevations

Areas within the communities studied by detailed engineering methods have base flood elevations established in A and V Zones. These are the elevations of the base (100-year) flood relative to the National Geodetic Datum (mean sea level) of 1929. In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the FIRMs. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first flood, including basement, is above the base flood elevation in A and V Zones.

3.3 Velocity Zones

The U.S. Army Corps of Engineers (Reference 15) has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones. This was based on a study of wave action effects on structures. This criterion has been adopted by the Federal Emergency Management Agency for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent flood plain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

The location of the V Zone is determined by the 3-foot breaking wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot breaking wave.

4.0 INSURANCE APPLICATIONS

The assignment of proper actuarial insurance rates requires that frequency and depth of flooding be estimated as accurately as possible. Because waves can add considerably to expected flood depths, it is important that insurance rates consider this additional hazard. The Federal Emergency Management Agency has developed a process to transform the data from this study into flood insurance criteria. This process includes the determination of Flood Hazard Factors and the designation of flood insurance zones.

4.1 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables.

The FHF is shown as a three-digit code that expresses the difference between the 10- and 100-year flood elevations to the nearest 0.5 foot. For example, if the difference between water-surface elevations of the

10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, the FHF is computed to the nearest foot.

4.2 Flood Insurance Zones

After wave elevations for the 100-year storm surge were determined and mapped, the study areas were divided into zones, each having a specific flood potential and FHF. Each zone was assigned one of the following flood insurance zone designations:

Zone V11:	Special Flood Hazard Areas inundated by the 100-year flood, and that have additional hazards due to velocity (wave action); base flood elevations shown, and zones subdivided according to FHFs.
Zones A7 and A8:	Special Flood Hazard Areas inundated by the 100-year flood, with base flood elevations determined and zone designations assigned according to the FHFs.
Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood plain, including areas that are protected from the 100- and 500-year floods by dike, levee, or other water control structure; and areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot, or where the contributing drainage area is less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas not subject to flooding by the 500-year flood. Zone C is not subdivided.

Table 2, "Flood Insurance Zone Data," summarizes the FHFs, flood insurance zones, and base flood elevations for each flooding source in the study area.

4.3 Flood Insurance Rate Map

After flood insurance zones were established for the study area, the FIRM for the City of Sea Isle City was revised to incorporate the new zone information. This map contains the official delineation of flood insurance zones and base flood elevations.

The base map was also revised to adjust for alterations of the corporate limits for the City of Sea Isle City.

5.0 OTHER STUDIES

Currently, wave height analyses are planned for the Borough of Avalon, New Jersey and the Township of Dennis, New Jersey. The information used for these analyses will be coordinated with the results of this study.

6.0 REFERENCES

1. National Academy of Sciences, Methodology for Calculating Wave Action Effects Associated with Storm Surges, 1977.

2. U.S. Army Corps of Engineers, Flood Plain Information on the Tidal Lands of Cape May County, New Jersey, Philadelphia, Pennsylvania, June, 1968.

3. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service Bulletin, October, 1979.

4. U.S. Army Corps of Engineers, "Phase I General Design Memorandum, Cape May Inlet to Lower Township, New Jersey," Philadelphia," Pennsylvania, 1980.

5. Walker, Previti, Totten and Holmes, Topographic Mapping, Scale 1"=100', Contour Interval 1 foot: Sea Isle City, New Jersey, November, 1980.

6. Keystone Aerial Survey, Aerial Photography, Scale 1"=600': Sea Isle City, New Jersey, February, 1978.

7. John R. Walker, Curb Grade Map for the City of Sea Isle City, New Jersey, 1973 (updated 1976).

8. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 10 feet: Sea Isle City, New Jersey (1952); Photorevised (1972); Avalon, New Jersey (1953); Photorevised (1972); Stone Harbor, New Jersey (1955); Photorevised (1972).

9. U.S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 5 feet: Woodbine, New Jersey (1958): Photorevised (1972).

10. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Some Devastating North Atlantic Hurricanes of the 20th Century, 1971.

11. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Climatological Data, National Summary, North Atlantic Tropical Cyclones, 1972, Volume 23, No. 13, 1972.

12. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Climatological Data, National Summary, North Atlantic Tropical Cyclones, 1976, Volume 27, No. 13, 1976.

13. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memorandum NWS NHC7, August, 1978.

14. Federal Emergency Management Agency, Users Manual for Wave Height Analysis, Revised February, 1981.

15. U.S. Army Corps of Engineers, Galveston District, Guidelines for Identifying Coastal High Hazard Zones, June, 1975.

Table 2. Flood Insurance Zone Data

Flooding Source	Stillwater Elevation 10-Year	Stillwater Elevation 100-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Atlantic Ocean/Ludlam Beach	6.3	9.8	055	V11	12-15
	6.3	9.8	040	A8	10-12
	6.3	9.8	035	A7	10

* Due to map scale limitations, base flood elevations shown on the FIRM may represent average elevations for the zones depicted.