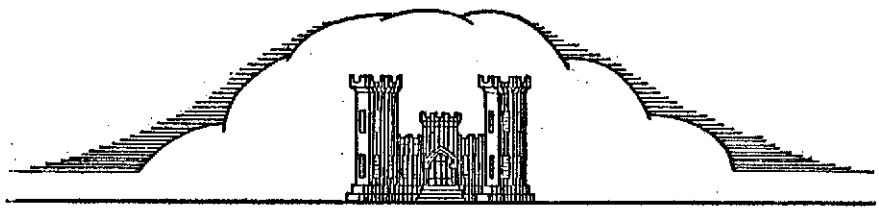
HURRICANE SURVEY

TIDEWATER PORTIONS OF PATUXENT, POTOMAC AND RAPPAHANNOCK RIVERS, INCLUDING ADJACENT CHESAPEAKE BAY SHORELINE

SURVEY REPORT

15 MAY 1963



U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

HURRICANE SURVEY

TIDEWATER PORTIONS OF

PATUXENT, POTOMAC AND RAPPAHANNOCK RIVERS

INCLUDING ADJACENT CHESAPEAKE BAY SHORELINE

PREPARED BY

U. S. ARMY ENGINEER DISTRICT, BALTIMORE
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S Y L L A B U S

Hurricanes seriously affect the western shore of the Chesapeake Bay and tributary estuaries of the Patuxent, Potomac, and Rappahannock Rivers. Damages to individual properties are often severe and the cumulative damages are great due to the long length of exposed shoreline. The comparatively light development makes the construction of single-purpose hurricane protection not economically feasible. In lieu of the construction of hurricane protection works, it is recommended that the following local action be taken: (a) zoning regulations and building codes be adopted to reduce exposure to hurricane damages; (b) the U. S. Weather Bureau warning system be supplemented on the local level; (c) evacuation plans be developed for areas subject to flooding and isolation; (d) highways be raised to reduce tidal flooding of evacuation routes. It is further recommended that this report be published and distributed to appropriate officials in the area who may find the information contained therein of use in the establishment of flood plain regulatory measures and evacuation procedures.

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Information called for by Senate Resolution 148, 85th Congress, 1st Session

U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
P. O. BOX 1715
BALTIMORE 3, MARYLAND

NABEN-R 15 May 1963

SUBJECT: Hurricane Survey - Tidewater Portions of the Patuxent, Potomac and Rappahannock Rivers Including Adjacent Chesapeake Bay Shoreline

TO: Division Engineer
U. S. Army Engineer Division, North Atlantic
New York, New York

I. AUTHORITY

1. AUTHORITY

This report is submitted in compliance with authorization contained in Public Law 71, 84th Congress, 1st Session, approved 15 June 1955, which reads:

> "Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled. That in view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York and New Jersey coastal and tidal areas, and the hurricane of October 15, 1954, in the coastal and tidal areas extending south to South Carolina, and in view of the damages caused by other hurricanes in the past, the Secretary of the Army, in cooperation with the Secretary of Commerce and other Federal agencies concerned with hurricanes, is hereby authorized and directed to cause an examination

and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.

"SEC. 2. Such survey, to be made under the direction of the Chief of Engineers, shall include the securing of data on the behavior and frequency of hurricanes, and the determination of methods of forecasting their paths and improving warning services, and of possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required."

2. ASSIGNMENT. A hurricane appraisal report, "Hurricane Survey, Chesapeake Bay, Potomac and Rappahannock Rivers," dated June 1956, was forwarded to the Office, Chief of Engineers, on 23 June 1956. This report recommended hurricane investigations of survey scope covering the shore of Chesapeake Bay from Cove Point, Calvert County, Maryland, to Wolf Trap Light, Mathews County, Virginia, including the tidewater areas of the Potomac, Rappahannock, and Patuxent Rivers in four separate reports as follows: (1) Colonial Beach, Virginia; (2) Garden Creek, Virginia; (3) Metropolitan Washington, D.C.; and (4) a Special Study, the remainder of the area which is covered by this report.

3. In a letter ENGWD to North Atlantic Division, dated 5 December 1956, subject: "Hurricane Appraisal Report," the Chief of Engineers approved the preparation of the four reports.

II. EXTENT OF INVESTIGATION

4. The scope of this report includes a general appraisal of the hurricane problem as related to the tidewater areas of the Patuxent, Potomac, and Rappahannock Rivers and the western shore of the Chesapeake Bay from Cove Point, Calvert County, Maryland, to Wolf Trap Light, Mathews County, Virginia, except Colonial Beach, Garden Creek, and Metropolitan Washington, D. C. The functional scope of the report includes public hearings to aid in defining problem areas and to record the public's interest and desires, an assessment of probable damages, compilation of information relative to frequency of hurricane activity and attendant tidal flooding, the need for flood plain regulatory measures, the need for protective warning and evacuation procedures, and other possible means of reducing damages. To assist individual property owners and small communities in protecting against the attendant problem of beach and shore erosion in areas where Federal participation in provision of extensive protective works against tidal flooding is not economically feasible, a non-technical bulletin of general information including typical plans of beach and bank protective works applicable to the area has been developed by the Corps of Engineers.

This bulletin is available from the U. S. Army, Corps of Engineers, Beach Erosion Board, Washington, D. C., free of charge. It is strongly emphasized, however, that qualified engineers should be consulted to design suitable protection. The cost of such services is a comparatively small part of either the construction cost or the value of the property to be saved. More detailed information regarding the planning and design of structures and the determination of wave characteristics needed for design is presented in the U. S. Army, Beach Erosion Board publication, Technical Report No. 4, "Shore Protection Planning and Design." This comprehensive publication, which will furnish engineers a guide in the planning and design of shore protective works, is available for purchase from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

III. PRIOR REPORTS

5. GENERAL

Numerous reports have been prepared on flood control and navigation problems on the Patuxent, Potomac, and Rappahannock Rivers and adjacent waters of Chesapeake Bay. Three, prepared under authority of Public Law 71 of the 84th Congress, deal with problems of tidal flooding. These are described in following paragraphs.

6. HURRICANE REPORTS

a. Colonial Beach, Westmoreland County, Virginia. An investigation was made to determine the advisability of hurricane protection works for the Town of Colonial Beach. It was found that the town is subject to severe damages from tides, waves and winds, but that the construction of protective works, including floodwalls, levees and gated barrier, is not economically feasible. It was found, however, that damages from future hurricanes could be reduced by raising roads and adopting zoning regulations. The District Engineer recommended that the report be published and distributed to local interests to serve as a guide in development of flood plain regulation, zoning ordinances, building codes, evacuation plans and other safety measures.

b. Washington, D. C. Metropolitan Area. A study to determine the economic feasibility of providing protective works to reduce damage from tidal flooding showed that such protection alone is not feasible. The predominant flooding problem in the area is from fluvial floods and this problem would control the design of any local protective works upstream of the National Airport and Bolling Air Force Base. Continuing encroachment on the tidal flats and flood plains of the Potomac River in the Washington area has seriously reduced the capacity of the stream to pass fluvial floods and absorb tidal floods without losses. The District Engineer reported that prevention of tidal flooding would be an additional

benefit to accrue to fluvial flood protection. Requirements for fluvial flood control are contained in the Potomac River Basin Report, in which upstream control by reservoirs is investigated.

c. Garden Creek, Mathews County, Virginia. The District Engineer found a reasonable probability that construction of works to protect against tidal flooding would be economically feasible. Local interests stated, however, that they were unable to contribute 30 percent of the estimated first cost of the plan of improvement which provided for protection against tidal floods to the level of the maximum of record. Alternative plans for lesser degree of protection were discussed with local interests, but no assurances were given that the local cooperation requirements would be fulfilled. In view of these circumstances, the District Engineer recommended that a project for construction of protective works not be authorized at this time. The report has not yet been submitted to Congress and the possibility remains that local interests may offer to fulfill the requirements of local cooperation for at least partial protection.

IV DESCRIPTION OF STUDY AREA

7. GEOGRAPHY

The area covered by this report includes the western shore of Chesapeake Bay in Maryland from Cove Point to the Maryland-Virginia Line, and in Virginia from the Maryland-Virginia Line at the mouth of the Potomac River to Wolf Trap Light except Garden Creek, Virginia. This includes the tidal reach of the Potomac River, downstream of the Metropolitan Washington area to the mouth, a distance of approximately 103 miles, with the exception of Colonial Beach, Virginia. Other major tidal reaches considered were the Rappahannock River from its mouth to Fredericksburg, a distance of 105 miles and the Patuxent River from its mouth on the Chesapeake Bay to Hills Bridge, a distance of 49 miles. There are numerous tidal tributaries to the Chesapeake Bay and the above rivers within the region that are affected by storm tides and waves.

8. PHYSIOGRAPHY AND GEOLOGY

The area covered by this report lies entirely within the Coastal Plain Province. The soils of the tidal shorelines of the region are unconsolidated alluvial terrace deposits of gravel, sand and clay over deep-lying rock formations. The terrace materials are easily eroded and the shoreline is in a continuous state of recession. This process of erosion is greatly accelerated by storm tides and wave action generated by hurricane activity and is a major problem to those owning shore properties.

9. MAPS

The area has excellent general coverage by maps and charts. The following U. S. Coast and Geodetic Survey charts are available: Nos. 77 and 78, scale 1:200,000 covering the entire Chesapeake Bay Region, 1:80,000 scale charts, Nos. 1222, 1223 and 1224 for Chesapeake Bay, and 1:40,000 scale charts, Nos. 534, 535 and 536 for the Rappahannock River, Nos. 557, 558, 559 and 560 for the Potomac River, and 553 for the Patuxent River. The area is also covered by the Army Map Service topographic maps, series V-501, scale 1:250,000 and in greater detail by Series V-833 and V-834, scale 1:25,000, except for the Leonardtown and Nanjemoy quadrangles which are scale 1:50,000. Similar coverage is also available in U. S. Geological Survey quadrangles scale 1:24,000 except for the Leonardtown and Nanjemoy quadrangles which are scale 1:62,500. Although the maps and charts are adequate for general appraisal work, the 20- and 10-foot contour intervals limit their use for detailed studies.

10. POPULATION

The tidewater sections of the Patuxent, Potomac, and Rappahannock Rivers are lightly populated with the exception of the Washington, D. C., Metropolitan Area at the head of tidewater on the Potomac, and Fredericksburg, Virginia, at the head of tidewater on the Rappahannock. Colonial Beach, Westmoreland County, Virginia, the only incorporated community with appreciable exposure to tide and wave action has been the subject of a separate report. The remaining incorporated towns located adjacent to tidewater with only limited exposure to tide and wave action have populations ranging from about 300 to 1,000. The 15 Virginia counties within this area have an estimated average population of 50 persons per square mile and the four Maryland counties have an estimated average population of about 70 persons per square mile. Population projection indicates that for these counties the population will increase about 15 percent by the year 2010. However, the proximity of the fast growing metropolitan areas of Washington, D.C., Baltimore, Maryland, and Richmond and Norfolk, Virginia, will cause increased use of the tidal waterfront for residential and recreational activities which will, in turn, tend to increase the hurricane damage problem.

11. COMMERCE

The area of the Chesapeake Bay and its tributaries covered by this report supports an extensive seafood producing industry which is the chief economic mainstay for the area. The salinity variation permits a great variety of seafood to flourish in the Bay and rivers. There are about 2,600 boats of varying size and drafts utilized in the seafood industry which are usually harbored in the small protected

creeks adjacent to the fishing grounds. The entrances to these small harbor areas are subject to shoaling by severe storms and silting action by material eroded from headlands.

12. AGRICULTURE

Agriculture is second in importance as an economic activity in the tidal area affected by hurricanes. Generally, the farming units are small and, in many cases, are operated in conjunction with commercial fishing and oystering. Losses to agricultural land result from tidal flooding and bank erosions.

13. RECREATION

The use of the area for recreational purposes is increasing, primarily due to the phenomenal rise in the use of pleasure boats. Many marina facilities have been built in recent years and more are planned. There are numerous summer-cottage communities and individual homes located on tidewater and it is expected that growth will continue. The tendency to place the buildings as near to the water as possible increases the vulnerability to damages from tidal flooding and bank erosion.

14. LAND TRANSPORTATION

There is an excellent network of State and Federal roads in the area although many are subject to tidal flooding. Rail transportation is available along the right bank of the Potomac River from Washington, D.C., 40 miles downstream to Aquia Creek, Virginia. Rail service is also available at Indian Head and Popes Creek, Maryland, on the left bank 25 and 58 miles respectively below Washington, D. C. The only other rail service in the area is at Fredericksburg, Virginia, at the head of tidewater on the Rappahannock River.

15. NAVIGATION

The numerous tributaries to the Chesapeake Bay and major rivers in the area provide many excellent natural harbors. There are 19 Federal projects for improvement of these harbor and channel facilities. The harbors and channels are subject to varying degrees of damage from hurricanes and other major storms.

V. HURRICANE CHARACTERISTICS

16. GENERAL

"Hurricane" is a term used to describe tropical cyclones that originate near but not directly over the equator. Tropical cyclones form over all the tropical oceans except the South Atlantic and are known

as hurricanes in the South Pacific, eastern North Pacific, southern Indian and North Atlantic Oceans. In other locations, they are known as typhoons or cyclones. The term "cyclone" has come into universal use as a term to designate all classes of storms rotating about centers of relatively low atmospheric pressure.

17. ORIGIN

Hurricanes usually develop in "the doldrums," the belt of equatorial calms lying between the two tradewind systems. This area of calm air exists between the prevailing northeasterly winds north of the equator and the southwesterly winds south of the equator. The two wind systems do not precisely balance each other and the belt of calms is always located north of the equator with its southern extent depending upon the advance and extent of the tradewinds. When the doldrums are within 6° of the equator, cyclones seldom form. In this area the deflective effect of the earth's rotation is small, becoming zero at the equator. Only when the doldrums are located north of 6° north latitude is the effect of the earth's rotation sufficient to initiate the counterclockwise rotation associated with hurricanes in the northern hemisphere. The North Atlantic belt of doldrums is farthest north during the months of August and September and at that time the deflective effect of the earth's rotation is the greatest. Near the equator this effect is small and there is no evidence of any West Indian hurricane originating south of about 6° north latitude in the Atlantic Ocean. Hurricanes originate when a large mass of calm air becomes warm or moist as compared to its surroundings and upward motion results on a large scale. If this condition occurs at a sufficient distance from the equator for the deflective effective of the earth's rotation to be operative, a cyclone is formed. Hurricanes which reach the Middle Atlantic States are formed either in the Atlantic Ocean in the Cape Verde Region or the western Caribbean Sea and move westerly and northwesterly, in most cases recurving to a northerly and northeasterly direction in the vicinity of the East Coast of the United States.

18. WINDS AND BAROMETRIC PRESSURE

In all hurricanes that originate in the North Atlantic or the Caribbean Sea, the rotation of the winds is in a counterclockwise direction due to the effect of the earth's rotation at the origin of the storm. The forward movement of the storm combined with its counterclockwise rotation causes the maximum wind velocities to occur in the right semi-circle of the hurricane. Each hurricane contains as "eye" or a calm center with a diameter usually of approximately 14 miles, although there are wide variations in individual cases. The highest winds of the storm encompass the eye of the hurricane. These winds diminish as the distance from the eye increases. The diameter of the hurricane in some cases is not more than 50 to 75 miles, but in the

majority the diameter is greater and in many instances has exceeded 500 miles. Tropical storms are generally not classified as hurricanes until they attain wind velocities of 75 m.p.h., but storms of lesser intensity do, in some cases, cause more damage than more intense storms due to their forward speed and path.

19. At any given point in the path of a hurricane the barometric pressure decreases as the storm approaches and reaches a low value as the eye of the storm passes. The low pressure in the eye of the storm is maintained by the centrifugal force of the rotating winds which keep air from entering the low pressure area of the eye. As the hurricane moves overland the topographic features tend to reduce the wind intensity, and the low pressure center starts to fill with air reducing the pressure differential and eventually dissipating the hurricane.

20. TRACKS

Most hurricanes that have affected the Eastern Coast of the United States have formed either near the Cape Verde Islands or in the western Caribbean Sea. Hurricanes originating near the Cape Verde Islands move westward for a number of days with a forward speed of about 10 miles an hour, then usually turn north, frequently crossing the West Indies and sometimes striking the Eastern Coast of the United States. Hurricanes originating in the Caribbean generally move northward, striking Cuba, the Gulf Coast or the Eastern Coast of the United States. After recurving, the forward speed usually increases to 25 to 30 miles an hour, and occasionally to 60 miles an hour. Cape Verde hurricanes commonly recurve (that is, turn northward, then east of north) after reaching the mid-Atlantic. Hurricanes that affect the Chesapeake Bay area most severely usually arrive from the south-southwest after recurving east of Florida and after skirting the coastline. These hurricanes frequently occur during the period from the first of August through the middle of October.

21. RAINFALL

Heavy rainfall usually accompanies a hurricane. The heaviest rainfall almost always precedes the passing of the center of the storm. The heaviest rainfall recorded in the area of investigation fell during the passing of Hurricane "Connie" in August 1955 when 7.82 inches of rain fell in a 24-hour period. The 24-hour maximum of 10.3 inches for the State of Maryland was recorded at Cambridge on 6 September 1935.

22. Hurricanes are also accompanied by thunder and lightning. Frequent and almost continuous lightning has been observed in the destructive wind circle of many tropical storms.

23. WAVES

Winds of hurricane intensity blowing over long fetches of open seas generate high waves. In deep water the wave height is dependent upon the wind speed, the length of fetch affected by the wind, and the duration of the wind over the fetch. As a deep water wave approaches the sloping bottom adjacent to a shoreline, the wave increases in height until it breaks. Waves generated at sea often reach the coast in advance of the storm. Waves that reach the coast can run up on a shelving beach or overtop structures well above the wave height.

24. TIDAL SURGES

Tidal surges are caused by the combination of hurricane winds and low barometric pressure. When the surge moves toward land over a rising ocean bed, the storm surge increases in height and results in flooding of lands that are above the influence of normal tidal fluctuations. The normal rise of the astronomic tide is only about two feet on the open ocean, but its range may be as high as ten to twelve feet at coastal points and even reach heights in excess of 20 feet in bays and estuaries. A maximum storm surge occurs when the slope of the ocean bed and the contour of the coastline are favorable to the rise of the surge and are combined with critical direction of the storm track and the speed of movement.

25. ANALYSIS OF THE HURRICANE SURGE

As a hurricane progresses over the open water of the ocean, a tidal surge is built up, not only by the force of the wind and the forward movement of the storm wind field, but also by differences in atmospheric pressure accompanying the storm. This surge is further increased as the storm approaches land over a gradually shoaling ocean bed and is influenced considerably by the contours of the coastline. An additional rise results when the tidal surge invades a bay or estuary and hurricane winds drive waters to higher levels in the shallow waters. Tidal surges are greater, and the tidal flooding more severe, in coastal communities which lie to the right of the storm path due to the counterclockwise spiraling of the hurricane winds and the forward movement of the storm. The actual height reached by a hurricane tidal surge and the consequent damages incurred depend on many complicated factors.

VI. HISTORY OF HURRICANES

26. GENERAL

Records of the U. S. Weather Bureau show that since 1889, at least 80 tropical hurricanes or their remnants have affected the lower

Patuxent, Potomac and Rappahannock Rivers to varying degrees. There are also historic accounts of such hurricanes extending back to the time of earliest habitation within the region. The major storms prior to the nineteenth century which undoubtedly produced extreme flooding levels are the hurricanes of August 1667, October 1749, September 1769, and of July 1788. In general, by the time the hurricane centers reach the study area, the intensity of the storms have been somewhat diminished by passing overland and sustained winds of hurricane velocity are relatively rare. However, the tidal surges generated at the mouth of the Chesapeake Bay are transmitted up the Bay and its tributaries with resultant high levels of tidal flooding and damages. Waves superimposed on the high tides, formed by the high winds moving over long fetches of the rivers and bay have destructive effects on banks, beaches, piers and shoreline buildings. Photographic evidence shows that waves on the order of 6 feet were generated at Colonial Beach, Virginia, by hurricane "Hazel" - October 1954, by a southeast wind moving over a 25 mile fetch of the Potomac River. The most significant of the recent storms which affected the study area, are those in which the eye or center passed over the Chesapeake Bay and the Potomac River. These storms produced high tidal surges at the ocean entrance to the Chesapeake Bay which, in turn, were transmitted up the Bay and tributaries, and were further influenced by the convergence of topography and local wind stresses. Major recent hurricanes are discussed in the following paragraphs.

27. 23 AUGUST 1933. The hurricane of 23 August 1933 was the most destructive on record for the Chesapeake Bay region. The hurricane center entered the mainland near Cape Hatteras, passed slightly west of Norfolk, Virginia, and continued in a northerly direction passing just east of Washington, D. C. The storm surge in the Bay and tidal tributaries was the highest of record and moved at near the critical speed for producing the maximum surge, which in this case coincided with the astronomical high tide as it proceeded upstream. The results were tides ranging from 7.2 feet above mean low water at the mouth of the Rappahannock to 11.0 feet at Washington, D. C. Recorded elevations and wind velocities are shown on Plate 2. In addition to flooding damage, destructive wave action resulting from the high winds caused extensive damages. A recurrence of this storm under the present state of development in the study area could conceivably cause damages in excess of $5,000,000. These damages would occur in the Patuxent River upstream as far as Lower Marlboro, Maryland, in the Potomac River upstream to the Washington Metropolitan area, in the Rappahannock River upstream to Port Royal, Virginia, and along the western shore of the Chesapeake Bay between Cove Point, Md., and Wolf Trap Light, Va. In addition to the above damages, there would be damages of $5,000,000 in the Washington Metropolitan area, $800,000 at Colonial Beach, Virginia, and over $500,000 at Garden Creek, Virginia.

28. HURRICANE "HAZEL," 15 OCTOBER 1954. Hurricane "Hazel," the second most destructive of recent hurricanes in the lower Potomac, Rappahannock and Patuxent Rivers, entered the mainland along the coast south of Wilmington, North Carolina, during the morning of 15 October 1954, and moved rapidly northward passing over Richmond and Fredericksburg, Virginia, in the early afternoon, and passed through Washington, D.C., about 6:00 p.m. The tidewater area was subjected to damaging winds, tides and waves throughout the day. The winds were from the east and southeast until the eye passed the latitude of each point. During this phase the effect was greatest along the western shore of the Chesapeake Bay and the right banks of the Rappahannock and Potomac Rivers. When the eye had passed, the wind shifted to the southwest with higher wind velocities and damages to the left banks of the same rivers were heavy. Wave action was severe during this storm because of the southeast winds moving over long fetches. The hurricane surge or departure from the normal predicted tide was not as high as that for the August 1933 or that of "Connie" in August 1955, but the tidal surge was superimposed on the normal high tide. Tidal flooding elevations for this occurrence are shown on Plate 2. The wind damage for this storm exceeded that caused by tides and waves in this region. It has been estimated that damages due to tidal flooding of the study area by a storm of this magnitude would now cause damages on the order of $4,000,000. These damages would occur in the Potomac River downstream of Washington, D.C., in the Patuxent River upstream to Benedict, Maryland, in the Rappahannock River upstream as far as Tappahannock, Virginia, and along the western shore of Chesapeake Bay within the study area. In addition, there would be $1,300,000 damage in the Washington Metropolitan area, $500,000 at Colonial Beach, Virginia, and $50,000 in Garden Creek, Virginia.

29. HURRICANE "CONNIE," 13 AUGUST 1955. The path of this occurrence as shown on Plate 2, was similar to that of the hurricane of August 1933. However, the tidal surge was about 2 feet lower and occurred on the normal low tide cycle. There were from six to eight inches of rainfall along the path of the hurricane throughout the tidewater area which increased the damages in areas subject to tidal flooding. The damage due to tide and wave action within the study area was estimated to be about $800,000 for a recurrence of these conditions. These damages within the study area would be predominantly along the western shore of the Chesapeake Bay and near the mouth of the Patuxent, Potomac and Rappahannock Rivers. In addition, there would be $100,000 damage in the Washington Metropolitan area, and $100,000 at Garden Creek, Va.

30. HURRICANE "DIANE," 18 AUGUST 1955. The track of this hurricane was too far west of the tidewater area to cause extensive tide and wave damage. However, excessive railfall accompanying the hurricane added to the problem in the tidewater area caused by the rainfall

of hurricane "Connie," 5 days previous. Fluvial flooding damages in the study area were estimated at $150,000. These damages occurred in the Rappahannock River at and below Fredericksburg, Va. In addition, severe damage to the oyster crop in the Rappahannock River was caused by the influx of fresh water and silt. This damage was estimated by the fishery industry to be about $2,370,000.

31. HURRICANE "DONNA," 12 SEPTEMBER 1960. This hurricane passed a short distance off the coast of Virginia, Maryland, Delaware and New Jersey and brushed the coast with winds of hurricane force. No excessively high water was recorded in the study area. The counter-clockwise winds actually tended to depress the water surface elevation in the portion of Chesapeake Bay included in the study.

32. NORTHEAST STORM, 6-8 MARCH 1962. This northeast storm caused great destruction along the Atlantic coast. Residents of Ocean City, Maryland, described the storm as the worst in the town's history. In the study area, tides of 4.9 feet above mean low water were recorded in the lower Potomac River. No wind accompanied the high tide and damages were minor within the study area.

VI. STANDARD PROJECT HURRICANE

33. The standard project hurricane represents the most severe combination of meteorological conditions that are considered reasonably characteristic of the region. The Hydrometeorological Section of the United States Weather Bureau studied the characteristics of extreme hurricanes consistent on meteorological grounds from point to point along the Atlantic Coast. The characteristics of the standard project hurricane derived by the Water Bureau showed a striking similarity to those of the hurricane of 14 September 1944 which is also referred to as the "Great Atlantic Hurricane" and the "1944 Cape Hatteras Hurricane." This storm when it was off Cape Hatteras had the greatest energy of any known hurricane along the Atlantic Coast.

VII. PROBABLE HURRICANE

34. The Beach Erosion Board calculated the effect the hurricane of 14 September 1944 would have on the Chesapeake Bay region if the storm had followed one of several different paths. It was found that the most critical track would be one that approached the coast south of the entrance to Chesapeake Bay and continued up the west side of the bay at a velocity of about 10 to 13 knots along the path of the 23 August 1933 storm. In selecting the critical path, the August 1933 hurricane was used as a model since it was this storm that caused the highest tide of record in the middle and upper Chesapeake Bay area. The hydraulics of the 1933 storm and the routing of the synthetically transposed 1944 storm were correlated. Variations in hydrographs

between selected cross sections on Chesapeake Bay during the 1933 storm were analyzed and empirical coefficients were applied as required in routing the 1944 storm. The effect of an increase of wind speeds by 5 miles per hour was investigated. The resulting surges are shown in Table 1.

VIII. TIDAL FLOODING

35. LEVEL OF TIDAL FLOODING. The extent and elevation of tidal flooding in the tidewater area of the area covered by this report generated by hurricane type storms are dependent on many factors and are difficult to forecast with any appreciable degree of accuracy. The storm surge or increase in water level over normal tide depends on the path of the storm, forward speed, wind speeds, pressure anomaly and the surge in the open sea at the mouth of Chesapeake Bay. In addition, the timing of the forward movement of the surge within the area as related to the normal tidal cycle would influence the level of tidal flooding.

36. HURRICANE SURGE PREDICTIONS for the Chesapeake Bay and tributary rivers by the Beach Erosion Board are included in Miscellaneous Paper No. 3-59 "Hurricane Surge Predictions for Chesapeake Bay," September 1959. A summary of surge predictions for various locations in the Chesapeake Bay area follows:

TABLE 1

SUMMARY OF SURGE PREDICTIONS FOR
HURRICANE "A" AND HURRICANE "B"

Location	Surge Elevations in Feet Above Predicted Astronomical Tide	
	Hurricane "A" (1)	Hurricane "B" (2)
Open Coast	11.1	12.2
Hampton Roads, Virginia	10.8 ± 0.4	11.7 ± 0.4
Mouth of York River	10.3 ± 0.4	11.3 ± 0.4
Mouth of Rappahannock River	9.8 ± 0.4	10.7 ± 0.4
Mouth of Potomac River	9.1 ± 0.4	10.0 ± 0.4
Mouth of Severn River	8.3 ± 0.4	9.1 ± 0.4
Mouth of Patapsco River	9.4 ± 0.4	10.2 ± 0.4
Norfolk, Virginia	8.3 to 11.1 ± 0.4	9.0 to 12.2 ± 0.4
Washington, D. C.	13.6 ± 1.0	14.8 ± 1.0
Baltimore, Maryland	11.5 ± 1.0	12.5 ± 1.0

(1) Hurricane "A" is the same as the 14 September, 1944 Cape Hatteras Hurricane transposed to the Chesapeake Bay area along the path of the August 1933 hurricane to produce maximum surge entering the bay and propagated to the various locations. Surge heights computed for Hurricane "A" might be associated with a design or standard project hurricane.

(2) Hurricane "B" is the same as Hurricane "A" except that all wind speeds are increased by 5 miles per hour. Surge heights computed for Hurricane "B" are probable surges.

37. FREQUENCY OF HURRICANE TIDAL FLOODING. The determination of the frequency of tidal flooding for the widespread tidewater study area was based on the past flooding experiences including records from official gages, field surveys, newspaper accounts and similar sources. The

Potomac River frequency is fairly well defined by tide records at Washington, D. C., and the U. S. Naval Weapons Laboratory, Dahlgren, Virginia. A frequency curve has been developed by the procedures given in "Statistical Methods in Hydrology" by L. R. Beard for the Potomac River. The curve is shown on Plate 3. The frequency of tidal flooding on the other main tributary rivers, the Rappahannock and Patuxent, is not as well defined because detailed records have not been maintained. Tidal flooding from the August 1933 hurricane, which is the maximum of record, appears to be about a 100-year event, or has a one percent chance of annual occurrence. Flooding from hurricane "Hazel," 15 October 1954, has been determined to be a 50-year flood, or has a two percent chance of annual occurrence. There is no indication that the frequencies of comparable degrees of flooding will be substantially different in the future.

IX. DAMAGES

38. GENERAL. The area covered by this report is located within the political boundaries of 15 Virginia and four Maryland counties. The shoreline includes 65 miles along the western side of Chesapeake Bay which are exposed to wind fetches varying from 8 to 30 miles in length. The Potomac River has 225 miles of shoreline with 2 to 25 mile fetches and the Rappahannock has 200 miles of shoreline exposed to 2 to 15 mile fetches. The smaller major tributary in the area, the Patuxent River has about 120 miles of shoreline with fetches ranging from 1 to 10 miles. In addition to the main shorelines there are an estimated 1,000 miles of tidal shores in the smaller bays and tidal tributaries. Located on or near the tidal shorelines are about 250 small communities consisting of permanent and summer residences, seafood processing houses and similar light structures.

39. TIDAL FLOODING. About 25 percent of the communities are affected by tidal flooding to some extent. Although generally the communities are located above the storm tide level, there are exceptions where summer residences and permanent type structures are constructed below this level. Tidewater communities subject to tidal flooding are shown in Table 2 of Appendix B, Weather Bureau Tidal Warning Plan.

40. BANK AND BEACH EROSION. The normal bank and beach erosion processes of the Chesapeake Bay region are greatly accelerated by the high tide and wave action during tropical storms. The terrace materials, which are generally unconsolidated and erode easily during storms, are usually not restored by natural processes. The major damage is done by steep short period waves moving the materials directly away from the shoreline. The long swells which tend to move the sand and other materials back toward the beach along the ocean fronts are not present in the Chesapeake Bay and tributaries. There are, therefore, only a few places in the region at which the beaches are building out. A publication by the Maryland Department of Geology, Mines and Water Resources,

Bulletin 6 "Shore Erosion in Tidewater Maryland," summarizes the erosion losses for a 90-year period ending in 1948. Within the four Maryland counties in the area covered by this hurricane report, there has been a loss of about 4,000 acres of land. No similar figures for the State of Virginia are available but many instances of bank and beach damages were reported at the public hearings held at Saluda and Colonial Beach, Virginia. Bank and beach erosion damages are primarily on private property and attempts of the individual owners to protect their waterfront properties have been both expensive and sometimes ineffective due to lack of proper planning. Table 2 shows some known areas of bank and beach erosion within the tidewater region of the Patuxent, Potomac and Rappahannock Rivers.

TABLE 2

TIDEWATER AREAS SUBJECT TO BANK AND BEACH EROSION

Community	State	County	Remarks
Colonial Beach	Va.	Westmoreland	Bank erosion threatens highway.
Dahlgren (U.S. Naval Weapons Laboratory)	Va.	King George	Caving banks endanger range stations and other structures.
Mason Neck	Va.	Fairfax	High eroding banks, requiring homes to be moved.
Quantico (U. S. Marine Base)	Va.	Prince Williams	Eroding shoreline undermines roadway at airfield.
Corrotoman River	Va.	Lancaster	Between Moran and Taylor Creek. Homes endangered.
Gwynn's Island	Va.	Mathews	Bank and Beach Loss.
Stingray Point	Va.	Middlesex	Necessitates homes to be moved.
Urbanna	Va.	Middlesex	Eroding banks require 12 homes to be moved.
Scotland Beach	Md.	St. Marys	Serious beach erosion.
Tall Timbers	Md.	St. Marys	Eroding banks and beaches, damages to existing protective works.
Point Lookout	Md.	St. Marys	Damage to State Highway.
Solomons Island	Md.	Calvert	Damage to highway and shoreline.
St. Georges Island	Md.	St. Marys	Shoreline erosion.

41. PIERS, WHARVES AND BOATS. The damages to piers and wharves by hurricanes has been extensive in the tidewater area. Generally the structures are of light construction and, where exposed to hurricane generated waves, are subject to damage. Extensive damage to small commercial and pleasure craft in the harbors along the bay and rivers, where exposed to extreme tides and waves, has also been experienced in recent hurricanes. Hurricane "Hazel" caused about $250,000 in damages to boats in Monroe Creek at Colonial Beach, Virginia, which is generally considered to be a safe harbor.

42. NAVIGATION CHANNELS. The tidal areas of the Chesapeake Bay and tributaries have numerous inlets which are used for small boat harbors. Generally the inlets are connected to deep water by narrow, fairly shallow channels which are subject to shoaling. While this is a continuing problem, the amount of shoaling is greatly increased during hurricanes and other storms. At the public hearings, local interests cited certain locations as being shoaled during recent hurricanes. The shoaled locations are shown in Table 3.

TABLE 3

NAVIGATION CHANNELS SUBJECT TO SHOALING BY STORMS

Location	State	County	Remarks
Queens Creek	Va.	Mathews	Shoaling of Existing Channel
Jackson Creek	Va.	Middlesex	Federal Project, channel shoaled
Little Wicomico River	Va.	Northumberland	Federal Project, channel shoaled
Meachims Creek	Va.	Middlesex	Channel shoaled to one-half foot
Tanners Creek	Md.	St. Marys	Entrance shoaled by storms
Monroe Creek	Va.	Westmoreland	Federal Project, entrance shoaled
Deep Creek	Md.	St. Marys	Entrance shoaled by storms

X. IMPROVEMENTS DESIRED

43. Public hearings were held at Colonial Beach, Virginia, 8 February 1956, covering the Virginia shore of the Potomac River from Washington, D. C., to Smith Point at the mouth of the river; at Saluda, Virginia, 9 February 1956, covering the Western shore of the Chesapeake Bay between Smith Point and Wolf Trap Light, and the estuaries of the Rappahannock and Piankatank Rivers; and at Leonardtown, Maryland,

14 February 1956, covering the Maryland shore of the Potomac River from Washington, D. C. to Point Lookout, the Patuxent River estuary and the western shore of the Chesapeake Bay from Point Lookout to Cove Point. The requests for protection of banks and beaches were prevalent throughout the hearings. Improvements were also requested to decrease shoaling of navigation channels during storms, to prevent tidal flooding and to increase drainage. There were also requests for improved warnings.

XI. CORRECTIVE MEASURES CONSIDERED

44. TIDAL FLOOD PROTECTION. Protection against tidal flooding was considered in separate reports for the large urban Washington, D. C., Metropolitan area; the small urban area at Colonial Beach, Westmoreland County, Virginia; and for the rural area of Garden Creek, Mathews County, Virginia. The initial local cost of the recommended improvement at Garden Creek, based on the 30 percent apportionment, adopted by the Flood Control Act of 1958, Public Law 85-500, 85th Congress for the Narragansett, New Bedford and Texas City projects, is beyond the financial capability of local interests. In general, the small amount of land and property that can be protected per unit length of levee or floodwall makes protection against tidal flooding economically infeasible.

45. REPAIRS TO NAVIGATION CHANNELS. The shoaling of navigation channels caused by hurricanes can be alleviated by procedures under existing authorizations. The Federal River and Harbor projects would be repaired under the normal maintenance program. Other harbors and channels would be eligible for consideration under Section 3 of the River and Harbor Act of 1945 which provides for clearing and snagging of channels in the interest of navigation. This authority may be used to rehabilitate a channel damaged by a severe storm but could not be used to restore a channel that had gradually shoaled over a long period of time.

46. BANK AND BEACH PROTECTION. The protection of banks and beaches against damage from hurricane tides and waves generally require substantial and costly structures usually beyond the financial capability of individual property owners and small communities. Federal participation in beach and bank protection may be accomplished under the beach erosion laws administered by the Corps of Engineers. Combination beach erosion and hurricane surveys can also be made by the Corps of Engineers. There is at present, however, no Federal program that could give aid directly to individual property owners in the construction of bank and beach erosion protective works either for hurricanes or lesser storms.

47. Shore protection and beach preservation problems may be studied by the Corps of Engineers upon formal application by appropriate agencies of the various States. Although private organizations and individuals are not eligible to apply direct to the Corps of Engineers for erosion control studies, they may request the appropriate State, county, or municipal agency to make application for the study. The studies result in a report containing plans and specific recommendations to improve or remedy a condition at a particular locality.

48. Many communities and individual land owners on the western shore of the Chesapeake and its tributary estuaries have bank and beach protection problems, which although important to the community and individuals, are not of sufficient magnitude or unusual character to warrant a study. To provide non-technical aid for individuals and communities not eligible for studies, general information on shore processes and protection, is available from the U. S. Army, Corps of Engineers, Beach Erosion Board, Washington, D. C., or from U. S. Army Engineer Districts. However, it is stressed that any structures built should be designed for the individual location, taking into account exposure and forces to which the structures will be subjected. It is suggested that the services of competent engineers be secured to prepare the detailed plans and supervise the construction. In view of the technical nature of coastal engineering, the Beach Erosion Board publishes Technical Report No. 4 entitled "Shore Protection Planning and Design" which may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. This report was written to provide guidance to engineering and scientific personnel who possess a basic knowledge of shore processes, but may be of limited value to non-technical persons. It is also emphasized that adjacent property owners should participate in any plan of protection in order to increase the chances of success. For any plan of improvement which may affect navigation, a permit must be obtained from the District Engineer of the U. S. Army Engineer District having jurisdiction in the area.

XII. OTHER PROTECTIVE MEASURES CONSIDERED

49. REGULATION OF USE OF SHORELINES. Where protective works to exclude tidal flooding and prevent wave damage are not feasible, zoning regulations and building codes should be considered to reduce damages. Appropriate zoning and building regulations by state and local governments should take into consideration the elevation and frequency of tidal flooding as well as the exposure of the structures to wave action.

Acceptable regulations may be difficult to establish since during non-storm periods, it is more convenient and efficient to place structures for seafood industry and recreation near the water. This in turn increases the likelihood of storm damage. The tabulation, "Tidewater Communities Subject to Tidal Flooding," in Appendix B may serve as a guide in establishing zoning regulations. Local interests are also urged to make use of the information as a basis for establishing or revising building codes in flood prone areas. These data represent the best information available at this time. There is a provision under existing law, however, whereby States or responsible local governments requiring more detailed information on specific areas may obtain assistance through Flood Plain Information Studies.

50. FLOOD PLAIN INFORMATION STUDIES. Flood Plain Information Studies are authorized in Section 206 (a) of Public Law 86-645 approved 14 July 1960 which reads as follows:

> "That, in recognition of the increasing use and development of the flood plains of the rivers of the U. S. and of the need for information on flood hazards to serve as a guide to such development, and as a basis for avoiding future flood hazards by regulation of use by States and municipalities, the Secretary of the Army through the Chief of Engineers, is hereby authorized to compile and disseminate information on floods and flood damages including identification of areas subject to inundation by floods of various magnitudes and frequencies, and general criteria for guidance in the use of flood plain areas; and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard: Provided, That the necessary surveys and studies will be made and such information and advice will be provided for specific localities only upon the request of a State or a responsible local governmental agency and upon approval by the Chief of Engineers."

51. PROCEDURES FOR OBTAINING FLOOD PLAIN INFORMATION STUDIES. The application of the State or local agency should be a letter to the District Engineer, prepared with his assistance if necessary, signed by an authorized officer of the sponsoring agency and containing the following information.

a. Authority of State of Local Agency. The authority, law, charter or resolution clearly establishing the local agency by the State or subdivision thereof, its interest and jurisdiction in flood plain regulation and planning, and its relation to other local agencies having responsibility therefor, should be cited or attached. The identity of the State agency designated by the Governor to cooperate in the program should be cited.

b. Desired Objectives of Study. The local applicant should state specifically the local objectives which prompt the application for a Federal study.

c. Scope and Limits of Study. The geographic area to be studied should be described together with the nature of present flood plain use and any contemplated flood plain development. The time available before local planning decisions must be made should be stated. The type and extent of descriptive and statistical data that are available and that will be furnished to supplement the study by the Corps of Engineers, without cost to the United States, should be described. Any local cooperation in gathering data, mapping or other services that can be provided should be stated.

d. Assurances of Local Cooperation. The letter of application should give assurances that:

(1) Available information and data will be furnished for the study.

(2) The applicant will publicize the information report in the community and make copies available for use or inspection by responsible interested parties.

(3) Zoning and other regulatory, development and planning agencies and public information media, will be provided with the flood plain information for their guidance and appropriate action.

(4) Survey markers, monuments, etc., established in any Federal survey for Section 206 studies or in regular surveys in the area concerned will be preserved and safeguarded.

52. WARNING AND EVACUATION PLANS. Hurricane and other severe weather warnings are the responsibility of the U. S. Weather Bureau. The Tidal Warning Plan covering the area is included as Appendix B to this report.

XIII. DISCUSSION

53. The western shore of the Chesapeake Bay and the tributary estuaries of the Patuxent, Potomac, and Rappahannock Rivers are seriously affected by hurricanes. Although the area is not subject to the more spectacular attacks of full hurricane force winds and accompanying tides and waves that occur on ocean fronts, the damages to individual property owners are often severe. Also the cumulative damages to the area are great due to the long length of exposed shoreline. The comparatively light development makes the construction of single-purpose hurricane protective works generally not feasible. However, it is expected that water-oriented development will continue on an increasing pace to fulfill the

recreational needs of the nearby metropolitan areas which will tend to increase the hurricane damage potential. In order to reduce future hurricane damages, local actions with respect to zoning regulations and building codes are advisable to control building in areas exposed to hurricane tides and waves. There are numerous roads now subject to tidal flooding which should be raised to serve as evacuation routes for isolated areas. The U. S. Weather Bureau warning system should be augmented by local warning and evacuation plans in order to be fully effective.

XIV. CONCLUSION AND RECOMMENDATIONS

54. The hurricane problem in the tidal estuaries of the Patuxent, Potomac, and Rappahannock Rivers and the intervening reach of the western shore of the Chesapeake Bay is very serious and costly but the costs of protective works would exceed the savings in damages. It is recommended that in lieu of the construction of hurricane protection works the following local actions be taken: (a) Zoning regulations and building codes be adopted to reduce exposure to hurricane damages; (b) the U. S. Weather Bureau warning system be supplemented on the local level; (c) Evacuation plans be developed for areas subject to flooding and isolation; (d) Highways be raised to reduce tidal flooding of evacuation routes. It is further recommended that this report be published and distributed to appropriate officials in the area who may find the information contained therein of use in the establishment of flood plain regulatory measures and evacuation procedures.

ROY S. KELLEY
Colonel, Corps of Engineers
District Engineer

ACKNOWLEDGEMENTS AND IDENTIFICATION OF PERSONNEL

1. The preparation of this report was administered by:

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2. The preparation of this report began in the Planning and Reports Branch of the Washington District under the direction of Floyd B. Morris. It was completed in the Baltimore District under the direction of Michael A. Kolessar. Principal authors were James B. Clark and Gordon F. Johnson.

3. The United States Army Engineer District, Baltimore, acknowledges with appreciation the cooperation and assistance rendered in connection with these studies by personnel of a number of other offices and agencies, particularly the following:

The Beach Erosion Board

United States Army Engineer Division, North Atlantic

United States Weather Bureau

* Of the former Washington District

NADEN (15 May 63) 1st Ind
SUBJECT: Hurricane Survey - Tidewater Portions of the Patuxent, Potomac and Rappahannock Rivers Including Adjacent Chesapeake Bay Shoreline

U. S. Army Engineer Division, North Atlantic, New York 7, N. Y., 24 June 1963

TO: Resident Member, Board of Engineers for Rivers and Harbors, Washington, D. C.

I concur in the conclusions and recommendations of the District Engineer.

John C. Dalrymple

JOHN C. DALRYMPLE
Brigadier General, USA
Division Engineer

WASHINGTON D.C.
ARLINGTON
ALEXANDRIA
MARYLAND
FAIRFAX
PRINCE GEORGES
ANNE ARUNDEL
HILLS BRIDGE
PRINCE WILLIAM
POTOMAC RIVER
CHARLES
CALVERT
CHESAPEAKE BAY
BENEDICT
PATUXENT RIVER
STAFFORD
MARYLAND
VIRGINIA
DAHLGREN
FREDERICKSBURG
KING GEORGE
POTOMAC RIVER
COBB ISLAND
WICOMICO RIVER
ST MARYS
SOLOMONS ISLAND
COVE POINT
PATUXENT RIVER NAVAL AIR STATION
CAROLINE
WESTMORELAND
ST GEORGE ISLAND
POINT LOOKOUT
NORTHUMBERLAND
KING AND QUEEN
ESSEX
RICHMOND
RAPPAHANNOCK
BOWLERS WHARF
RAPPAHANNOCK RIVER
LANCASTER
URBANNA
WINDMILL POINT
MIDDLESEX
YORK RIVER
GWYNN ISLAND
SCALE IN MILES
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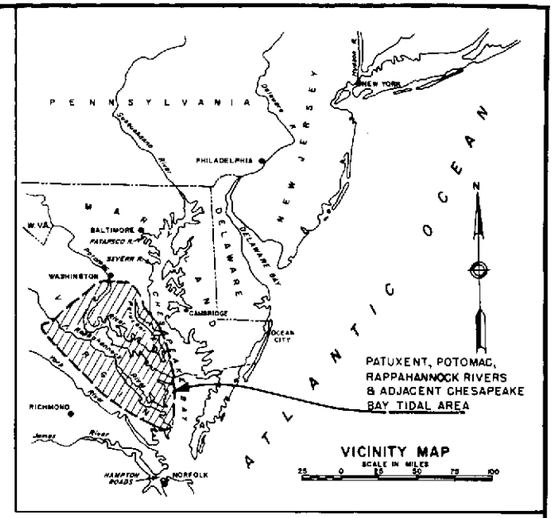

IMPROVEMENT CONSIDERED
Protection to prevent tidal flooding from hurricane – induced high tides.
NOT RECOMMENDED

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
BALTIMORE DISTRICT
BALTIMORE, MARYLAND

SURVEYED BY:
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CHIEF, NAVIGATION REPORTS BR.
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CHIEF, ENGINEERING DIVISION

HURRICANE SURVEY
TIDEWATER PORTIONS OF
PATUXENT, POTOMAC AND RAPPAHANNOCK RIVERS
INCLUDING ADJACENT CHESAPEAKE BAY & SHORELINE
AREA INVESTIGATED

APPROVED:
COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

TO ACCOMPANY REPORT DATED
31 OCTOBER 1962

SCALE: AS SHOWN
FILE 100 MAP 8

CORPS OF ENGINEERS

U. S. ARMY

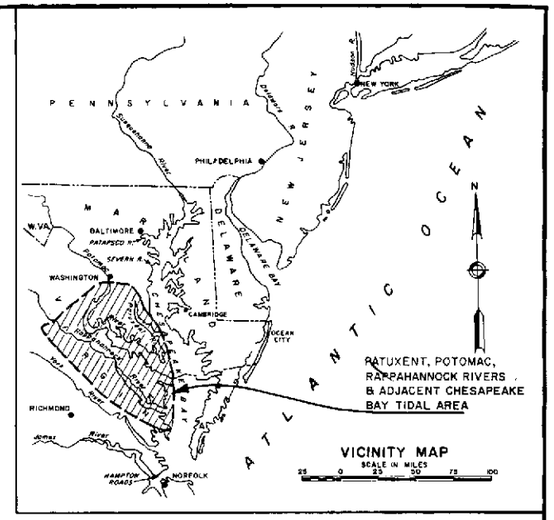
WASHINGTON METROPOLITAN AREA
HURRICANE PROTECTION CONSIDERED BUT NOT RECOMMENDED UNDER SEPARATE REPORT

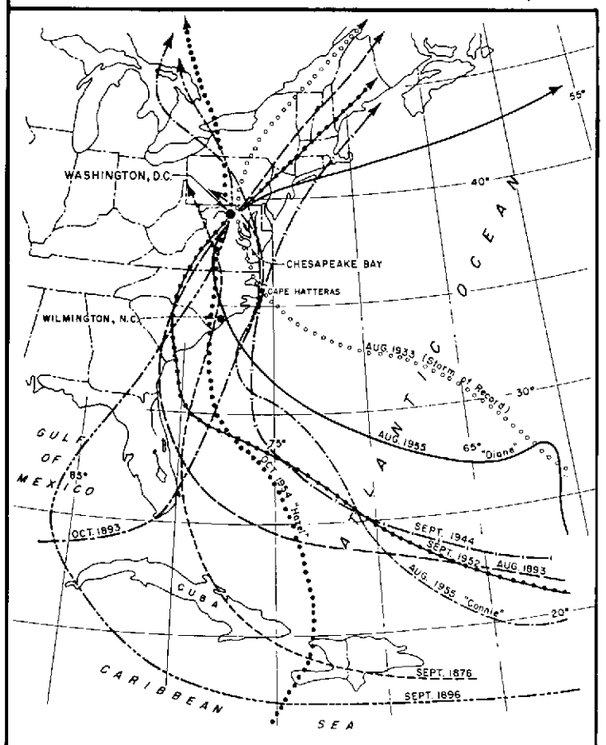
COLONIAL BEACH
HURRICANE PROTECTION CONSIDERED BUT NOT RECOMMENDED UNDER SEPARATE REPORT

GARDEN CREEK
HURRICANE PROTECTION CONSIDERED BUT NOT RECOMMENDED UNDER SEPARATE REPORT

TRACK OF AUG. 1933 HURRICANE

SCALE IN MILES





HURRICANE TRACKS

PATUXENT, POTOMAC AND RAPPAHANNOCK RIVERS

LEGEND

- WIND SPEED M.P.H.
- WIND DIRECTION
- FLOODING ELEVATION ABOVE MEAN LOW WATER
- SOLID LINES = AUGUST 1933 DATA
- DASHED LINES = OCT. 1954 DATA

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
BALTIMORE DISTRICT
BALTIMORE, MARYLAND

HURRICANE SURVEY
TIDEWATER PORTIONS OF
PATUXENT, POTOMAC AND RAPPAHANNOCK RIVERS
INCLUDING ADJACENT CHESAPEAKE BAY SHORELINE

ELEVATIONS OF TIDAL FLOODING

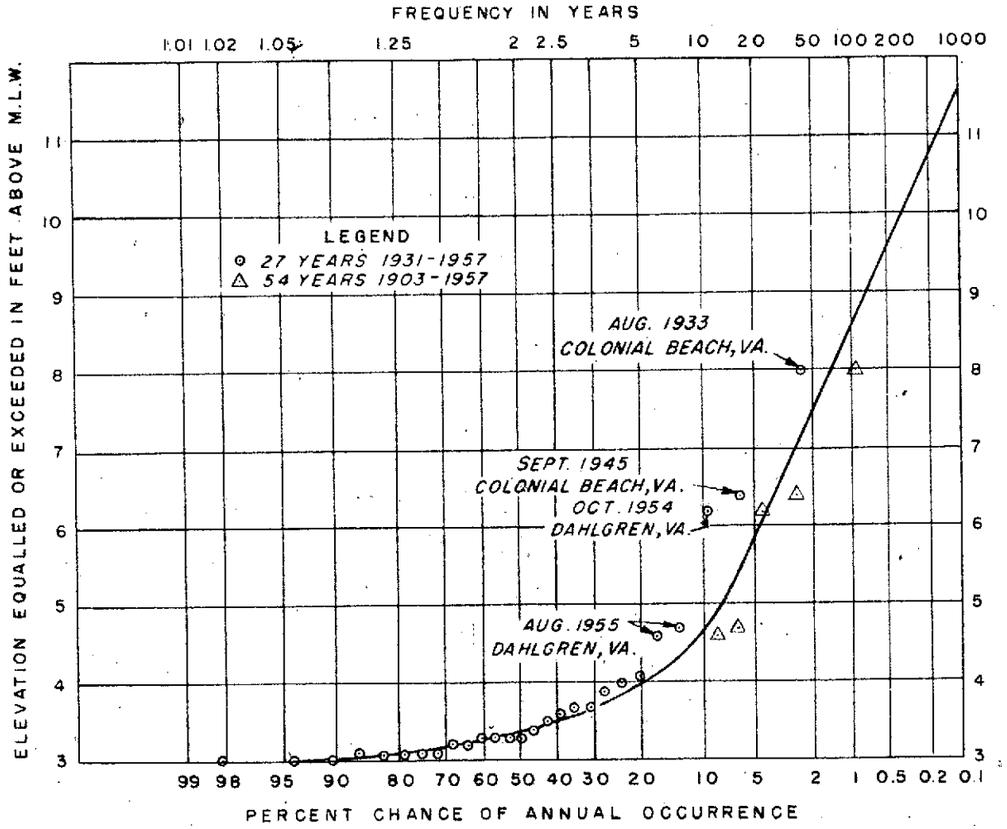
SURVEYED BY:
DRAWN BY D.B.P.
CHECKED BY J.B.C. G.F.J.
RECOMMENDED: Chief, Navigation Reports Sec.
SUBMITTED: Chief, Planning & Reports Br.
RECOMMENDED: Chief, Engineering Division
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

TO ACCOMPANY REPORT DATED 31 OCTOBER 1962

SCALE: AS SHOWN

FILE 100 MAP 9

PLATE 2



HURRICANE SURVEY

TIDEWATER PORTIONS OF

PATUXENT, POTOMAC AND RAPPAHANNOCK

RIVERS INCLUDING ADJACENT CHESAPEAKE

BAY SHORE LINE

FREQUENCY OF TIDAL FLOODING

PLATE 3

HURRICANE SURVEY

TIDEWATER PORTIONS OF

PATUXENT, POTOMAC, AND RAPPAHANNOCK RIVERS

INCLUDING ADJACENT CHESAPEAKE BAY SHORELINE

APPENDIX A

BRIEFS OF PUBLIC HEARINGS

CONTENTS

BRIEF OF PUBLIC HEARING AT COLONIAL BEACH, VIRGINIA, 8 FEBRUARY 1956
RELATIVE TO HURRICANE DAMAGE IN COLONIAL BEACH AND POTOMAC RIVER AREA.

Hurricane "Hazel" inflicted greatest damage to Town of Colonial Beach. Insurance claims numbered 110 of which 25, representing damage from water, were not insurable. All property south of New Atlanta Hotel was damaged. Sewerage system flooded..... Pgs. 3-4

Protection of Irving Avenue is problem. Beach and shoreline have receded. Houses at south end of town damaged slightly from wind driven water. Approximately $500,000 storm damage in Town of Colonial Beach..... Pgs. 4-5

Waterfront roads, streets and sidewalks damaged during "Hazel," "Connie" and Diane." Approximately 30 feet of bank washed out in front of houses at north edge of town. All amusement piers except two demolished..... Pgs. 5-8

More damage in 1954 ("Hazel") than in 1933 due to growth of town since 1933..... Pg. 8

Large amusement pier valued at 25 to 30 thousand dollars demolished during "Hazel"..... Pg. 9

Water washed over road at south of town, wetting foundations and lower floors of houses. Furnaces damaged..... Pg. 10

Water 1 to 2 feet higher in 1933 than 1954 ("Hazel")..... Pg. 12

Newspaper accounts show 2 million dollar damage at Colonial Beach in 1933..... Pg. 13

Virginia Department of Highways constructed sloping concrete wall for distance of 1,000 feet along bank between Irving Avenue and river to protect roadway. Cost $25,000. Constructed after "Hazel." Wall was not damaged by "Connie" or "Diane." State plans to continue wall toward southern end of town to protect highway under four year program costing an additional $100,000. Work would protect same area covered by approved Federal beach erosion project..... Pgs. 15-17

Hurricanes have shoaled Federal channel project into Monroe Bay..... Pg. 18

Naval Proving Ground at Dahlgren, Va. (5 miles north of Colonial Beach) suffered damage from "Hazel" estimated at $656,000, primarily from wind which registered maximum of 71 knots. Water height was 6.2 feet above mean low water. "Connie" showed maximum of 41 knots and water height of 4.7 feet. Highest wind velocity during "Diane" was 33 knots and water height 4.8 feet. Storm damage greatest when storm centers pass to west of Dahlgren. Control stations for firing range destroyed by caving banks..... Pgs. 18-21

Natural banks and from 30 to 50 feet of shoreline which afforded protection to Colonial Beach in past have been destroyed. Storm similar to "Hazel" in later years might do five times as much damage..... Pg. 22

Permanent population of Colonial Beach is 1,500. Summer population is 6,000 to 8,000, and summer weekend and holiday population is 12,000 to 20,000..... Pgs. 22-23

Weather Bureau is attempting to improve Hurricane warnings and is studying predictions for high tides. Gages established throughout area would be helpful during anticipated high tidal stages.....Pgs. 24-25

Town of Colonial Beach would assist to limit of its ability in cooperating with any plan for protection..... Pg. 27

Mason Neck Civic Association reports serious bank erosion problem on south bank of Gunston Cove, Va., opposite Ft. Belvoir. Two hundred homes - three miles of waterfront..... Pg. 28

Representative of Westmoreland County, Va., called attention to receding shoreline and caving bank problem on waterfronts along Potomac River. Homes valued at $30,000 to $40,000 are endangered in various communities. Property values have been depreciated. No zoning regulations..... Pgs. 28-30

Town of Colonial Beach is spending $650,000 for remodeling sewage disposal plant..... Pg. 30

Discussion of Federal project for protection of shoreline adjacent to State road. State to pay two-thirds of cost; Government to pay one-third of cost. No agreement with Colonial Beach for payment of one-half of State share..... Pgs. 31-32

BRIEF OF PUBLIC HEARING AT SALUDA, VIRGINIA, 9 FEBRUARY 1956 RELATIVE TO HURRICANE DAMAGES IN RAPPAHANNOCK RIVER AND CHESAPEAKE BAY AREAS.

Urbanna, Va. - About 30 feet of bank on Rappahannock River at edge of town has been washed away by storms since 1933. Ten or twelve homes must move if protection is not provided. One lot owner estimates cost of $2,000 to protect property..... Pg. 20

General - Heights of water during the several hurricanes in the lower Rappahannock River area discussed. Storm of 1933 highest. Several offers made for volunteer services for reading tide gauges and reporting during tidal storms, including drawtenders on highway department bridges. More accurate predictions on storm tide heights would help prevent damage to boats and waterfront structures. Utility companies maintain stand-by crews costing $500 to $1,000 per hour, during hurricanes. More accurate warning on maximum wind velocities and timing would reduce cost. "Connie" and "Diane" missed predicted time by 12 to 18 hours..... Pg. 20

BRIEF OF PUBLIC HEARING AT LEONARDTOWN, MARYLAND, 14 FEBRUARY 1956
RELATIVE TO HURRICANE DAMAGES IN SOUTHERN MARYLAND

Tanners Creek, Md. - Entrance blocked by "Connie," also by "Hazel" in 1954. No drainage from creek. Entrance needs opening. Approximately 75 homes on creek, permanent population of Scotland Beach: 50. Several hundred acres of farm land flooded and corn and wheat damaged. Health hazard..... Pg 3-6

Scotland Beach, Md. - Foundations of hotel and cottages on beach damaged by "Connie." About $8,000 damage for one interest with 500' frontage - No total estimate of damage for entire area. Serious erosion problem along beach..... Pg 6-7

Deep Creek, Md. - Entrance blocked by sand washed from the bay during each bad storm. Eleven farms around creek inundated. Building and barn damage from wind described. Health hazard - malaria mosquitoes breed in creek. State Roads have in past opened drainage ditches to drain creek. Watershed association has been formed. Dead fish are problem. Wells flooded ..... Pg. 7-9

Maryland State Health Department testified that odor from dead fish not health hazard. Malaria type mosquito present but no cases of malaria reported in St. Mary's County in years..... Pg. 10-11

It was stated that if Deep Creek were opened for use of fishing boats it would be worth $50,000 to community. Barrier between bay and creek is 400 - 500 yards wide. Other estimates 250' wide. Entrance opened one day, closed next. About 250 - 300 acres damaged by salt water..... Pg. 12-14

Tall Timbers, Md. - County bulkhead for length of 50 - 60 feet damaged..... Pg. 14

General. - 15 - 20 feet erosion on Potomac shore. Many piers destroyed. Damage centers from hurricanes described as being Tall Timbers, Point Lookout, Scotland Beach and Seven Gables. Flood damage due to inadequate drainage is severe at Tanners Creek, Deep Creek, Breton Bay, St. Marys River..... Pg. 15

Area between Piney Point and Point Lookout, and inland about 3 to 5 miles is low (4 to 8 M.S.L.). Most of area underwater in 1933, 1954 and 1955 storms. (6,000 acres) damaged by salt water. Adequate warnings necessary for evacuation of persons and livestock..... Pg. 24-25

HURRICANE SURVEY

TIDEWATER PORTIONS OF

PATUXENT, POTOMAC, AND RAPPAHANNOCK RIVERS

INCLUDING ADJACENT CHESAPEAKE BAY SHORELINE

APPENDIX B

WEATHER BUREAU

TIDAL WARNING PLAN

WEATHER BUREAU TIDAL WARNING PLAN

FOR USE WITH WASHINGTON LOCAL SURGE WARNING LIST AND MAP

During July and September of 1958 the surge specialist at Washington National Airport visited all the communities in the Washington local surge area which were suspected of being vulnerable to flooding from hurricane tides. Most of these places were found to be relatively safe from such tides but at those places where it was believed loss of life might occur, arrangements were made whereby a local resident could be called in case of an expected severe hurricane. These local contacts consist of permanent residents, sheriffs, rescue squads, etc.

Table 1 (not printed) contains a list of the communities that should be warned and map number 1 displays the location of the communities. The individual figures in the "Height above MHW Needed for Warning" column were determined from a consideration of a number of factors such as height of damage zero, height of highest ground in the immediate area, height at which the highways become cut off, etc. Since the range of these figures (about 3'-5') is at least as small as the range in height which would be given in a surge forecast, it is probable that if anyone on the list is notified, they should all be notified.

A second list (table 2) was made containing information about all the communities visited.

The two hurricanes that seriously affected this area in the recent years were Hazel of October, 1954 and the hurricane of August, 1933 with the latter producing the higher water levels. Even though there is no record of any drownings in this area as a result of these storms, it is believed the communities on the warning list should be notified in case a hurricane is expected to move over or just to the west of this area. If a hurricane should produce tides greater than those produced by the August, 1933 hurricane, loss of life due to drowning could result unless proper precautions were taken.

Many of the highways leading inland from the communities contain low spots which would flood first, long before the water reached serious proportions (see table 1 and map number 1). This means that if evacuation is indicated, it must be carried out well in advance of the rise in water level.

Voluntary evacuation is not the best method, so every effort should be made to reach the sheriffs shown on the warning list.

It is believed that a large number of people could be drowned by a severe hurricane tide at the following places unless there was evacuation: Colonial Beach, Coles Point, Ragged Point, Sandy Point, Lewisetta, Westland, Morattico, Stingray Point, St. George Island, and Point Lookout.

WEATHER BUREAU TIDAL WARNING PLAN

DESCRIPTION OF LOCAL WASHINGTON SURGE FORECASTING AREA
(See attached map)

In general the coastlines of the Potomac and Rappahannock Rivers are such that flooding begins between 3 and 5 feet above MSL. However there are some areas that consist of a steep bank 8-12 feet high which has been found to be sufficiently high to protect against hurricane surges in the past. These banks extend on the west side of the Potomac River from just below Quantico to just above Dahlgren and on the east side of the River from Washington, D. C. to just above Popes Creek (see attached map).

Most of the communities along these rivers are small and consist generally of summer cottages but some contain a high percentage of permanent homes and a few have business establishments. The largest town and one of the most vulnerable to flooding is Colonial Beach.

Some communities are located on islands or are so situated that a small rise in the water level floods the highway leading inland, thus cutting off their only escape route. In such cases, if there is going to be need of evacuation, it must be done well in advance of the main surge.

Since the number of cases for study of hurricanes producing high tides in this area is small and little accurate information on the resulting tidal departures is available, no objective method can be devised at this time for forecasting the magnitude of these departures. It is believed, however, that a few general statements can be made.

Hurricane Hazel of October 15, 1954, which moved rapidly northward some distance to the west of this area with a strong wind field favorable for producing surges in these rivers, caused tides estimated to be between 4 and 7 feet above MSL. The hurricane of August 23, 1933 moved northward over or slightly to the west of this area. It has a slower forward speed and its winds were not as strong as those of Hazel but the tides produced in these rivers were higher - 6 to 9 feet above MSL. It may be that in the case of Hazel the winds which were favorable for producing surge in these rivers did not operate long enough to have their maximum effect, due to rapid forward speed of the hurricane itself. It would seem from the above that a surge forecase of between 4 and 10 feet above MSL (depending on intensity of wind field, path and speed of the storm) would be in order for hurricanes with wind fields favorable for producing surges in these rivers. It is conceivable, however, that an exceptionally intense hurricane under certain conditions could cause a surge in these rivers of more than 10 feet.

Since storms which move northward some distance to the east of this area do not have favorable wind fields for surge production in these rivers, they cause tidal departures of lesser magnitude. Surge heights for these storms should be forecast to be considerably lower than for the former type. Perhaps a forecast within the 2 to 5 feet above MSL range would be appropriate for the majority of these storms.

TABLE 2

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN JULY 1958 WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Fort Belvoir, Va.	Fairfax	Ponton bridges, boats.	4	Yes
Occoquan, Va.	Prince William	30 homes.	15	No
Belmont, Va.	Fairfax	80 homes.	20	No
Lynwood, Va.	Prince William	80 homes.	20	No
Featherstone, Va.	Prince William	80 homes.	3	Yes
Quantico, Va.	Prince William	Dock and airfield.	4-1/2	Yes
Widewater, Va.	Stafford	15 homes and cottages.	12	No
Marlboro Point, Va.	Stafford	5 homes.	12	No
Fairview Beach, Va.	Stafford	8 cottages.	12	No
Mathias Point, Va.	King George	10 homes.	15	No
Dalgren, Va.	King George	15 homes, dock.	4	Yes
Colonial Beach, Va.	Westmoreland	Population 1500 (much more during summer).	3-1/2	Yes
Westmoreland Shores, Va.	Westmoreland	Several homes, 10 cottages.	2-1/2	Yes

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN JULY 1958 WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Westmoreland Beach, Va.	Westmoreland	8 cottages.	12	No
Berkley Beach, Va.	Westmoreland	8 cottages.	18	No
Ebb Tide Beach, Va.	Westmoreland	8 cottages.	18	No
Wakefield National Park, Va.	Westmoreland	Nothing.	--	No
Muses Beach, Va.	Westmoreland	15 cottages.	6	No
Tidwells, Va.	Westmoreland	5 houses.	16	No
Horners Beach, Va.	Westmoreland	5 homes and cottages.	12	No
Driftwood Beach, Va.	Westmoreland	5 homes and cottages.	12	No
Westmoreland State Park, Va.	Westmoreland	5 cottages.	3	Yes
Stafford, Va.	Westmoreland	5 cottages.	10	No
Kingcopsico Point, Va.	Westmoreland	20 homes.	14	No
Coles Point, Va.	Westmoreland	150 homes and cottages.	6	Yes
Ragged Point, Va.	Westmoreland	240 homes and cottages.	6	Yes
Cherry Grove Beach, Va.	Westmoreland	10 homes and cottages.	6	Yes

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN JULY 1958
WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Sandy Point, Va.	Westmoreland	50 homes and cottages.	4	Yes
Upper Sandy Point, Va.	Westmoreland	8 cottages.	4	Yes
Springfield Beach, Va.	Westmoreland	12 homes and cottages.	9	No
Mundy Point, Va.	Northumberland	20 homes and cottages.	9	No
Harryhogan Point, Va.	Northumberland	20 homes and cottages.	8	No
Lewisetta, Va.	Northumberland	35 homes and 150 cottages.	2	Yes
Northumberland Shores, Va.	Northumberland	15 cottages.	3	Yes
Walnut Point, Va.	Northumberland	1 home.	6	No
Neuman Neck, Va.	Northumberland	8 homes and cottages.	12	No
Hull Neck, Va.	Northumberland	8 homes and cottages.	12	No
Mob Neck, Va.	Northumberland	8 homes and cottages.	12	No
Virmare Beach, Va.	Northumberland	5 homes and cottages.	12	No
Ginny Beach, Va.	Northumberland	8 homes and cottages.	12	No
Reedville, Va.	Northumberland	300 homes and 5 business establishments.	4	Yes

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN JULY 1958
WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Fleeton, Va.	Northumberland	30 homes.	3	Yes
Fairport, Va.	Northumberland	20 homes.	12	No
Ocran, Va.	Lancaster	20 homes.	2-1/2	Yes
Bald Eagle, Va.	Lancaster	10 cottages.	2-1/2	Yes
Westland, Va.	Lancaster	25 homes and cottages.	2-1/2	Yes
Foxwells, Va.	Lancaster	25 homes.	6	Yes
Palmer, Va.	Lancaster	25 homes.	3-1/2	Yes
Cherry Point, Va.	Lancaster	2 homes.	4	No
West Irvington, Va.	Lancaster	Ice plant and 25 homes.	3) 15)	No
Boer, Va.	Lancaster	4 homes	12	No
Morattico, Va.	Lancaster	50 homes.	3	Yes
Simonson, Va.	Richmond	1 home and 17 cottages.	3-1/2	Yes
Tarpleys Point, Va.	Richmond	20 cottages.	5	Yes
Sharps, Va.	Richmond	25 homes.	12	No

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN JULY 1958
WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Stingray Point, Va.	Middlesex	80 homes and cottages.	5	Yes
Deltaville, Va.	Middlesex	200 homes.	10	No
Ruark, Va.	Middlesex	30 homes.	7	No
Stove Point Neck, Va.	Middlesex	80 homes.	5	Yes
Urbanna, Va.	Middlesex	4 homes.	2	No
Balls Point, Va.	Middlesex	10 homes and cottages.	8	No
Kilmeres Point, Va.	Middlesex	10 homes and cottages.	8	No
Waterview, Va.	Middlesex	12 homes and cottages.	12	No
Bowlers Wharf, Va.	Essex	10 homes.	14	No
Eubank, Va.	Essex	25 cottages.	2-1/2	Yes
Wares Wharf, Va.	Essex	15 homes and cottages.	11	No
Lowery Point, Va.	Essex	15 homes and 75 cottages.	2-1/2	Yes
Tappahannock, Va.	Essex	Population 1000.	9	No
Leedstown, Va.	Westmoreland	10 homes.	10	No

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN SEPTEMBER 1958 WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Popes Creek, Md.	Charles	2 houses 2'-3'; 2 restaurants 2'-4'. High ground in vicinity.	2	No
Allens Fresh, Md.	Charles	1 house 5'; 11 houses 10' or more.	5	No
Newport, Md.	Charles	2 stores 4'; 10 houses 8' or more; road 3'.	4	No
Morgantown, Md.	Charles	1 cottage 3'; 14 cottates 8' or more; Street 3'; ground 12' in area.	3	No
Banks O'Dee, Md.	Charles	1 cottage 3'; 19 cottages 5' or more; street 5'.	3	Yes
Woodberry Beach, Md.	Charles	15 cottages 3'-8'; some 12'.	3	Yes
Wicomico Beach, Md.	Charles	15 cottages 3'-8'; some 12'; road 3'.	3	Yes
Windmill Point, Md.	Charles	5 cottages 3'-8'; some 12'.	3	Yes
Potomac View, Md.	Charles	30 cottages 4'-7'.	4	Yes
Rock Point, Md.	Charles	20 cottages 10'-14'; 1 store 14'.	10	Yes

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN SEPTEMBER 1958 WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Cobb Island, Md.	Charles	400 cottages and homes 6'-10'; highway 2'.	6	Yes
Mills Point, Md.	St. Marys	30 cottages 12'.	12	No
Chaptico, Md.	St. Marys	2 stores 4'-6'; 20 homes 7' or more; road 4'.	4	No
Bushwood Wharf, Md.	St. Marys	2 stores 3'; 2 homes 3'; 18 homes 10' or more; street 2'.	3	No
Whites Neck, Md.	St. Marys	1 store 2'; 1 cottage 3'; 29 houses 8' or more street 2'; ground 10' or above in vicinity.	2	No
Crew Point, Md.	St. Marys	20 cottages and homes 8'.	8	No
River Springs, Md.	St. Marys	20 cottages and homes 8'.	8	No
Colton Point Area, Md.	St. Marys	50 cottages, 50 homes 5' or more.	5	Yes
Palmers, Md.	St. Marys	30 cottages and homes 5'-8'	5	Yes
Waterloo Point, Md.	St. Marys	5 cottages 8'.	8	No

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN SEPTEMBER 1958 WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
Brenton Beach, Md.	St. Marys	20 cottages 2-1/2' or more.	2-1/2	Yes
Shipping Point, Md.	St. Marys	10 homes 6'-8'.	6	No
Huggins Point, Md.	St. Marys	20 cottages and homes 7' or more.	7	No
Leonardtown, Md.	St. Marys	Wharf 3'; warehouse 4'; Oil Co. 4'.	3	No
Abell, Md.	St. Marys	25 homes 6'-8'; street 7'.	6	No
St. Clement Shores, Md.	St. Marys	100 cottages and homes 10-15'; street 10'-15'.	10	No
Newton Neck, Md.	St. Marys	1 house 3'; 49 cottages and homes 7'-10'; road 7'.	3	No
Brenton Bay Estates, Md.	St. Marys	15 cottages 8' or more.	8	No
Abells Wharf, Md.	St. Marys	1 restaurant 2'; 1 house 6'; high ground in vicinity.	2	No
White Point Beach, Md.	St. Marys	25 cottages 12'; road 13'.	12	No
Lane Beach, Md.	St. Marys	15 cottages 13'; road 14'.	13	No

TABLE 2 (Cont'd)

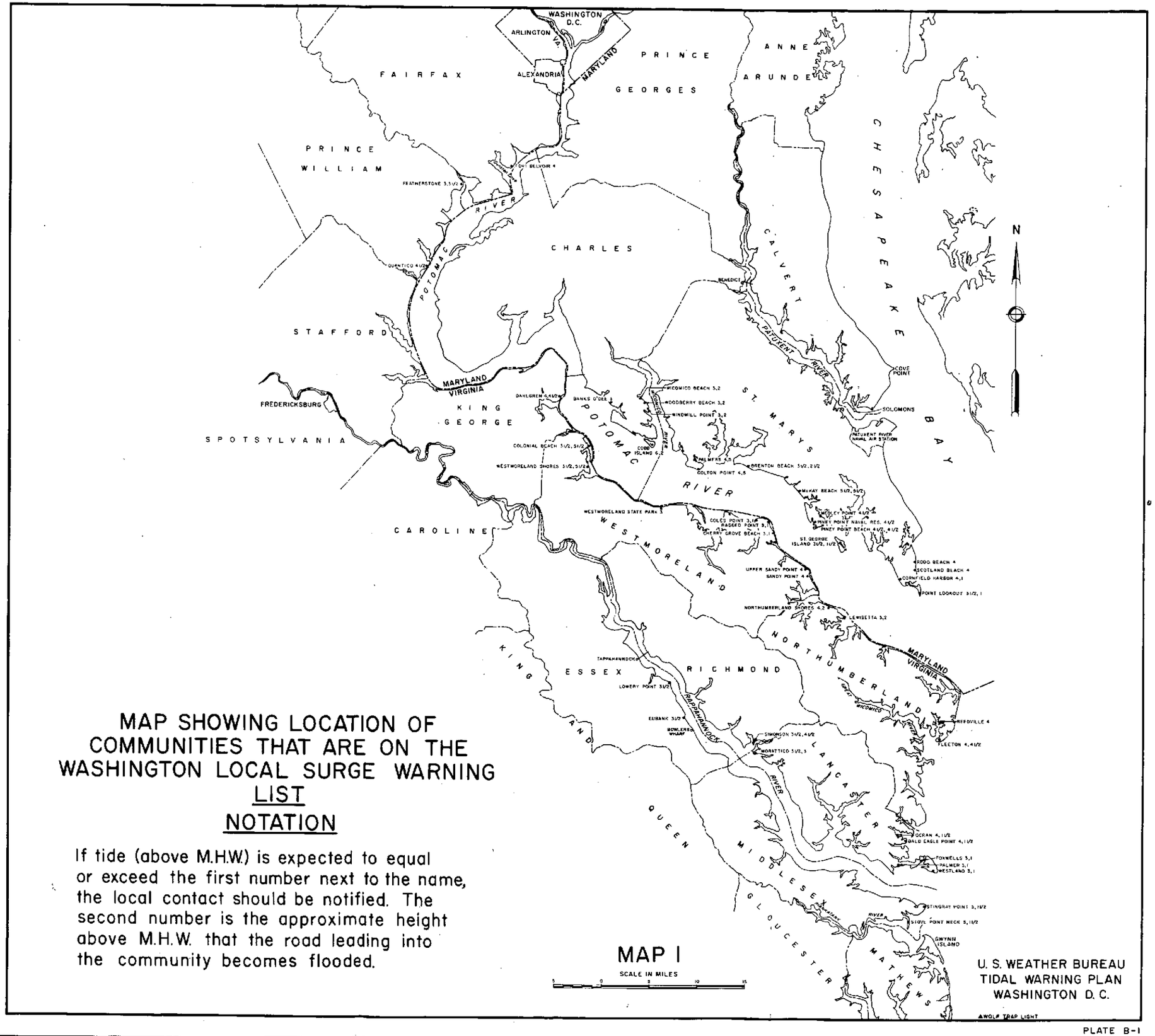
COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN SEPTEMBER 1958
WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
McKay Beach, Md.	St. Marys	Several cottages 4-1/2'; 100 cottages and a few homes 5'-8'.	4-1/2	Yes
Tall Timbers, Md.	St. Marys	4 cottages 4'; 30 cottages 6'-8'; road 8'.	4	No
Tall Timbers Post Office, Md.	St. Marys	2 houses 4'; store and 8 houses over 7'; road 7'.	4	No
Locust Grove Cove, Md.	St. Marys	15 homes 6'.	6	No
Morgan Beach, Md.	St. Marys	4 cottages 3'; 6 cottages 6'; road 6'.	3	No
Morgan Point, Md.	St. Marys	30 cottages and homes 4'-6'; road 3'.	3	No
Medley Point, Md.	St. Marys	10 cottages and homes 3-1/2'; 10 cottages and homes 5'.	3-1/2	Yes
Piney Point Beach, Md.	St. Marys	60 cottages and homes 3-1/2' or more.	3-1/2	Yes
Naval Reservation at Piney Point, Md.	St. Marys	100 homes 5'-7' (mostly unoccupied); road 7'.	5	No

TABLE 2 (Cont'd)

COMMUNITIES IN THE WASHINGTON LOCAL SURGE AREA INVESTIGATED IN SEPTEMBER 1958 WITH REGARD TO FLOODING DUE TO HURRICANE TIDES

Community	County	Installations	Hgt of damage zero (Ft abv MHW)	On warning list
St. George Island, Md.	St. Marys	180 cottages and homes 3-1/2'-6'; road 2'.	3-1/2	Yes
Wynne, Md.	St. Marys	Shipyard 3'; 15 houses 10'.	4	No
Potomac View, Md.	St. Marys	1 store 3'; 1 restaurant 4'; 5 warehouses 3'; 20 houses 5'.	3	No
Camp Earnest Brown, Md.	St. Marys	Summer boys' camp 8'.	8	No
Cornfield Harbor, Md.	St. Marys	15 cottages 3'; road 2'.	3	Yes
Rodo Beach, Md.	St. Marys	10 cottages and homes 4'.	4	Yes
Scotland Beach, Md.	St. Marys	40 cottages 3'-5'.	3	Yes
Point Lookout, Md.	St. Marys	Hotel 4-1/2'; lighthouse 4-1/2'; road 4-1/2'.	4-1/2	Yes



MAP SHOWING LOCATION OF COMMUNITIES THAT ARE ON THE WASHINGTON LOCAL SURGE WARNING LIST

NOTATION

If tide (above M.H.W.) is expected to equal or exceed the first number next to the name, the local contact should be notified. The second number is the approximate height above M.H.W. that the road leading into the community becomes flooded.

MAP I

SCALE IN MILES

U. S. WEATHER BUREAU
TIDAL WARNING PLAN
WASHINGTON D. C.

HURRICANE SURVEY

TIDEWATER PORTIONS OF

PATUXENT, POTOMAC AND RAPPAHANNOCK RIVERS

INCLUDING ADJACENT CHESAPEAKE BAY SHORELINE

Additional information called for by Senate Resolution 148,
85th Congress, 1st Session, adopted January 1958

OCTOBER 1962

1. The information contained in this supplement is in response to Senate Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958.

2. The geographical scope of this report was limited to a general appraisal of the hurricane problem as related to the tidewater areas of the Patuxent, Potomac, and Rappahannock Rivers, and the western shore of the Chesapeake Bay from Cove Point, Calvert County, Maryland, to Wolf Trap Light, Mathews County, Virginia. The functional scope of the report included public hearings to ascertain the kind and extent of hurricane induced problems and the expressions of local interests in this matter.

3. Federal participation in providing protection by structural means to prevent tidal flooding, bank and beach erosion was considered to be economically unfeasible. As an alternate consideration, the basic report contains recommendations including regulations on the use of the shoreline and development of warning and evacuation plans. These recommendations appear to be the most appropriate means of providing for reduction of future tidal flooding damages.

4. Application of the standards contained in Senate Resolution 148 will not change the recommendations presented in the Basic report.