REPORT BY

BOARD OF COMMERCE AND NAVIGATION

NEW JERSEY

ON THE EROSION AND PROTECTION OF THE

NEW JERSEY BEACHES

1924

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ON THE

Erosion and Protection of the New Jersey Beaches

1924

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LETTER OF TRANSMITTAL

TRENTON, N. J., February 17, 1925.

To the Legislature:

GENTLEMEN—The following report is a supplement and extension to the report made to the Legislature by the Board of Commerce and Navigation in 1922 and transmitted to your Honorable Body January 10, 1923.

The preservation of the New Jersey beaches is vital. It is a matter of economic life and death to certain of the communities of New Jersey between Sandy Hook and Cape May. The four ocean front counties, Monmouth, Ocean, Atlantic and Cape May have a net valuation of taxable property of $498,553,829.00. Approximately 80% of this total is represented by the net taxable valuation of the municipalities fronting on the Atlantic Ocean. This vast total is a measure of the attraction which the New Jersey shore front offers to the people of the country, millions of whom visit these shores annually. The jeopardy of such great wealth to attack from the ocean needs to be removed from possibility. Comparison of the present shore line with that indicated on the earliest maps available indicate that approximately 2,000 acres of land has been lost to the ocean in the intervening period. True there has been considerable accretion at some points, but the net loss is over 2,000 acres. It is well known that the tendency of the sea is to level down all land formations so that shore line recession will continue unless adequate protection is supplied. The losses from erosion extend beyond the actual material loss of land and property at a place under attack. There is a resulting discouragement to investment in other localities where similar loss may be imminent.

The Board of Commerce and Navigation has been charged with the administration of the State's interest in the projects to aid municipalities to protect their shores, pursuant to which grants of funds have been made under the provisions of Chapter 318 of the Laws of 1920. The proper application of these funds necessarily requires detailed, continuous study of the causes of coast erosion and the means for combating such losses. The Legislature has for several years past appropriated relatively small sums for the prosecution of these studies. The continuing policy of the Legislature appropriating sums of money for such studies is respectfully urged upon your Honorable Body.

The Board, through its Coast Erosion Committee and the Engineering Advisory Board, is making a systematic study of the New Jersey coast from Sandy Hook to Cape May, using this strip of beach as a physical laboratory, rejecting all conjecture and guesswork, and basing its observations upon accurate, repeated measurements of changes in the shore line.

The State of New Jersey is the only State in this country that has ever undertaken the accurate continuous systematic study of the subject. The scheme of study follows closely the lines laid down by eminent British engineers who testified before the Royal Commission which took testimony on this subject as it affected the British Isles between the years 1906 and 1911. The British Government did not accept the recommendation of these engineers, and so far as is known, New Jersey is the only sovereign that has manifested its appreciation of the importance of this subject by the establishment of a properly equipped body to prosecute the studies.

It was recognized from the outset that the United States Government through various of its departments, had obtained valuable records and information that could be profitably

employed in the investigation. Highly valuable assistance and the most courteous co-operation has been obtained from some of these departments, notably the U. S. Coast and Geodetic Survey through Colonel Jones, the director, who has permitted Commander R. S. Patton, Chief of the Division of Charts to become a member of the Engineering Advisory Board. Much valuable help has also been received from the Division of Tides of the Coast and Geodetic Survey through Commander Rude, Chief of that Division.

The War Department has rendered notable help and co-operation in this project. The Chief of Engineers has permitted Colonel Earl I. Brown to join with the Board in all its meetings and inspections, and it is proper here to acknowledge the assistance rendered by Colonel Brown. Colonel H. C. Newcomer also sat with the Board until his retirement from the service.

The surveys have been conducted by the Director of the Board, aided by Assistant Engineer Robert Simon.

The following were the members of the Engineering Advisory Board and its associates —Commander R. S. Patton, U. S. Coast and Geodetic Survey; Mr. Charles W. Staniford, Consulting Engineer, Board of Commerce and Navigation; Mr. Henry J. Sherman, Consulting Engineer, Board of Commerce and Navigation; Mr. Edward J. Murphy, Civil Engineer, Board of Commerce and Navigation; Mr. Victor Gelineau, Director and Chief Engineer, Board of Commerce and Navigation, Chairman. The associates from the War Department were: Colonel Earl I. Brown, and until his retirement, Colonel H. C. Newcomer. Mr. Edward H. Russell, Chief Clerk of the Board of Commerce and Navigation served as Secretary.

The Board of Commerce and Navigation has accepted the recommendations and conclusions contained in the engineers' report.

The Board of Commerce and Navigation takes this opportunity to commend the Engineering Advisory Board and its associates, and to express its thanks to Honorable Herbert Hoover, Secretary of Commerce, and to Colonel E. Lester Jones, Director of the Coast and Geodetic Survey, who enabled the Board to obtain the services of Commander Patton, and to Major General Lansing H. Beach, Chief of Engineers, U. S. Army, retired, and to Major General Harry Taylor, the present Chief of Engineers, U. S. Army, for enabling the Board to obtain the highly valuable assistance of Colonel Earl I. Brown.

Respectfully yours,

ROBERT F. ENGLE,
Chairman Committee.

STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION

Report on Erosion and Protection of New Jersey Beaches 1924

MAIN REPORT

This work is a continuation of the report on this subject published in 1922 by the Board of Commerce and Navigation, and in addition sets forth the results of the detailed investigation recommended by the Engineering Advisory Board which prepared the 1922 report.

On January 25, 1923, occurred the death of Mr. Benjamin F. Cresson, Jr., Chairman of the Engineering Advisory Board and Consulting Engineer of the New Jersey State Board of Commerce and Navigation. The death of Mr. Cresson was a great loss to the engineers interested in coast protection studies.

The Engineering Advisory Board met in Atlantic City on June 7, 1923, and reorganized, the members being:

Commander R. S. Patton, Chief, Division of Charts, U. S. Coast and Geodetic Survey;
Mr. Charles W. Staniford, Consulting Engineer, New Jersey Board of Commerce and Navigation;
Mr. Henry J. Sherman, Consulting Engineer, New Jersey Board of Commerce and Navigation;
Mr. Edward J. Murphy, Civil Engineer, New Jersey Board of Commerce and Navigation.
Mr. Harrison P. Lindabury, Special Counsel, New Jersey Board of Commerce and Navigation;
Mr. Victor Gelineau, Director and Chief Engineer, New Jersey Board of Commerce and Navigation, acting as Chairman.

The following representatives of the War Department were nominated to act, not as members of the Board but to sit with and aid and advise the Board.

Col. H. C. Newcomer, Corps of Engineers, U. S. A.
Col. Earl I. Brown, Corps of Engineers, U. S. A.

Mr. Edward H. Russell, Chief Clerk of the Board of Commerce and Navigation was appointed Secretary.

The Board reviewed the report of 1922, of which five hundred copies had been printed by the Legislature, and agreed that it covered adequately the general and historical features of this field. It was unanimously agreed also that the work of the Engineering Advisory Board should be greatly enlarged in scope and should be mainly devoted to the making of detailed, accurate surveys and examinations on which to base the comparisons necessary for the evaluation of the natural forces which produce erosion and accretion. These surveys, it was agreed, would yield an accurate and definite answer to the question as to the efficiency of various coast protective measures which have been applied to the New Jersey beaches.

It was recognized that continuous accurate surveys were essential, since in order to furnish means for comparison of conditions at different epochs, data on which to base theorems must first be obtained. Detailed surveys of the character required had never been undertaken prior to the field work carried out by the Board of Commerce and Navigation during 1921. It was immediately decided to repeat these surveys and to extend their scope to the following schedule:

1. Systematic and frequent observations of cross sections over the same lines at various localities, and the plotting of the results. These cross sections would be taken under varying effective conditions, as, immediately after easterly and northeasterly storms, which cause intensified erosion, and after protracted periods of westerly weather, which on the New Jersey shore is favorable to accretion. These cross sections to be measured in particular detail in the vicinity of important coast protection structures, to determine accurately their efficiency and their effect upon neighboring beaches.

2. Taking of soundings, which merely would extend to submerged lands the areas covered by the observations described under Section 1.

3. Observations and formulæ based thereon, to determine the rates and directions of currents under varying conditions of tide and water; this to include tests of the applicability to inlet gorges of the ordinary formulæ on flow of water in channels.

4. Measurements of the height and velocity and angle of waves on this coast.

5. Observations of the rate and direction of alongshore drift by tracing travel of marked articles and experiments to determine the depths at which storm waves operate to change the contour of bottom. This was recognized as an ambitious program but the obtaining of this information is absolutely essential to an intelligent study of the question. So far as known, at least in this country, no such work has ever been undertaken.

Field parties were reorganized in 1923 and 1924 which resurveyed the sections covered by the survey of 1922. The base lines of 1922 were rerun and the cross sections and soundings were repeated. These resurveys yielded the data on which to make the comparisons. The results are set forth in detail later in this report with reference to the locality in question.

It is believed that New Jersey is the first among the States to recognize the need for the prosecution of a systematic continuous study of this great problem. Just such a program was urged by eminent British Engineers in testifying at the inquiry of the British Royal Commission whose final report was published in 1911 and covers the testimony of a large number of experts adduced during several years. The British authorities declined to undertake such a work on the ground that there is no obligation resting on the Crown to protect the realm against the sea. In the words of the Commission: "We are not prepared, on the evidence laid before us, to recommend that there is any case for going further and for making grants from public funds in aid of sea-defence. We think that the evidence to the effect that there is an alleged obligation upon the Crown to defend the coasts of the United Kingdom from the inroads of the sea does not prove that there is any settled prin-

ciple of the Common and Statute Law to support the contention that there is a responsibility for sea-defence 'resting primarily upon the nation at large.' The main question appears to us to be whether there is sufficient evidence that the defence of the United Kingdom from the 'outrageous flowing, surges, and course of the sea,'—to adopt the picturesque description in the preamble to the Statute of Sewers of 5 Henry VIII.—is a national service which should be undertaken and paid for by the State. We cannot see that there is any ground for the contention that sea-defence is a national service; it is true that there is serious erosion in places, but this erosion does not affect the nation at large. We do not think that the case calls for any intervention by the State beyond that resulting from the extended administrative assistance which we have suggested; any adoption by the State of a general policy of giving grants in aid of sea-defence would, in our opinion, subject the State to serious difficulties. We therefore recommend on this question that the making of grants from public funds in aid of sea-defence should not be encouraged, although we think that the provisions of the Development, etc., Act of 1909, might in some cases be reasonably used so as—while primarily directed to public purposes—to give incidental assistance to some poor communities whose land is in danger of being destroyed by the sea—particularly where the authorities affected have done their utmost to provide adequate defence."

The Royal Commission Report in Vol. III, P. 153, in further reference to the question of the policy or obligation on the Government to make grants for coast protection, states that in Belgium the greater portion of the cost of sea defense works is borne by the state on the theory that the whole country is interested, not only from the standpoint of sea defense, but also for the purpose of rendering attractive the coast line of the country in the interests of the numerous visitors who make use of the health resorts on the coast in the Summer months.

The late Dr. Elmer L. Corthell, the eminent American engineer, in 1914 wrote an article entitled "The War Against the Waves, a Review of Forty-four Years' Experience in the Protection of Sandy Shores from the Endless Attack of the Sea." (Engineering Record, Vol. 69, No. 15.) Dr. Corthell recommends therein the constitution of a department of foreshore protection to be composed mainly of several engineers expert in riparian engineering, and outlines a program which is virtually the same as that followed by this Board since 1921.

DEFINITIONS

In this report the word "jetty" signifies a massive structure for protection of the coast at particularly important or vulnerable points. The word "groyne" is used for a lighter structure protecting a short length of the beach.

Walls generally parallel to the beach are called sea walls if built of concrete or rock, bulkheads if built of piles and timber. The latter may or may not be protected by loose rock at the base.

CONCLUSIONS AND RECOMMENDATIONS

I. Neither bulkheads nor groynes can be recommended for use separately except in special cases.

II. The use of concrete for bulkheads is not recommended except for those heavier and more permanent types which may be classed as sea walls. Its use is highly hazardous where any serious settlement may be expected.

III. Timber bulkheads should always be provided with rock protection. The rock should be of large size.

IV. The construction of shore bulkheads and sea walls seaward of ordinary high water line is to be permitted only when absolutely necessary for the immediate protection of existing structures such as buildings, roadways, etc. When their construction is unavoidable they should be supplemented by suitable groynes.

V. The distance between groynes requires for its determination, due consideration of many factors including the slope of the beach, height of waves, distance to offshore bar, proximity of ocean inlets, etc. If the space between groynes is too great, the frontage to the leeward of the groynes will be left without protection. If this space is insufficient, scour may result from back wash and interference of the two groynes. In general, groynes should be spaced from one to one and one-half times their length.

VI. Groynes must always be securely and tightly connected to a bulkhead or extend well inshore to points beyond the reach of the highest waves. Disaster will almost certainly follow if the water is permitted to pass the inshore end of the groynes. Any breach or poor connection between a groyne and a bulkhead on a sandy beach is almost certain to nullify the effect of the structures.

VII. In groynes sheet piles should have a minimum penetration of 10 feet. Even this will be inadequate in some situations. The groynes must be of tight construction, preferably of tongued and grooved sheet piling well lined and braced by wales and piles. The piles must have a penetration of at least 25 feet and the timber should generally be treated with creosote. All bolts, rods, spikes, etc., shall be galvanized.

The rock should be of large size. Stone less than 100 pounds should not be used. Even rock of such small units as 100 pounds is of very slight value. Where the exposure is severe, nothing less than one-half ton should be considered, and approximately 75% of the rock should be of units weighing two to six tons or more. In general, rock should have a least dimension at least equal to one-third its largest dimension.

The incorporation of a sand tight core in groynes is essential. This should be ordinarily of timber piles and sheet piling. It may be of rock where sufficient material is used, in the class of large structures such as in the Longport 11th Avenue jetty, which contains a very deep, wide foundation of rock and foundry slag. The core must be a substantial structure. If of timber it must be supported by piling or by rock or by both.

VIII. Groynes or other structures designed to gather large areas of beach should be permitted only for special reasons and after careful study of the probable effect upon adjacent communities. What is to be sought is coast protection and not coast extension. Extension at one place is likely to be accompanied by recession at points in the vicinity.

IX. The height and slope of the groyne with respect to the profile of the beach depends upon many factors. Structures of the type found to be necessary on the steep beaches of northern New Jersey would be needlessly expensive in many sections of the southern New Jersey beaches where the profile is much flatter and where greater fluctuation of the shore line may be permitted.

If the beach has been seriously lowered and the slope permits, it may be most economical to build a low structure, that is, some three feet above the normal profile of the beach, but so design the core as to permit the addition of wales and sheeting to obtain higher level of the beach when the low jetties attain their maximum effect.

X. The construction of curved groynes or jetties should be permitted only after thorough investigation. There is no evidence that curved groynes offer any greater promise of success than straight groynes.

XI. Coast protective works must be adequately maintained. The tendency has been to pay little or no attention to maintenance until serious damage occurs. Where State aid is given to protect the shores, provision should be made for the maintenance of such works in good repair. Municipalities fronting on the ocean should adopt and maintain general programs for the adequate protection of their ocean front. Perhaps the best means to accomplish this would be the establishment of a fund into which moneys would be paid every year, the expenditures to be made therefrom as required. The almost universal tendency is to view with indifference the inroads of the ocean, making no effort to hold the beach until valuable structures are actually attacked.

XII. The growth of sand dunes along the coast should be encouraged and promoted. Unfortunately, in New Jersey the tendency has been to level the sand dunes as construction of roads and dwellings progresses. Public authorities should discourage the removal of sand from the beaches where this sand is used for construction purposes or for filling of low lands. The artificial removal of sand from the New Jersey beaches is a serious evil.

The best means of encouraging the growth of sand dunes is to plant beach building vegetation, such as sea oats, sea wheat and other beach plants. In some places, particularly low spits, fences may be employed to gather the drifting sand.

XIII. There is no evidence to justify the contention that the protection of the beaches can well be attained by means of heavy key works of great extent and massiveness, such as heavy outshore breakwaters or current deflectors.

XIV. To control the location and navigable depth of inlets, tight jetties are necessary, and in the case of many inlets two parallel jetties are needed to carry the current into deep water.

XV. Twin jetties at inlets possess a superiority over a single jetty, whether straight or curved, and may be used with more confidence of results.

XVI. In length jetties should always extend from high water line, or from a proper bulkhead outward to such distances as may be required by the problem at hand. For navigation purposes they must necessarily extend out sufficiently far to obtain the low water depth sought. For fixation of location of inlets and for beach protection purposes an extension to or only slightly beyond low water mark is necessary. It should be borne in mind in all cases that long jetties may temporarily cut off from the leeward beach the supply of drifting sand upon which its maintenance in normal conditions depends.

XVII. The northern beaches of New Jersey, that is from the vicinity of Long Branch northward, are relatively steep. This is a situation which requires the application of substantial structures, that is heavy rock breakwater jetties. Light wooden structures, not adequately supported with heavy rock will not serve on this frontage.

The southern beaches are less steep, and here the construction of such heavy works is not ordinarily justified from the standpoint of economy, except in the vicinity of inlets.

XVIII. Every section of beach presents a problem with its own peculiarities. It is therefore impossible to give precise rules that can be applied offhand to particular localities, but the types of structures discussed and recommended in this report have proved their effectiveness as shown by the results obtained during the past few years, and consequently much of the confusion and uncertainty on this subject has been removed.

XIX. For breakwater jetties of magnitude the tight sheet pile core type surrounded by large rock is recommended. The dimensions of the jetty should be suitable for the location.

XX. In extensive, or key construction of magnitude, as distinguished from local protection on the beaches, no small stone should be used. Contracts should call for large

stone, say 85% of three tons and upward, with no stone of less than one ton. In general, rock should have least dimension at least equal to one-third of its major dimension.

XXI. Preparations for jetty contracts where rock is to be used, should include in addition to soundings, borings to locate a hard bottom, if one exists.

XXII. Where hard or firm bottom exists, and a core wall is to be used, plans should call for piles and sheet piles to extend well into it. Where no hard bottom is found, then the longest piles and sheet piles should be used within reasonable expense.

Respectfully submitted,

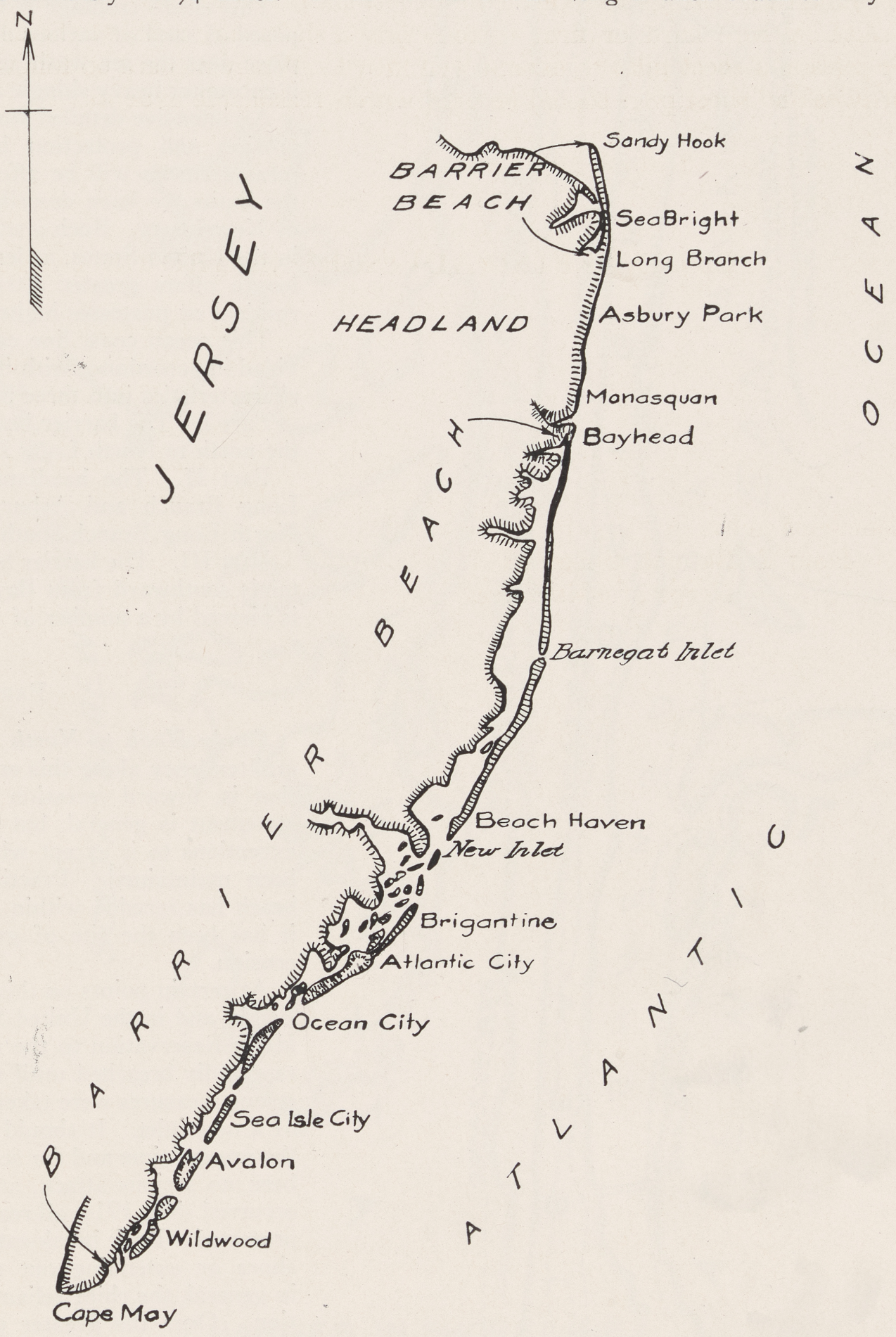
ENGINEERING ADVISORY BOARD ON COAST EROSION,

R. S. PATTON,
CHARLES W. STANIFORD,
HENRY J. SHERMAN,
EDWARD J. MURPHY,
VICTOR GELINEAU, *Chairman*,
EDWARD H. RUSSELL, *Secretary*.

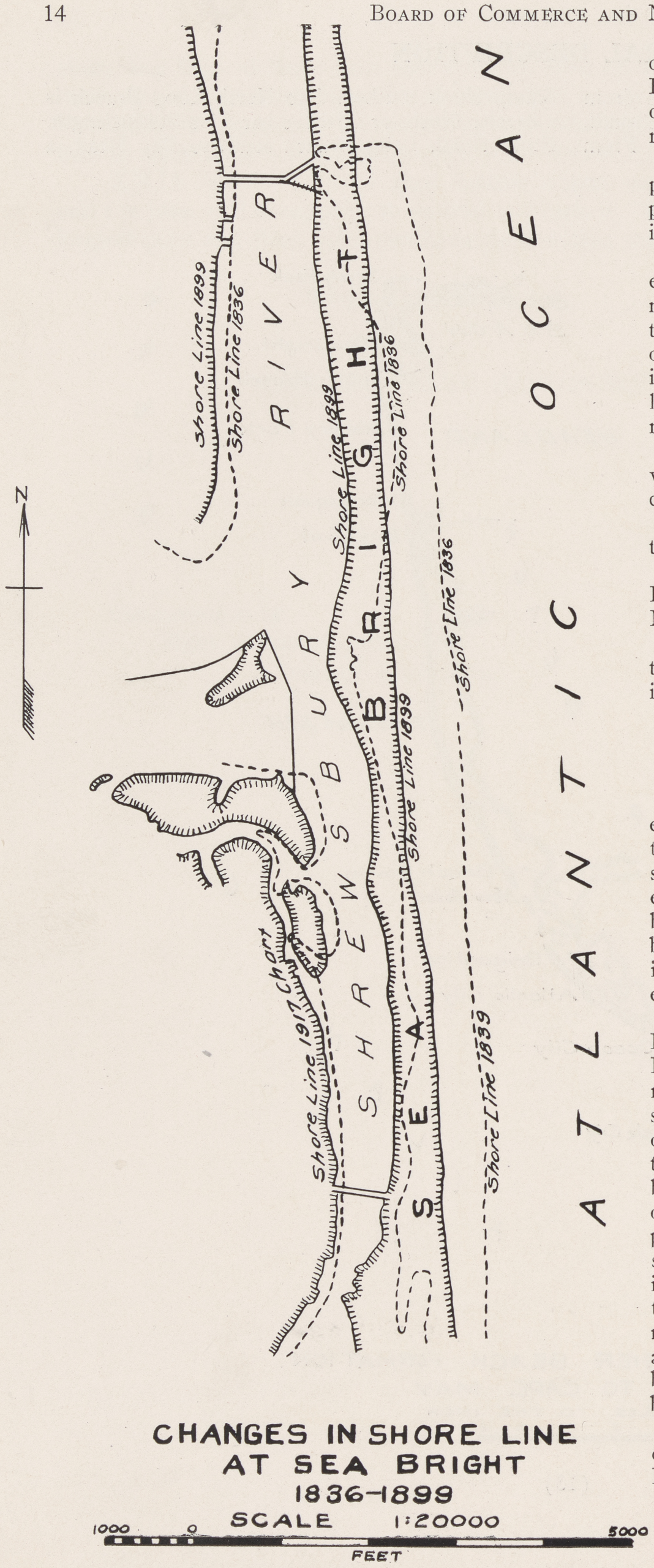
Concurred in by
EARL I. BROWN, COLONEL,
Corps of Engineers.

GENERAL DESCRIPTION

The ocean coast of New Jersey extends from Sandy Hook on the north to Cape May on the south, a distance of approximately 123¾ miles. From Sandy Hook southward to North Long Branch is a barrier beach, or offshore bar 11 miles in length. From North Long Branch south to Bay Head, a



HEADLAND AND BARRIER BEACH FORMATION
SANDY HOOK TO CAPE MAY
SCALE 14 MILES TO THE INCH
10 5 0 5 10 15 20



CHANGES IN SHORE LINE
AT SEA BRIGHT
1836-1899
SCALE 1:20000
1000 0 5000
FEET

distance of 17¾ miles, the sea washes the mainland. From Bay Head southward to Cape May, a distance of 95 miles, is barrier beach. Thus Long Branch rests on what has been termed a winged headland.

This entire frontage is faced by a foreshore composed of sand of various degrees of fineness. At no place does the sea wash against rock cliffs nor does it encounter heavy shingle as on some foreign coasts.

An intensive detailed study of the subject of coast erosion and protection based upon instrumental measurements will be afforded ample scope within the limits we have described, *i. e.*, the ocean front of New Jersey. Such a study is well warranted, for in the United States, at least, no coast line of equal length offers greater attraction for the tourist or resident or possesses higher aggregate land values.

This ocean coast line can for convenience be divided in accordance with its configuration and other characteristics into three parts described as follows:

Part I. The barrier beach from Sandy Hook on the north to North Long Branch on the south.

Part II. The headland on which are situated Long Branch and Asbury Park, extending from North Long Branch southward to Bay Head.

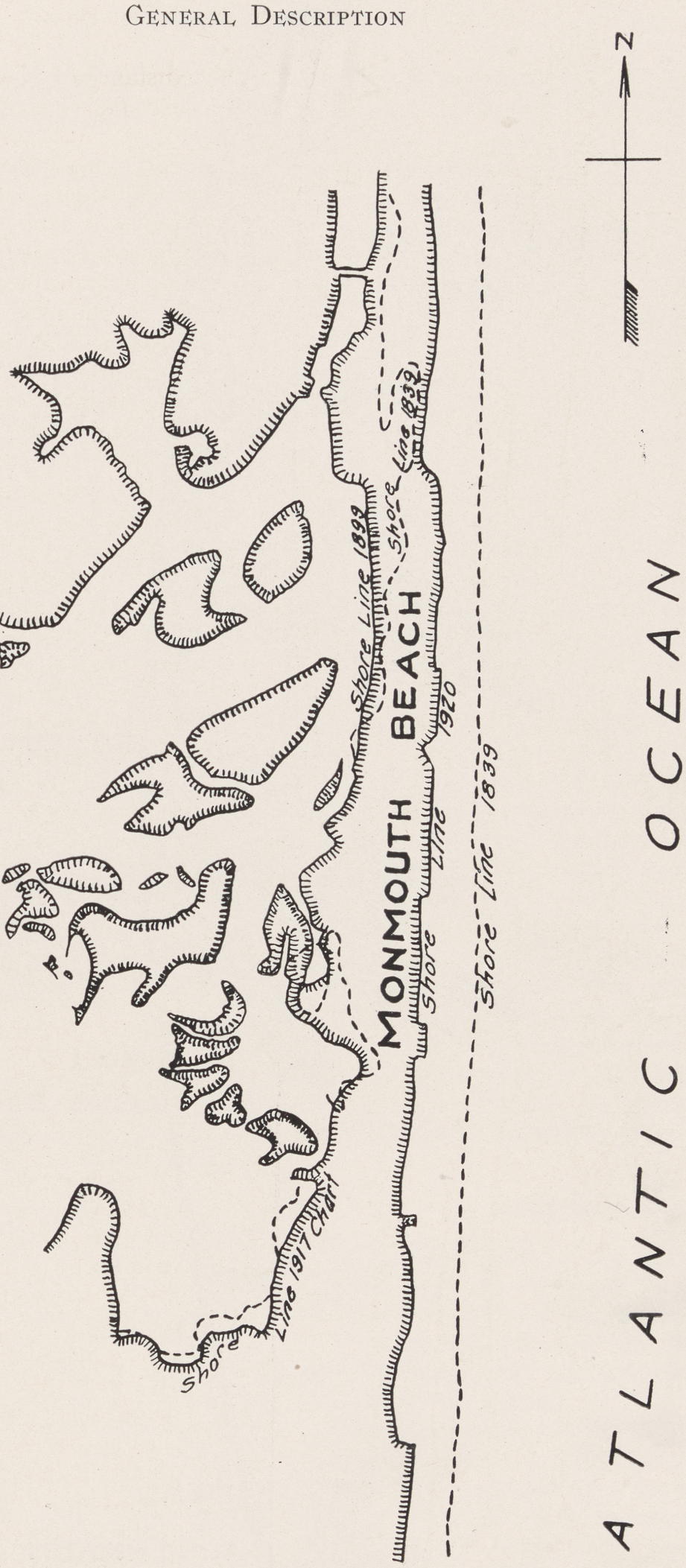
Part III. The barrier beach formation which extends southward from Bay Head to Cape May and is pierced by a number of inlets.

PART I

Sandy Hook to North Long Branch. The general tendency along this entire front is unfavorable, that is, toward recession of the shore line. This statement is general, but there are no outstanding exceptions to it except where adequate works have been maintained. Practically every foot of this beach has receded within the last thirty years, and it has been the site of grievous losses from coast erosion.

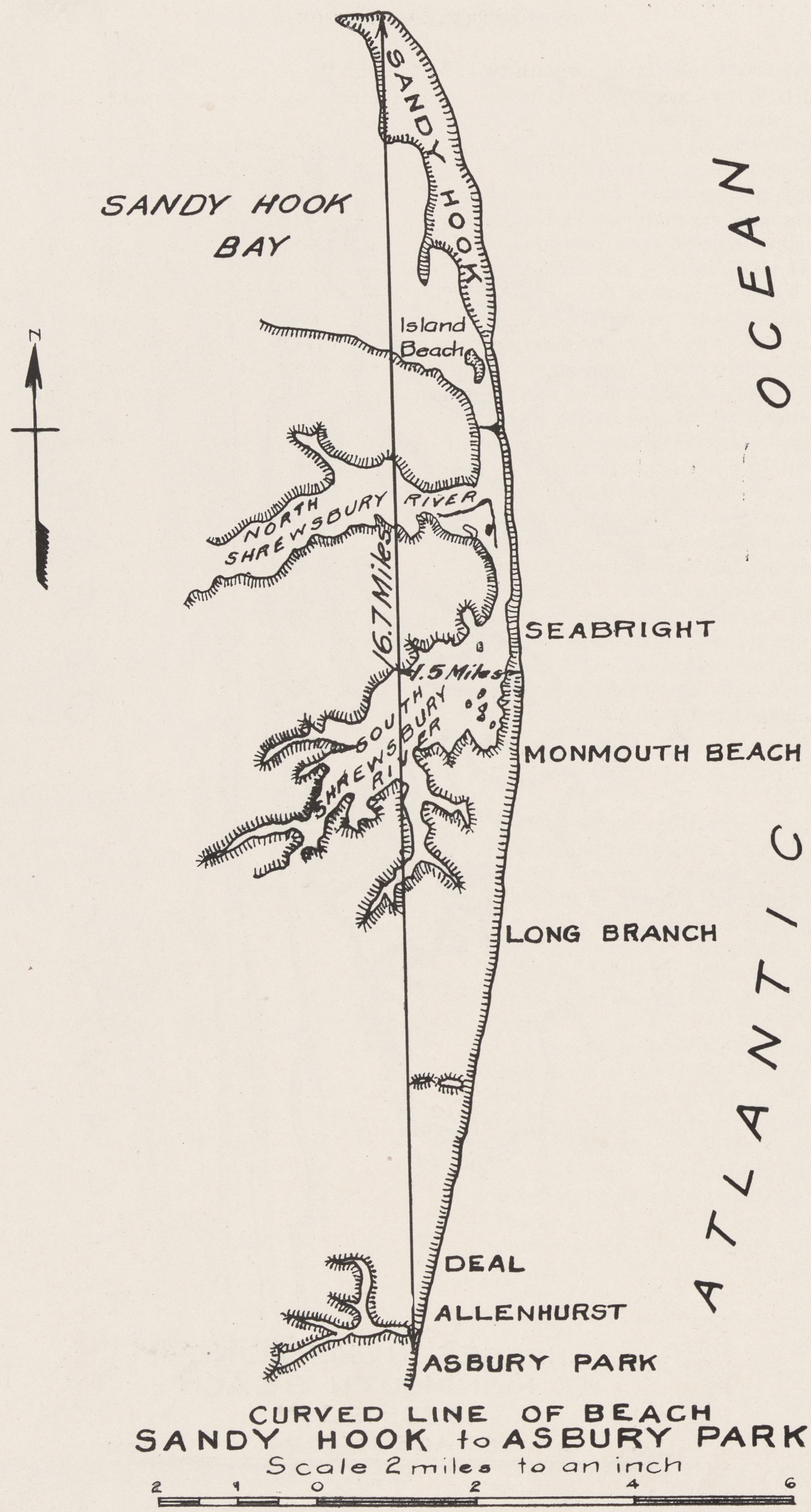
At certain points on this frontage, namely, at Sea Bright and in the United States Government Sandy Hook Reservation to the north, the beach has been repeatedly breached until within recent years, when strong measures were taken to prevent the formation of a new inlet. It should be said, however, that at the present time and for several years past, there has been no serious attack, and no serious losses have occurred since 1914, all really weak places being now protected. Rock breakwaters or walls either on the shore or extending out at an acute angle form, in general, the chief reliance for protecting this section. Over the greater part of this entire front, much of the sandy beach which existed thirty years ago washed away and has unquestionably gone to build up Sandy Hook, or to rest in the waters of the bay.

This beach extends in a roughly north and south direction, curving to the west from Monmouth Beach toward Sandy Hook. It is bounded on the



CHANGES IN SHORELINE
AT MONMOUTH BEACH
1839-1920
SCALE 1:20000

1000 0 5000
FEET



CURVED LINE OF BEACH
SANDY HOOK to ASBURY PARK
Scale 2 miles to an inch

2 1 0 2 4 6

west by Shrewsbury River, a lagoon with two chief branches, much of this waterfront being of great beauty.

This curved line of the beach strip under consideration merits attention. In the evolution of a shore front the forces at work operate over long periods of time to eliminate or flatten pronounced curves, whether horizontal or vertical. If we strike a chord on the map from the northerly outer corner of Sandy Hook on the north, to the mouth of Deal Lake, which forms the northerly boundary of Asbury Park, on the south, we find that the middle ordinate passes through Sea Bright and is about 1½ miles in length (Sea Bright being to the eastward of the long chord). The length of this long chord is approximately 16.7 miles. We should therefore expect to find that this section is undergoing serious erosion, if we agree that the tendency of the ocean is to flatten out such curves and particularly those of convex alignment. (See Map, page 16.)

It should be noted that the land formations of Long Island are very effective in protecting Sandy Hook from the attack of heavy northeast seas. But from Island Beach southward, there is no such protection available. The difference in the alignment of the beach from Island Beach northward and from that point southward offers grounds for careful study on this point. Of course this alignment is not entirely a result of the unimpeded forces of the ocean or other natural agencies, since extensive sections which have hitherto been seriously attacked or even breached, are now protected by heavy rock wall constructions.

The beach is connected to the mainland by 3 bridges which cross the lagoon. The northerly approach is supplied by two bridges between the Highlands of Navesink and Highland Beach, and the southerly approach is the Rumson Road which passes through Sea Bright.

The northerly approach can be reached by the drive over the Highlands of the Navesink, which is known as "The Sky Line Drive," from which a noble panorama is presented. Below it are spread out the beach communities, Sandy Hook Army Reservation, Raritan Bay and the ocean. Staten Island and Coney Island and Rockaway Point are plainly visible on clear days, and all these features, together with the ocean shipping which converges as it approaches New York Harbor, and the excursion steamers and fishing boats which run to Atlantic Highlands and into the Shrewsbury River, compose a splendid picture.

The southerly approach is reached over the Rumson Road which is situated on the neck or peninsula which separates the Navesink and Shrewsbury Rivers. This differs greatly from "The Sky Line Drive" over the Highlands of the Navesink, but offers great attractions nevertheless. It is a perfect pavement, bordered on either hand by great estates with their beautiful residences and well kept grounds and opens suddenly on the Shrewsbury River and the ocean.

On the beach itself is the Ocean Boulevard, also a perfect pavement, a drive over which is delightful, with the ocean on the east and the lagoon (Shrewsbury River) on the west. Near the boulevard and along the river are many residences and club houses, and, visible among the heavy foliage of the slope of the Highlands of Navesink, are beautiful villas. The large number of yachts and pleasure cruisers anchored or sailing on the Shrewsbury add greatly to the picturesqueness of the scene.

This brief description is enough to indicate that no elaborate argument is required to demonstrate the need for protecting this beach. Over its entire front the ocean has attacked and is now in contact with improved property and over a considerable section, reaches the line of the railroad tracks or the side of the Ocean Boulevard. Portions of the existing sandy beach which would appear to contradict this generalization, were in 1913 occupied by residences and hotels which were destroyed in the storms of the winter of 1913-1914.

Further recession of this shore line cannot be permitted. Shore protection measures which, however effective under average conditions, would permit serious wasting during easterly storms cannot serve in this district. Extreme conditions, not averages, must form the basis for design of protection here. This is a highly important factor economically since it eliminates from consideration relatively light and cheap structures which may well meet the requirements in localities more favorably situated, where a certain degree of fluctuation in the shore line could be tolerated, provided there is no definite rapid tendency toward ultimate loss.

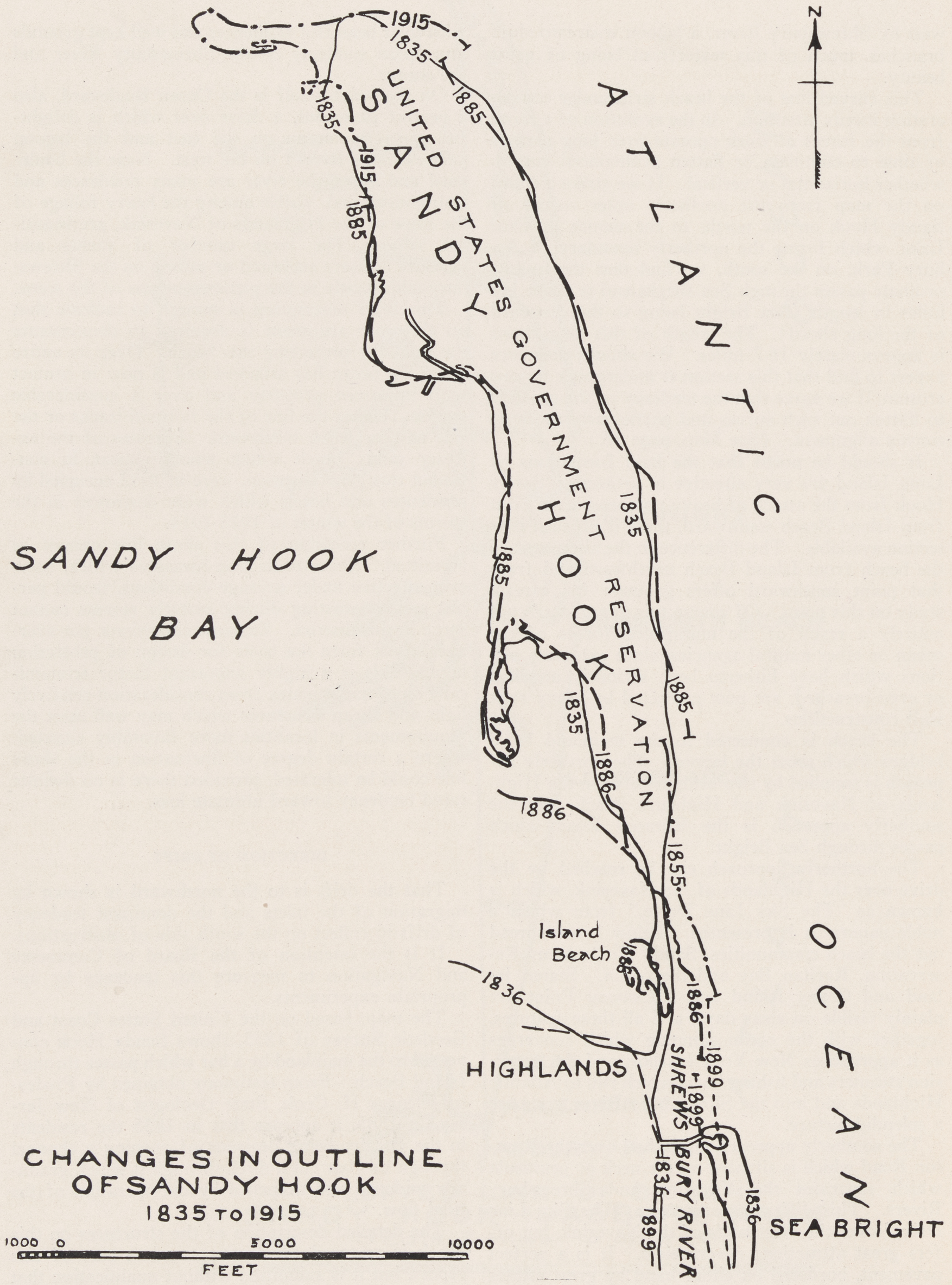
DIRECTION OF DRIFT

That the drift is to the northward is shown by migration of the inlets and the dominant tendency of drift to collect on the south side of obstructions.

It is the intention of the Board of Commerce and Navigation to measure this tendency by appropriate experiments.

The map, based on the United States Coast and Geodetic Survey of 1835, shows Sandy Hook connected to the mainland by a bar which passes through Island Beach. From testimony obtained by Professor George H. Cook, State Geologist of New Jersey, in 1885, it appears that in 1835 the residents in the vicinity being desirous of opening a channel through this bar cut a ditch through it which gradually widened and deepened by the operation of the tidal flow.

The detailed description of the structures on this beach is reserved for the appropriate part of this report, but it is submitted without qualification that



CHANGES IN OUTLINE OF SANDY HOOK 1835 TO 1915

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protection measures suitable for this area require massive structures to overcome the hammering of the seas. We have the expression that these forces should be guided and not opposed. We shall not quarrel with that, but we need structures strong enough to stop the onset before valuable property is destroyed. The provision of masses adequate to overcome the forces of the seas represents the primary factor in protection, but the design requires supporting elements having for their purpose the gathering of beach material, or more properly, the arrest of alongshore drift. The construction of a riprap wall on the beach below high water mark, intended to break up the seas, will not usually of itself furnish a satisfactory solution of the problem where erosion is severe, unless adequate works designed to intercept alongshore drift are also provided. Undoubtedly such a wall if heavy enough will, without intercepting features, prevent the breach of the beach by the ocean, but it only delays ultimate losses by substituting for the yielding sand a less easily moved material, namely, rock; undermining will continue as the sand base is transported. It is a matter of common knowledge and absolutely demonstrated by our surveys of the past years, that the presence of a vertical wall at or below high water mark is only too frequently a cause of increased erosion, or, as it has been expressed, "Seawalls are only too often agencies of their own destruction."

Part II

North Long Branch to Bay Head. This section is relatively well settled. Over the greater part of its length the division lines between adjoining municipalities are hardly perceptible. It is entirely different in formation from Parts I and III, in that it is a headland as distinguished from a barrier beach or offshore bar, hence possesses no lagoon features except that it is pierced by a number of inlets or what were formerly inlets, such as Takanassee Lake, between West End and Elberon; Deal Lake, between Allenhurst and Asbury Park; Wesley Lake, between Asbury Park and Ocean Grove, and two ponds at the north and south limits of Bradley Beach. So far as our subject is concerned, the foregoing waterways have no importance at all, being without exception closed off from the tides by means of bulkheads or causeways. Shark River Inlet between Avon-by-the-Sea and Belmar is the first inlet worthy of consideration. It has not been very important from the standpoint of navigation prior to the construction in 1924 of the south jetty, but was always important from the standpoint of erosion and accretion prior to its fixing by the north jetty which was constructed in 1911. (Breached in January, 1924.)

Silver Lake in Belmar, Lake Como, Spring Lake and Wreck Pond are of no importance, only Wreck Pond being open to the sea, and this outlet is frequently closed during long periods as a result of sand drifting.

The next in order is Manasquan Inlet, which is of great interest in our study and forms the connection between the beautiful waterway known as Manasquan River and the ocean. Bay Head is at the head of Barnegat Bay, and between Bay Head and Manasquan Inlet lie a string of small ponds which mark the connection that existed in the past, between the two waterways. Manasquan Inlet is discussed in detail below.

Part III

Bay Head to Cape May. This is a barrier beach of varying width pierced by a number of inlets, some of which are large and relatively important to navigation interest, while others, of no value to navigation, are menaces to beaches during high storm tides which carry the sand from the beaches through these inlets and deposit it in the lagoons. Between this beach and the mainland there is a large lagoon and extensive areas of salt marsh. (An interesting feature of this salt marsh is the alignment of its inshore boundary, that is, where it joins the mainland. This follows with hardly any perceptible deviation a straight line from Cape May to the mouth of Barnegat River.) On this beach is to be found almost every degree of development ever attained by sea coast resorts. It includes the largest and richest shore resort in America as well as extensive areas of beach which are uninhabited, except for the coast guards and in proper season by fishermen and gunners. For these latter it offers great inducements and attractions. Again, its wonderful bathing beaches are famed everywhere. In connection with our study it is worth while noting a peculiar alignment on the beach which, from Barnegat Inlet, deflects over a large angle to the southwestward to Atlantic City. The beaches from Atlantic City south present a concave alignment, the points on the south side of the inlets being offset from the north points. We shall discuss these features very fully in the detailed description.

General Principles of Coast Protection

It may be objected that the question of the source of the material composing these beaches is not so important at this time, since we are confronted by the practical fact that the beaches exist and by the practical problem of preventing erosion or inducing accretion. But this question is easily answered. Unless the forces now in operation in moulding the contour of our beaches are recognized and evaluated, all designs and calculations having for their object the arrest of erosion or inducement of accretion will be mere unscientific guesses. There is no more

fruitful source of trouble and failure in this sphere of engineering than the blind application, to a selected area, of plans which were successful in another section where conditions may be entirely divergent. The hazards and difficulties which confront the engineer in planning coast protection works are too formidable to permit of ignoring any possible sources of information bearing directly on the problem.

In studying this question the engineer is compelled to resort to the works of the geologists and physiographers. Some information has been derived from the reports and special works of the State Geologists of New Jersey, namely, Dr. Henry B. Kümmel, present State Geologist, and predecessors, Dr. George H. Cook, Prof. R. D. Salisbury and Mr. John C. Smock.

It is necessary from the outset to keep in mind certain important differences in the problem of the physiographer and that of the engineer interested in coast protection. The physiographer from the evidence at hand endeavors to trace the changes in land formations both past and present; he merely records and theorizes. The engineer on the other hand is called upon to interfere with or at least guide and direct the processes in operation for the benefit of those interested in the waterfront under consideration. The measure of time is a tremendously important factor. The physiographer or geologist speaks in terms of ages, but the engineer must plan for the present and the relatively immediate future.

We shall not attempt to formulate any decision between the assumptions of geologists and physiographers with respect to a subject which is so purely speculative and in which the element of time virtually has not been introduced. Our task is to view the problem from the standpoint of the engineer and the land owner and all others to whom the element of time is a very practical and important factor and who will tell us that what they need is reasonably permanent protection now from the conditions which confront them. It is submitted that for all practical purposes we can look to our bays and lagoons as the destination of the material which has been eroded from our beaches, duly accounting, of course, for that material which has lodged on our beaches in the form of accretion. We shall point to the flood tide entering our inlets as the most effective agency in altering the contour of the coast lines such as those of New Jersey, pierced as it is by inlets of more or less importance at every few miles.

We have said of the New Jersey beach that in general the net tendency has been toward erosion. That is to say, measurement of the areas of lands gained through accretion and of lands lost through erosion during the past one hundred years shows considerable balance on the side of erosion. Whether or not this tendency will continue no one knows. Certain forces operated to create these beaches in front of our mainland. These forces unquestionably continue at work, the only question being whether they are overcome by opposite forces tending to tear down the beaches. There has always been great shifting in the vicinity of inlets. The testimony of ancient witnesses in the inquiry of 1885 to fix the line of division between Atlantic and Burlington Counties on the Atlantic beach, developed that in the year 1800 what is now known as New Inlet formed during a violent storm. We know that the changes in the vicinity of Sandy Hook, Highlands and Sea Bright have been very great. We have authentic maps (U. S. Coast & Geodetic Survey of 1836) showing Island Beach (Sandy Hook Region) connected to the Highlands by a narrow sand spit, there being no beach at what is now Highland Beach and other settlements north of Sea Bright. There are many forces at work and constantly varying, which operate to alter the profile of the shore. The set of conditions existing at any time works to mould the shore profile to best accord with these forces then in operation. There is no precise stability because the numerous forces at work are in a continual state of change and they operate on a readily yielding material.

We leave for a future report the discussion of major theories of barrier beach formation.

There is disagreement as to which is the major force in producing erosion or accretion. Many contend that the waves have relatively little effect, the greater cause of transportation being the alongshore current, while other authorities urge that the waves really cause the travel of beach material. In considering this question with respect to the New Jersey Coast, it is submitted that both forces are very effective. There is no question that the heavy seas beating upon a sandy beach rapidly agitate and raise into suspension the fine material of which the beaches are composed. Heavy seas are invariably caused by or accompanied by high onshore winds; which, on a shelving shore like that of New Jersey, exert a great influence in raising the level of the water alongshore to heights much greater than normal. Under these conditions the water flows with high velocity through the inlets which break the continuity of the offshore bar which protects the greater part of New Jersey's coast. There is no point on the New Jersey oceanfront that is distant more than thirteen miles from an ocean inlet of some degree.

In reading the literature on Coast Erosion and Protection one finds ample evidence that some engineers are ready to offer a panacea for coast erosion, however this may be caused or wherever it has occurred. The forms and type of structures for coast protection are unlimited in number, but there is grave danger in adopting the type of protec-

tion not designed for the shore front under consideration.

The British Royal Commission on Coast Erosion in its final report of 1911, in Vol. III, P. 89, very properly cautions against the indiscriminate adoption of plans not adapted for conditions in Great Britain however impressive and successful they may be in other situations. Quoting from the report,—"The foreshore works on the coasts of Holland and Belgium, examined by a Committee of the Commission, although of extreme interest, and attended with considerable success, and also, in such cases as Blankenberghe, Heyst, Scheveningen, Callantsoog and Petten, of great magnitude and importance, do not, in our judgment, afford examples to be followed as affecting the sea-defences of the United Kingdom. The principal conditions with which these works have to conform, viz., a low flat foreshore, consisting entirely of sand, are wholly different to those generally associated with sea-defence works in this country."

And by a parity of reasoning, it is fair to say here that designs, however successful on the British shores, should not be indiscriminately adopted as examples of good practice on our shores where conditions are so essentially different.

It has been suggested, and is worthy of consideration, that coast protection can be attained by constructing a breakwater parallel to the shore at a considerable distance, based on circumstances, outshore from the high water line. The top of this rock breakwater would be below mean high water so that the waves could wash over it, but the difference in elevation between the water level and the top of the wall would be so determined that heavy seas rolling in would be broken by the breakwater, and as a result we would have only small waves in the zone between the breakwater and the shore and consequently no source of trouble from erosion. This plan has been advocated lately by Mr. Henry C. Ripley (Member Am. Soc. C. E.) in an article entitled "Beach Erosion, Its Causes and Cure," in Vol. L No. 1 of the Proceedings of the American Society of Civil Engineers. This paper was discussed by a number of engineers including members of the staff of this Board in Vol. L No. 4 of the Proceedings of the American Society of Civil Engineers. (Transactions Am. Soc. C. E., Vol. LXXXVII, P. 589.)

The article is interesting and undoubtedly there are localities where conditions are suitable for the construction of such works which would certainly eliminate the smashing blow of storm waves which would be tripped before reaching the shore line. But along the Northern New Jersey beaches, at any rate, the depths of water are sufficiently great at the necessary distance offshore to require enormous volumes of rock for the construction of such a wall. The real difficulty in coast protection on sandy coasts is likely to be financial rather than technical. The problem confronting the engineer is to protect the coast at a relatively low cost and there are many cases where this is impossible. For example, when the slope of the shore is such that heavy seas beat against improved property which must be preserved, there is no occasion for wasting time and money in designing or constructing cheap means of protecting the shore front. Under these circumstances, the type of structure required must be adequate to resist the encroachment of the sea. This means massive structures of great strength which cannot by any possibility be constructed cheaply.

At the inlets the chief forces which operate to mould the shores of the inlet points are believed to be the currents which are generated by the difference in elevation between the waters of the bays and those of the ocean. However, the flood tide waves and the flood current are both tremendously effective. That is, inlet points which are the areas in which by far the greatest changes occur within a given period of time, owe these changes to the rapid currents, whether flood or ebb, generated as the result of the change in water levels. Wave action does not operate with any greater force upon these inlet points than it does upon the exposed beaches remote from inlets. It is the current of high velocity which has the greatest effect. Therefore, to arrest erosion on an inlet point it is necessary to deflect these currents by jetties or other structures. One method which should be carefully considered is that of building out the inlet point by means of one or more jetties or bulkheads on radial or axial lines. By doing this we lengthen the distance between the water in the bay and the water on the ocean front, and correspondingly reduce the velocity of the water flowing between the two points with a given difference of elevation. This is analogous to the practice of engineers in construction of dams where sheet piling is driven into the ground to preclude rapid percolation of the water from behind the dam.

The flood tide is particularly effective in causing changes of the shore line at the inlets as with the shallow waters of our beaches a heavy onshore wind causes rapid piling up of the water adjacent to the beach. This results in greatly increased current flow through the inlet during the periods when there is relatively important difference in level between the ocean and the bay waters. Of course under some conditions the flow of the ebb tide is very effective but undoubtedly the flood tide is by far the more important.

It has been deemed unnecessary to include in the following summary, detailed descriptions and plans of old structures that have been built by private property owners to protect their holdings. A very comprehensive set of drawings of these various types of structures was annexed to the 1922 Report and need not here be repeated. As we have indicated

above, owners of ocean-front property in New Jersey have employed almost every type of means of protection structure that ingenuity could suggest. Some have been successful; others, successful for a time, were not designed with regard to any comprehensive plan, and with changes of conditions in the adjacent property, failed. Other works, correctly designed for conditions existing at the time, failed eventually through lack of maintenance.

The following describes the ocean-front municipalities successively, proceeding southward along the coast from the borough of Sea Bright, the most northerly municipality. The statistics of population refer to the last census of 1920, and the figures of taxable property refer to the year 1924.

Sea Bright Borough

Population, 856.
Net valuation taxable, $1,641,893.00.

This borough is situated on a very narrow offshore bar, with the Shrewsbury River lagoon on the west, and has a frontage of approximately four miles on the ocean. The attacks it has received from the sea have been more severe than on any other section of the State. It lies just south of Sandy Hook Reservation, and is exposed to northeast storms and to the wind, and to the tide waves and currents flowing toward Lower New York Bay. It is of low elevation, which with the other natural features described, combined to render its existence very precarious until adequate protection was provided by the Central Railroad Company of New Jersey and by the municipality. It is fortunate for Sea Bright that the railroad company has taken and maintained energetic measures to protect its line by constructing along the ocean front a heavy riprap wall which is supported by low groynes which extend out approximately normal to the line of the wall. In the winter of 1913-1914 three severe storms in close succession wrought havoc with a greater part of the ocean-front property of Sea Bright. A number of houses were undermined and other property damage was very severe.

On the bay side of Sandy Hook, to the south of this spit, the changes are not rapid. Sandy Hook Peninsula was formerly an island—it is so shown on the old map by J. F. W. Des Barres of 1779, and the map of Lieutenant John Hills dated 1782; the inlet at the southerly end of the island being that referred to by the novelist, J. Fenimore Cooper in his work "The Water Witch." This opening was in the vicinity of what is now Island Beach. This latter inlet has been closed for many years, the beach, however, has been breached a number of times. In 1835-1836 Sandy Hook was connected to the mainland by a narrow strip of land which extended due north from the pronounced angle in the shore line, between Water Witch and Highlands. This strip formed the westerly boundary of an inlet the east point of which terminated, in 1836, just north of the present Highlands bridge at Highland Beach. This breach was closed at, or prior to, 1850. The beach in the vicinity of Highland Beach and south has been opened on various occasions. The Railroad Company, in 1856, closed the breaches opposite the Navesink and Shrewsbury Rivers.

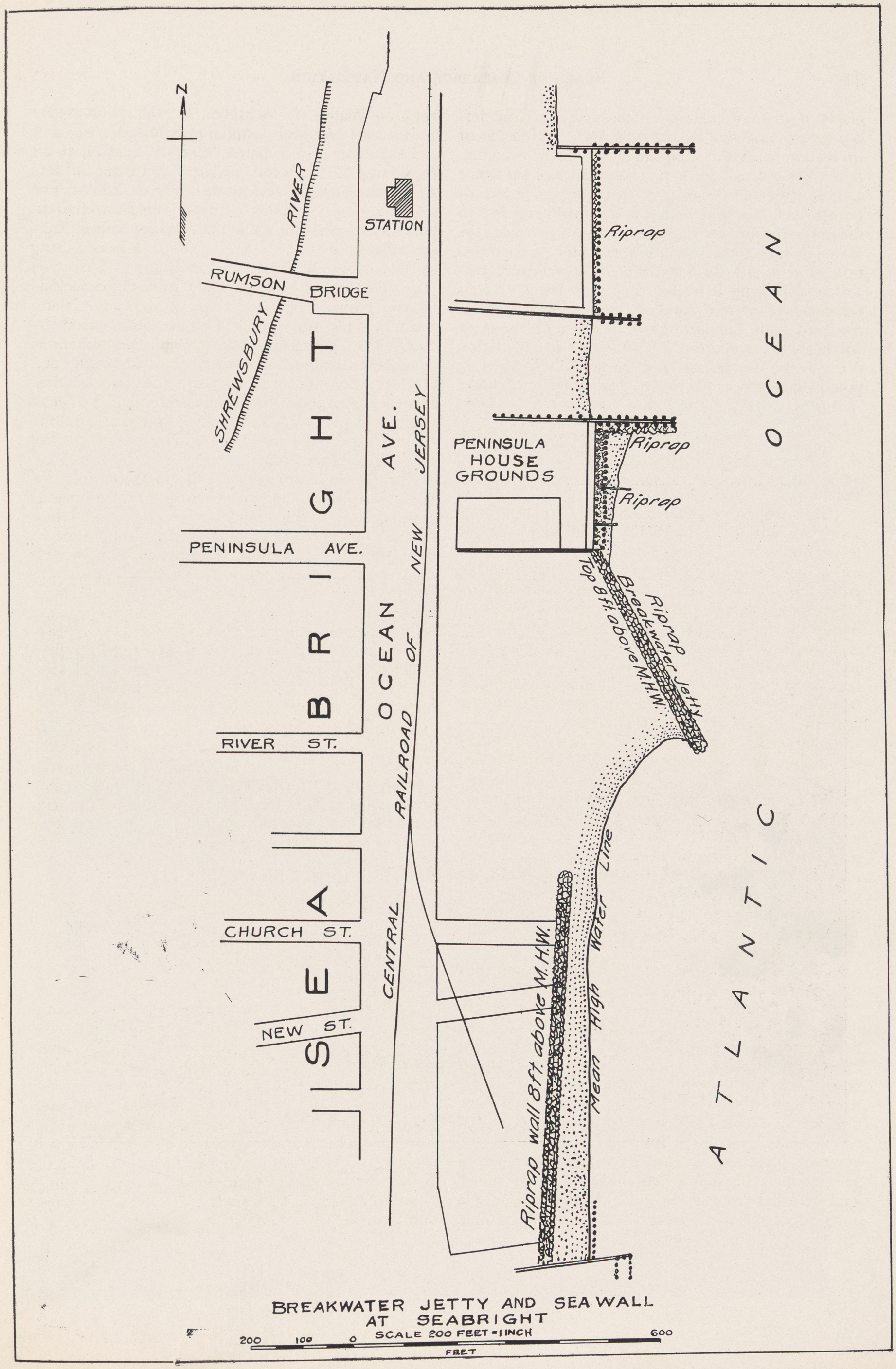
In 1896-1897 the beach broke through the neck of Sandy Hook Peninsula, nearly opposite Island Beach. This was closed by the Government by 1900-1901; the closing was effected by the deposit of stone along the Government railroad trestle, and the placing of the dredged sand immediately adjacent thereto. These various breachings of the ocean beach resulted in the carrying of the sand into the navigable channel of the Shrewsbury River to the great detriment thereof.

The attack continuing, the Borough on July 10, 1921, began work on a large breakwater jetty beginning at the Peninsula Hotel property and extending oceanward on an acute angle with the shoreline to the south. The jetty was completed October 1, 1921. This is supported by a heavy riprap wall further south which runs approximately along or parallel with the old high water mark as this existed at the time of beginning construction. This breakwater jetty and the wall to the south form in effect a sand trap which has been very successful. In December, 1924, a sand beach well above high water mark extends out almost to the outshore end of the large breakwater jetty. In addition to protecting the Borough, this construction has built up a beach sheltered from easterly storms on which a large colony of fishermen are enabled to land their boats, in addition to meeting a real need as a bathing beach. The contractor was Jesse A. Howland of Seabright.

Monmouth Beach Borough

Population, 410.
Net valuation taxable, $1,577,904.
Ocean front, 1½ miles in length.

This is the next municipality proceeding southward. It has a high degree of exposure and has also suffered greatly although since the beach is much wider than at Sea Bright it has not been threatened with breaching. But here, as in other ocean-front municipalities, the residents built up and improved their waterfront to the farthest possible limit, and as a result great losses occurred during the severe storms of 1913-1914. The exposed position of the Ocean Boulevard has required the county's maintenance of heavy riprap sea walls over extensive frontage to protect the roadway.


N
RIVER
STATION
RUMSON
BRIDGE
SHREWSBURY
B R I G H T S E A
PENINSULA AVE.
RIVER ST.
CHURCH ST.
NEW ST.
OCEAN AVE.
NEW JERSEY
RAILROAD
CENTRAL
PENINSULA HOUSE GROUNDS
Riprap
Riprap
Riprap
Riprap Breakwater Jetty Top 8 ft. above M.H.W.
Line
Mean High Water
Riprap wall 8 ft. above M.H.W.
A T L A N T I C O C E A N
BREAKWATER JETTY AND SEA WALL
AT SEABRIGHT
200 100 0 SCALE 200 FEET = 1 INCH 600
FEET

Here, as in other places, the individual owners expended vast sums in the aggregate to protect their individual properties, only too frequently with limited success or ultimate failure. In 1924 the State Legislature voted to Monmouth Beach a grant of twenty-five thousand dollars to aid in providing protection pursuant to Chapter 318 of the Laws of 1920. The board and the borough authorities promptly agreed on plans for a heavy rock breakwater jetty with a timber core, and this was constructed during the spring and summer of 1924 at a total cost of $124,593.06; the unit costs being as follows:

Cost of Stone

16,944.01 tons of stone at $6.25,	$105,900.06
1,645.00 tons of stone at 3.40,	5,593.00
Total cost of stone,	$111,493.06

Cost of Timber Work

300 feet at $17.00,	$5,100.00
400 feet at 20.00,	8,000.00
Total cost of timber,	$13,100.00

The contract was awarded to Jesse A. Howland, of Sea Bright, in February, 1924, and completed in August, 1924.

The work to date (December 1, 1924) has been very successful as indicated by the photographs shown here and plate 1 in the appendix.

Photograph No. 1 taken February 3, 1924, at the beginning of the work, at the site of the inshore end of the present breakwater. The dark areas just to the right of the row of old piling show the exposed marl substratum, the sand having been entirely denuded.

Photograph No. 2 shows conditions of December 13, 1924, with a high sand bar near the outer end of the breakwater.

Photograph No. 3 was taken from the outer corner of the old bulkhead to the south, part of which appears in the lower left-hand corner of the picture. Note that the backwash from this old bulkhead has eroded even the black marl substratum. The riprap wall in the background is immediately adjacent to the County Boulevard, which it is designed to protect. There was practically no sand beach above high water mark outshore of this County Boulevard, which was seriously attacked during bad storms.

No. 1



Photograph No. 4 shows the exposure south of the breakwater jetty before the sand piled up.

Photograph No. 5 taken December 13, 1924, shows the high sand beach south of the breakwater

No. 2



No. 3



No. 4



No. 5



jetty, reaching almost to the top of the piling shown in No. 4. The house shown in the upper right-hand corner of No. 4 is identical with the house in the upper left-hand corner of Plate No. 5.

Photograph No. 6 taken early in the work, looks southward from the breakwater jetty. It is an excellent illustration of the various means that have been resorted to in the past to protect highly exposed sections of the North Jersey coast. Note the rock fill inside the outer rows of piling and the watertight decking over the cribs inshore.

No. 6



City of Long Branch

Population, 13,521.
Net valuation taxable, $17,619,375.
Ocean frontage nearly five miles.

The shore line has receded greatly, and apparently the process has been continuous since early times. In 1868 the State Geologist of New Jersey, Professor George H. Cook, reported that the wear at Long Branch was very serious. He says that the spot where the first boarding house was located thirty years before, *i. e.*, 1838, together with the road which ran behind it were at the time of writing all worn away, with a new shore line to the west of it.

North Long Branch marks the northerly point of the headland formation which extends southward to Bay Head, and as we have already pointed out, the theory has been advanced that the material forming the barrier beaches to the north and south originated in this headland, which, if this be correct, must have extended very much farther oceanward than at present. From Sea View Avenue northward to the boundary line of Monmouth Beach is a cove which owes its present form to serious erosion extending over at least 30 years. The shore line at Troutman Avenue in 1886 was about 175 feet easterly or oceanward from the easterly line of Ocean Avenue, whereas the high water line of 1917 at Troutman Avenue is approximately 270 feet inshore of or westward of the easterly line of Ocean Avenue, showing a net loss in 38 years of 445 feet. This of course necessitated a relocation of Ocean Avenue.

The State in 1922 appropriated a grant of $25,000 to aid Long Branch in providing coast protection works. The municipality desired to expend this money at Sea View Avenue and south thereof, that is, entirely south of the above-mentioned cove, but the Board declined to approve these plans and insisted that the protection works should be constructed at the northerly end of the city, that is, to leeward, with a view to building up the beach in the cove, gradually working from leeward to windward.

The Board further favored the construction of heavy rock jetties with a timber core, but the city desired to build works along the lines of what may be termed the standard Long Branch jetty, that is, two rows of piling with sheeting on one or both sides, the space between to be filled with rock. (Plate 2.) In 1923 the Board finally agreed to this plan and a contract was awarded by the city on October 30, 1923, with the approval of the Board, to Messrs. Woolley and Howland, of Long Branch, for the reconstruction of two jetties on the plan just described, to be located just south of Atlantic Avenue as shown on the plan. Work is still in progress (December, 1924), the construction work having suffered in the October storms. This is a difficult situation which calls for adequate structures. The vertical concrete sea wall throws back the high storm seas (backwash), a condition which almost always results in forming a gully or "low" immediately in front of the sea wall. Too frequently these gullies form channels through which the water flows at high velocity with consequent danger of undermining any adjacent works.

The cost of the work is as follows:

LONG BRANCH—JETTIES "A" AND "B"

Jetty "A"

Cost of Stone—	
2,687.69 tons at $6.00,	$16,126.14
Cost of Timber—	
400 lineal feet at $58.00,	23,200.00
134 piling at $25.00,	3,350.00
Cost of Jetty "A" to Dec. 9, 1924,	$42,676.14

Jetty "B"

Cost of Stone—	
2,222.66 tons at $6.00,	$13,333.96
Cost of Timber—	
300 lineal feet at $43.00,	12,900.00
49 piling at $25.00,	1,225.00
Total cost of Jetty "B,"	$27,458.96

The city early in 1923 completed the construction of a number of jetties on the standard Long Branch plan extending southward from Sea View Avenue. These jetties are in fact on the sites of old jetties constructed some fifteen or thirty years ago. Each jetty extends oceanward approximately at right angles to the beach, and then deflects to the south (windward) approximately 35 degrees. These jetties have in general been effective in holding the beach as it existed when they were constructed, although there is considerable fluctuation of the beach lines.

Deal Borough

Population, 420.
Net valuation taxable, $7,030,246.00.
Ocean front, 1½ miles.

The public property has not suffered in this municipality, but in general the shore owners have found it necessary to maintain bulkheads and other structures to protect their holdings. Recession has been considerable since 1839, though of course not excessive since property owners have undertaken protection measures. Nevertheless, the tendency has been unfavorable and the State in 1924 appropriated a grant of $8,000.00 under Chapter 318 of the Laws of 1920 to aid this Borough in constructing protection devices. The contract was awarded to Thomas Procter, of Long Branch, with the approval of the Board for the construction of two timber jetties or groynes at the Casino. These extend oceanward at right angles to the beach for a distance of 225 feet measured from the concrete retaining wall. The cost of the work is itemized as follows:

JETTY "A"

4,600 ft. B. M. stringers, at $119.50,	$549.70
141 piling at $20.50,	2,890.50
21,600 ft. B. M. sheathing at $113.00,	2,420.80
743 bolts, washers, &c., at $1.50,	1,114.50
Removal of old jetty,	800.00
144 ft. new C. I. pipe at $11.00,	1,584.00
81 ft. pipe relaid at $1.50,	121.50
Total cost of Jetty "A,"	$9,481.00

JETTY "B"

21,600 ft B. M. sheathing at $113.00,	$2,420.80
4,600 ft. B. M. stringers at $119.50,	549.70
95 piling, at $20.50,	1,947.50
283 bolts, washers, &c., at $1.50,	424.50
Total Cost of Jetty "B,"	$5,342.50

The charge for the cast-iron pipe was not considered by the Board to be part of the coast protection devices, hence no contribution was made toward these two items of $1,584.00 and $121.50 respectively.

The Board on November 25, 1924, paid the Borough $6,559.00 representing 50% of the cost of the work strictly designed for coast protection measures.

Allenhurst Borough

Population, 343.
Net valuation taxable, $3,431,285.00.
Ocean frontage, approximately ½ mile.

The tendency here has been unfavorable, a comparison of later maps with the first survey of 1839 showing considerable erosion. With a view to establishing definitely the operation of the large breakwater jetty southward from the southerly boundary of Deal Borough, surveys have been run over this ocean front repeatedly with particular attention to cross sections of the beach. During the construction of the large breakwater by Asbury Park City, considerable erosion took place immediately north of the jetty, that is in Allenhurst and Loch Arbour, and to combat this condition quantities of rock were deposited in front of the bulkhead adjacent to the breakwater jetty. The result of the surveys is indicated in the plan in the appendix.

City of Asbury Park

Population, 12,400.
Net valuation taxable, $18,560,313.00.

Although considerable erosion is indicated by the maps of 1839, erosion has not been severe for at least twenty-five years along this frontage, which has an extent of somewhat less than a mile. Prior to the construction of the large breakwater jetty which extends southeastward from the boundary between Asbury Park and Loch Arbour (Neptune Township), reliance had been placed chiefly on timber jetties, the last system having been constructed in 1907 or early in 1908. Mr. Charles H. Higgins, in an article which appeared in the Engineering News, calls attention to the fact that in the severe storms of December, 1913, and January, 1914, Asbury Park suffered very little damage and in fact these low groynes had between 1908 and 1914 operated to build up the beach in a very satisfactory manner. Mr. Higgins' article is quoted at page 60 of this Board's 1922 Report and need not here be repeated.

The 1922 Legislature voted an appropriation of $25,000.00 under Chapter 318 of the Laws of 1920 to aid Asbury Park in protecting its beach. The City on 6th September, 1922, entered into a contract with Jesse A. Howland, of Sea Bright, which was approved by the Board of Commerce and Navigation, for the construction of the large breakwater jetty already referred to. An unusual feature of the agreement is that the payment of a large proportion of the entire contract price of $100,000.00 was conditioned upon the building up of the beach immediately south of the jetty to a height of eighteen inches above mean high water mark. Payments were to be made for each section of 100 lineal feet as follows:

First	Section, 100 lineal feet, ...	$9,000.00
Second	Section, 100 lineal feet, ...	10,000.00
Third	Section, 100 lineal feet, ...	11,000.00
Fourth	Section, 100 lineal feet, ...	12,000.00
Fifth	Section, 100 lineal feet, ...	13,000.00
Sixth	Section, 100 lineal feet, ...	14,000.00
Seventh	Section, 100 lineal feet, ...	15,000.00
Eighth	Section, 100 lineal feet, ...	16,000.00
	Total aggregate bid, ...	$100,000.00

or quoting from the contract, "As each one hundred feet (100 lineal feet) of jetty is completed by the Contractor, sixty (60) per cent of the total amount bid for said section will be paid to the Contractor, the remaining forty (40) per cent of said total amount for said section will be retained by the Board of Commissioners, until the beach immediately south of and adjacent to the jetty is built up with sand eighteen (18) inches above mean high water mark of the Atlantic Ocean. As the beach shall attain this level at each succeeding section of one hundred (100) lineal feet of completed jetty, the forty (40) per cent. thus retained, shall become due and payable to the Contractor; except, however, that the last section, that is, the eigth section of one hundred lineal feet, is to be paid for in full amount bid, when the same is completed."

The specifications call for employing
25% small stone
25%-½ to 2½ tons
25%-2½ to 5 tons
25%-5 to 7 tons

The plans in the appendix (Plate 3) indicate the type of construction much more satisfactorily than can any written description.

This structure has suffered severely since its completion, and in fact serious difficulties were encountered during the work in the storm of late December, 1922. An inspection, on December 28, 1922, revealed a blowout about fifty feet in width between approximately stations 1 plus zero and 1 plus 50. It was observed also that the jetty had been badly battered especially on the north side from about the end of the third section, and a breach was made at about the end of the fourth section. In addition, the top of the stone work within the fourth and fifth sections had been beaten down or displaced.

This damage was repaired by the contractor at his own expense. The Board approved payment of the State's contribution in amounts and dates as follows:

May 9, 1923	$12,500.00
Sept. 26, 1923	12,500.00

This jetty may be considered as a work of magnitude extending, as it did, a long distance seaward. It was built on a sand bottom with no possibility of reaching a hard bottom, or a better bottom which might perhaps retain the rock after the upper sand had been scoured away by the current incited at the end of deposit of rock as it progressed outshore.

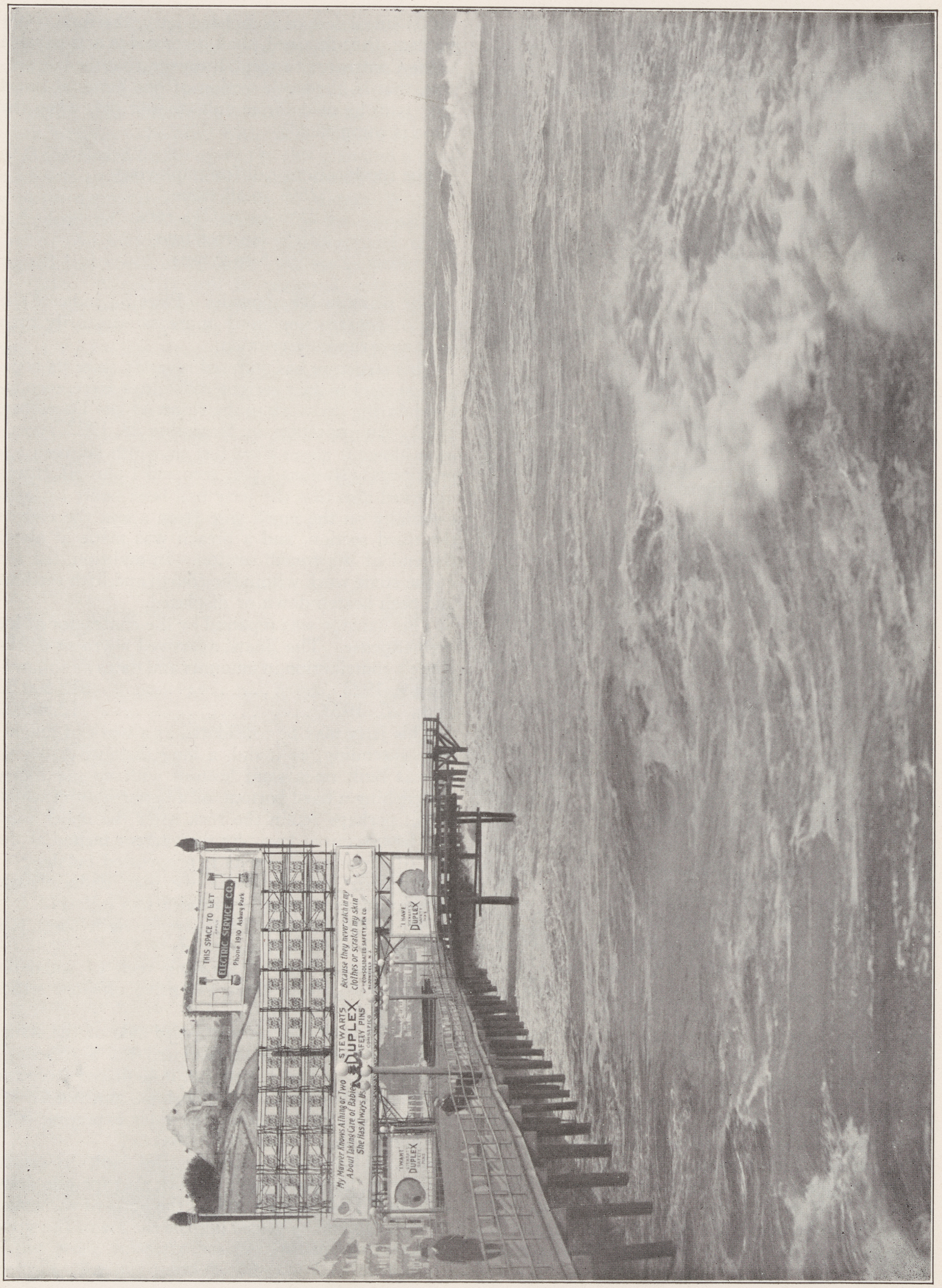
From its partial failure we may deduce some standard construction requirements as follows:

1st. The necessity of having a tight sheet pile core in the body of the structure.

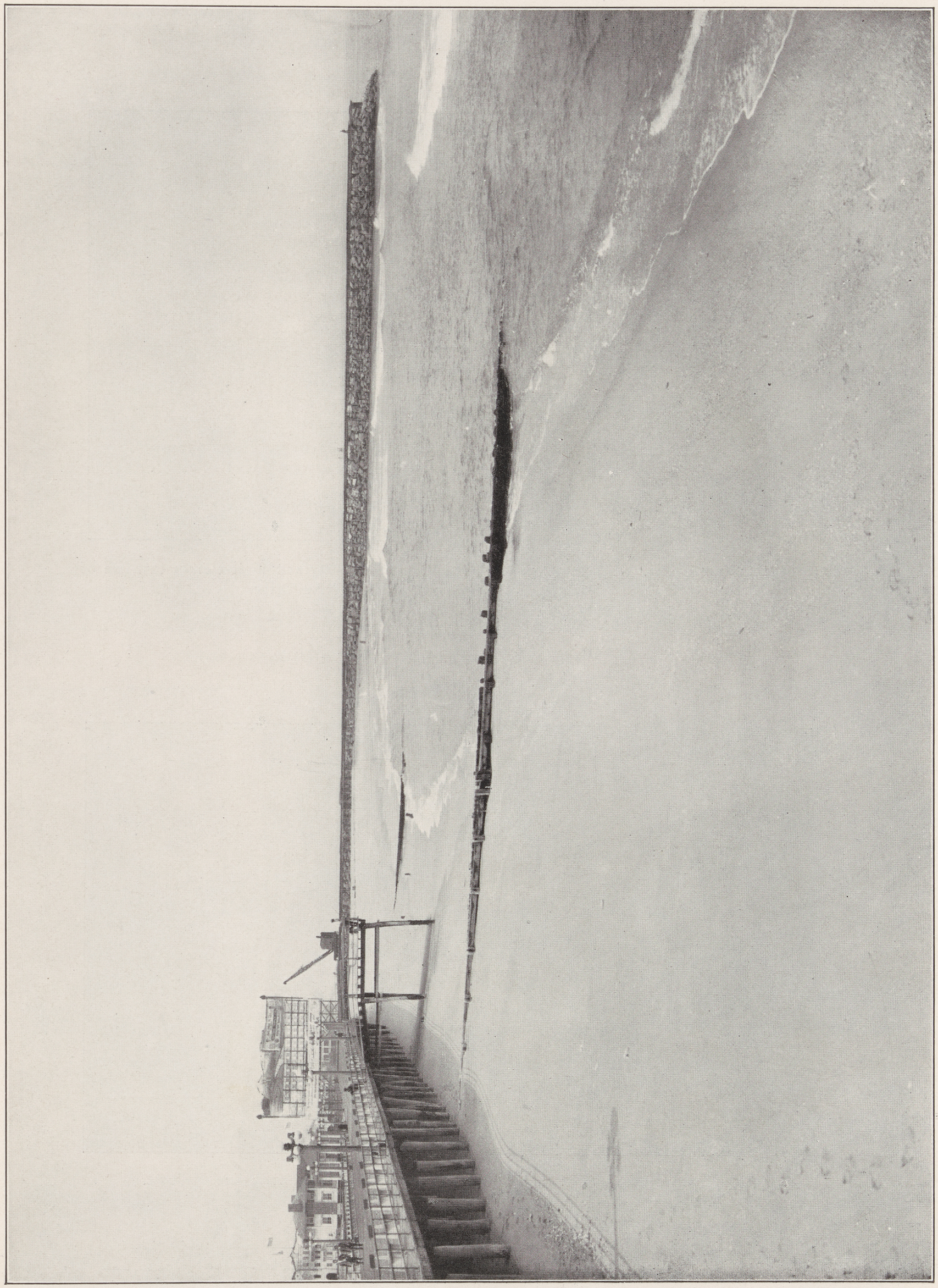
2d. The futility of allowing rock of small dimension to go into these extensive offshore structures.

3d. That on the most exposed side of the structure, the rock should be designed for a full slope approximating 1 to 1, and that it be placed from the outside toe building upon this slope, and not be deposited so as to fall down the sides expecting it to assume a slope.

4th. That construction trestles built to create driveways for the deposit of rock and for pile driving, should not be built within the body of the structure, but should be placed outside the toe of the slope of rock deposit.



Before starting the Asbury Park Jetty.



Asbury Park Jetty nearing completion.



Saturday, October 27, 1923, 2:15 P. M. From 300 feet south of jetty and 45 feet from east line of Boardwalk at water's edge, foot of Deal Lake Drive.



Sunday, October 28, 1923, 8:15 A. M. Taken off wooden jetty north line of flume.



Outer section Asbury Park Breakwater Jetty, January 8, 1925, looking north.



Middle portion Asbury Park Jetty, January 8, 1925. Looking north.



Asbury Park Jetty, outer end, January 8, 1925. Looking oceanward.



Asbury Park Jetty, north side, looking oceanward from inshore end, January 8, 1925.



Asbury Park Jetty, January 8, 1925, typical breach.



Asbury Park Jetty, January 8, 1925, breach near outer end of the remaining work.

Neptune Township (Ocean Grove)

Population, 6,470.
Net valuation taxable, $10,474,453.00.

Ocean Grove's shore front is somewhat less than a mile in extent. It is described in the 1918 industrial directory of New Jersey as having a permanent population of 2,754. It is not a borough but is part of Neptune Township.

Quoting the industrial directory further, it was —"Founded many years ago under religious auspices as a camp meeting grounds, its subsequent development into a first class Summer resort has been marked by a remarkably close adherence to the underlying purpose of its original plan of government."

The preservation of its beach has never been precarious so far as is known, but naturally some form of protection has been required, which, however, does not at this time seem to call for extended treatment.

Bradley Beach Borough

Population, 2,307.
Net valuation taxable, $4,271,720.00.

There are no new developments since the 1922 Report that requires detailed treatment of the shore of this borough. There has been considerable recession since 1839 and the tendency, though not rapid, has continued since the riparian surveys of 1883 and 1893. It has a shore front of approximately three quarters of a mile in length.

Avon Borough

Population, 647.
Net valuation taxable, $2,333,650.00.

In January, 1924, the sea broke through the north jetty. Avon is on the northerly side of Shark River and Shark Inlet on the opposite side of which is Belmar. The tidal portion of Shark River is really a large shallow bay with an inlet gorge and is in no sense a true river. It is of some importance to the navigation interests, being used by a large number of fishing boats.

The position, and indeed the existence of this inlet were very uncertain as we have described in the 1922 Report, until it was fixed in position by the reinforced concrete jetty or training wall which was constructed on the north side under the direction of the State Geologist of New Jersey pursuant to Chapter 305 of the Iaws of 1911, entitled "An Act making an appropriation for the survey of the mouth of Shark River and for the further purpose of securing plans for and estimates of the cost of making a permanent inlet or mouth to the said river." Various means had been previously applied with a view to fixing this inlet in position and incidentally to obtain a better channel. The first of these aims was attained, that is, the concrete jetty on the north side fixed the position of the inlet, but navigation thereof remained rather precarious owing to the formation of a bar on the south side of the inlet and opposite the outshore end of this jetty, so that even the fishing dories were frequently obliged to wait for high tide before attempting to cross the bar. This condition has been greatly improved by the construction of a large breakwater jetty on the southerly (Belmar) side of the inlet during the current year (1924) which we shall describe more fully in treating of Belmar Borough and its problems.

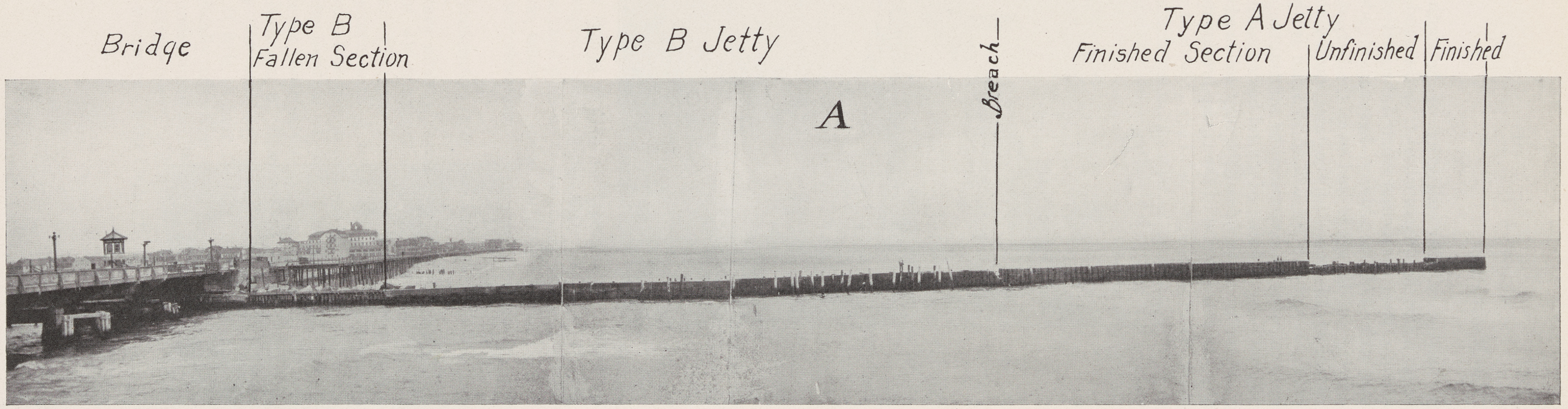
For the basis of the design of this concrete training wall or jetty on the north side of the inlet, the reader is referred to Bulletin 8 published by the State Geologist of New Jersey for the year 1912. Briefly, it was predicated on the principle that the northerly movement of sand must be provided for and taken care of by allowing it to be carried into the inlet on the flood tide; and further provided that it shall be carried outward on the ebb tide past the end of the jetty. The report states that the prime purpose and object is to confine the inlet to a fixed position and expresses the hope that it will be effective to prevent transportation of large quantities of sand into the inlet during northeasterly storms.

The report offers the following reasons for the omission of a south jetty through the beach: that it is practically impossible to hold the northward moving sand on the beach by means of a south jetty; that it is a practical impossibility to fix accurately the most suitable location of a south jetty from the north jetty.

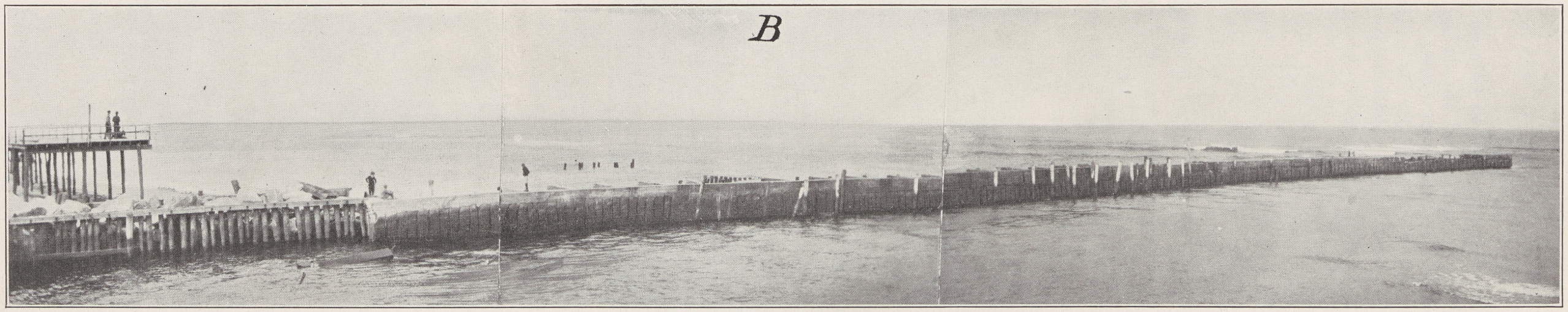
This north jetty was severely damaged as a result of a storm in the middle of January, 1924, a large section near the inshore end toppling outward into the channel, and endangering the new Ocean Boulevard bridge constructed by Monmouth County. Engineers of the Board on January 23, 1924, made an inspection and reported to Governor Silzer that unless conditions were remedied promptly there was serious danger that a northeast storm would destroy other portions of the jetty and imperil the bridge. The county officials immediately constructed a pile and rock crib to close this breach, and the engineers of the Board on January 28th reported to Governor Silzer recommending measures to be taken and estimating the cost of this repair work. The Legislature appropriated the sum estimated, $55,000.00, which became available July 1, 1924. The work was advertised and the following three bids were received:

A.	Thomas Proctor, Long Branch, N. J., ...	$44,130.00
B.	Jesse A. Howland, Sea Bright, N. J., ...	49,522.00
C.	Thomas J. Scully, Newark, N. J., ...	138,915.00

NORTH JETTY, SHARK RIVER INLET.



General View of Jetty looking northeast from Belmar Jetty.

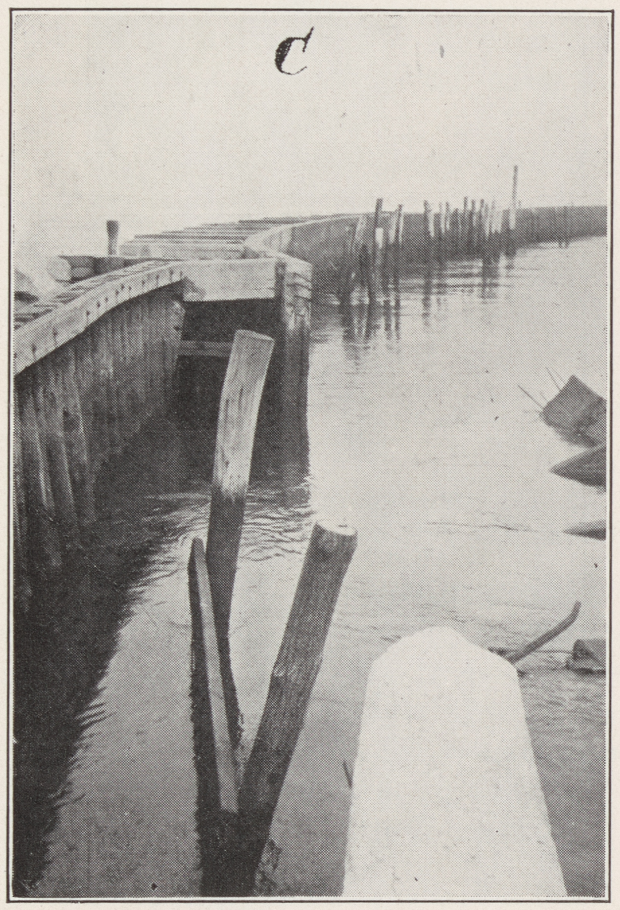


General view of Jetty looking northeast from the Bridge.

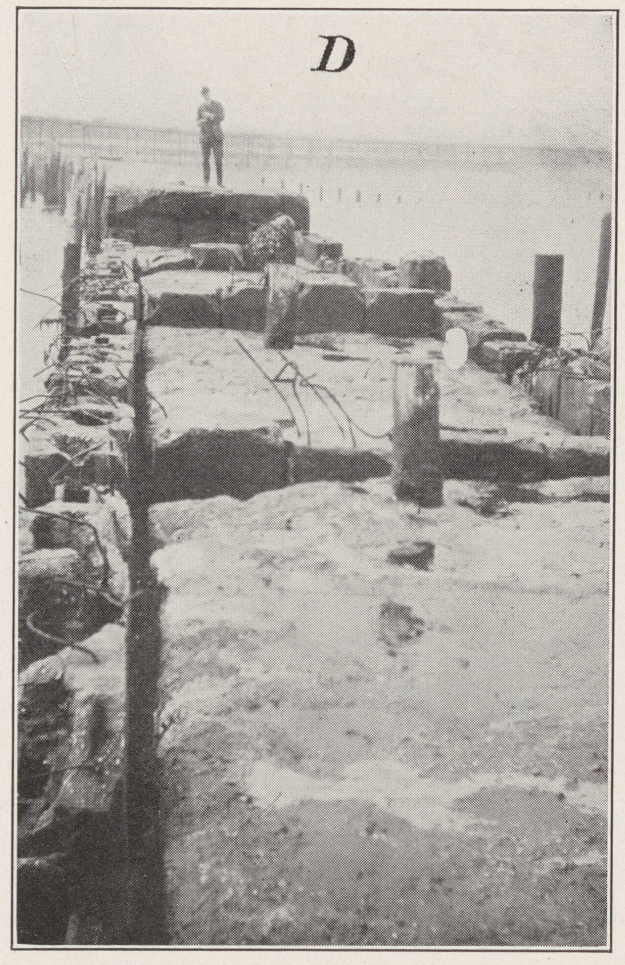
The contract was awarded to Thomas Proctor, the lowest bidder, the agreement stipulating the use of creosoted timber throughout. (Plate 4.)

In addition to the breach near the bridge, a smaller breach had existed for a considerable period well out along the jetty and a large section of the outer concrete mass construction had never been completed, although apparently contemplated in the original design pursuant to the Act of 1911.

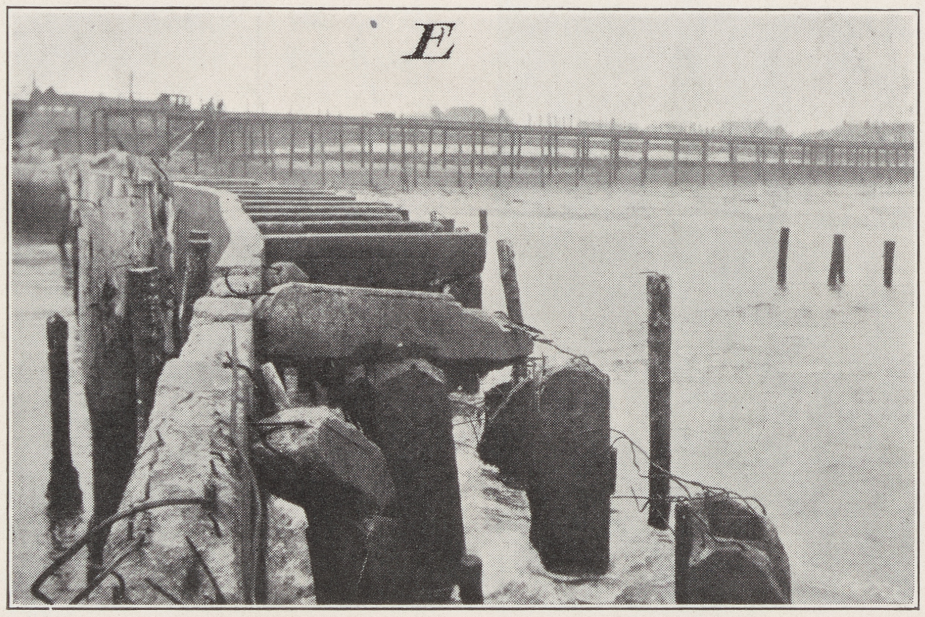
The work at present (December, 1924) is well advanced toward completion, but it has become almost certain that quantities of rock in excess of that originally contemplated will be required. This is due in part to the construction of the south breakwater which has operated to trap the sand, which prior to this construction entered the inlet on every flood tide and in addition has caused additional scouring in the gorge and over the bar, which is crossed at all stages of the tide now by the local boats. Whether a bar will form again further outshore can only be determined by the future. At any rate, the disappearance of a sand bar of considerable extent on the south side of the inlet followed quickly upon the construction of the riprap breakwater jetty on the south point.



Looking oceanward from bridge along fallen section Type B.



Type A Jetty, unfinished 73′ section. Looking landward.



Looking landward along Type B Jetty.

Only the future can reveal whether extensive dredging operations now contemplated in the upper or westerly part of the lagoon will have any appreciable effect upon the volume of water that will pass through the inlet on each tide. This is a complicated question because the congested condition of the gorge between the railroad bridge and the inlet unquestionably has a pronounced tendency to check the free flow of the tidal waters. The improvement of the gorge, that is, the inlet and the river approach thereto, will, if continued, have a tendency to modify the tidal range in the wide shoal lagoon which lies to the west of the railroad bridge. This probable change in the tidal regime will require consideration if the Inland Waterway system is continued northward to Shark Inlet.

Belmar Borough

Population, 1,987.
Net valuation taxable, $5,403,894.00.

Erosion of the beach is causing Belmar considerable losses each year, which are caused chiefly by the undermining of the gravel surfaced shoulders of the roadway. Occasionally slabs of the concrete roadway are undermined also. The bulkhead on the outer edge of the roadway was designed with a view to immediate economy rather than efficiency and permanency and has required constant maintenance. Timber and sheet pile groynes or jetties, with the aforesaid bulkhead, have formed the means of defense at Belmar until the current year when, as additional protection, the large breakwater jetty already referred to was built on the south side of Shark Inlet. Some of these timber jetties are relatively high and have been subject at times to serious strain by reason of great difference in the sand level on the respective sides of the groynes. That is, generally the sand piles up to the top of the jetty on the south side, whereas on the north side it is at a very much lower elevation.

Rock Breakwater Jetty, South Side Shark River

We have already referred to this structure, the details of which appear clearly in the plans in the appendix. (Plate 4.) It is essentially a heavy riprap structure with a tight timber core, and has proved very effective to date, as can be seen by comparing the location of the shore lines both before and since its construction.

The Borough of Belmar is confronted by the necessity for building additional coast protection devices, if it is to save the heavy expense involved in continually repairing the present light bulkhead and the undermined sections of roadway. Apparently no private property is involved, all dwellings being situated westward of the Ocean Boulevard.

Spring Lake Borough

Population, 1,009.
Net valuation taxable, $4,586,219.00.
Approximately 2½ miles frontage.

The Borough constructed, and has for years maintained a series of timber jetties or groynes somewhat similar to those at Belmar immediately to the north. The Ocean Boulevard roadway is situated a considerable distance westward of the high water mark, and no serious damage has occurred in Spring Lake so far as we know. In fact, except at the northerly end of the borough the shore has prograded rather than receded since 1839.

The Legislature in 1920 appropriated a grant of $20,000.00 to aid Spring Lake in coast protection devices.

The Board of Commerce and Navigation and the Borough agreed on the construction of timber jetties or groynes, and a bulkhead at the southerly end of the borough. This work is not yet complete, but the plan is shown in the appendix.

The Borough on July 21, 1924, entered into contract with Wooley and Howland, of Long Branch.

The southerly boundary of Spring Lake is Wreck Pond Inlet which is frequently closed at all stages of the tide for considerable periods of time. It is utterly useless from the standpoint of navigation and the Board a few years since entertained favorably a proposition from this Borough to build a sluice or flume at the highway bridge for the purpose of maintaining a fixed low water level in the lagoon to the west of the highway bridge.

Sea Girt Borough

Population, 110.
Net valuation taxable, $1,275,068.
Frontage, approximately 1½ miles.

This is the site of the State Military Encampment. It is understood that plans for jetties in front of the State property are in preparation, but these have not as yet been presented to this Board. The maps indicate that considerable erosion has occurred since 1839, but comparatively little change is indicated for a considerable number of years prior to 1920.

Manasquan Borough

Population, 1,705.
Net valuation taxable, $1,930,920.00.
Frontage, approximately 1 mile.

Manasquan is on the northerly side of Manasquan River and Inlet, which is the boundary between Monmouth County and Ocean County. We have dealt very fully with Manasquan Inlet in the 1922 report,

STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
SURVEY OF
MANASQUAN INLET
NOVEMBER 17, 1922

Victor Gelineau
DIRECTOR

Robert Simon
Asst. Engineer

Joseph P. Chapman
Surveyor

MANASQUAN RIVER

MANASQUAN

POINT PLEASANT BEACH

OCEAN AVENUE

OCEAN AVENUE

BULKHEAD

TIMBER

HAUPT JETTY

October 12, 1922. High Water Line

October 12, 1922 High Water Line

SCALE 1" = 200'
0 100 200 300 400 500

+1.5
-0.5
-0.1
C
+1.8
-0.7
-1.6
3.1
-2.3
-2.3
-2.3
-2.3
C
-0.3
-1.8
-0.3 -1.9
-1.8
-0.4
C

ATLANTIC OCEAN

M.H.W.
M.S.L.
M.L.W.

POINT PLEASANT BEACH

MANASQUAN

Profile along Crest of Bar - C - C - C - C

HORIZONTAL SCALE
0 100 200 300 400 500
VERTICAL SCALE
0 10 20 30 40 50

NOTE:-
DEPTHS SHOWN REFER TO ELEVATION 1.9 FEET
BELOW SANDY HOOK MEAN SEA LEVEL DATUM

STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
SURVEY OF

MANASQUAN INLET

DECEMBER 14, 1922

Victor Gelineau
DIRECTOR

Robert Simon
Asst. Engineer

Joseph P Chapman
Syrveyor.

MANASQUAN RIVER

MANASQUAN

BULKHEAD

TIMBER

OCEAN AVENUE

OCEAN AVENUE

POINT PLEASANT BEACH

High Water Line October 12, 1922

High Water Line October 12, 1922

HAUPT

SCALE 1" = 200'

0 100 200 300 400 500

-0.2

B

+1.6

B

-1.0

1.4.4

-0.3

-0.3

1.8 -2.2 -2.2

B

+0.7

-0.8

B

-0.6

-1.4

-0.9

-1.1

-2.1

-0.7 -2.1 -2.5

-2.0 -1.7 -1.8

-2.0

ATLANTIC OCEAN

HORIZONTAL SCALE

0 100 200 300 400 500

VERTICAL SCALE

0 10 20 30 40 50

M.H.W.

M.S.L.

M.L.W.

POINT PLEASANT BEACH

MANASQUAN

Profile along Crest of Bar - B-B-B-B

NOTE:-
DEPTHS SHOWN REFER TO ELEVATION 1.9 FEET
BELOW SANDY HOOK MEAN SEA LEVEL DATUM

STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
SURVEY OF

MANASQUAN INLET

APRIL 13, 1923

Victor Gelineau
DIRECTOR

Robert Simon
Asst. Engineer

Joseph P Chapman
Surveyor

MANASQUAN RIVER

MANASQUAN

BULKHEAD

TIMBER

OCEAN AVENUE

OCEAN AVENUE

POINT PLEASANT BEACH

SCALE 1" = 200

0 100 200 300 400 500

October 12, 1922 Mean High Water Line

October 12, 1922 Mean Low Water Line

HAUPT JETTY

A

A

A

A

-0.6
-1.3
-1.7
-1.8
-1.3
-2.1
-0.7
-0.3
-1.3
-2.3
-0.5
-1.5
-1.9
-2.3
-0.7
-1.0
-1.6
-1.1

ATLANTIC OCEAN

M.H.W.
M.S.L.
M.L.W.

POINT PLEASANT BEACH

MANASQUAN

Profile along Crest of Bar - A-A-A-A

HORIZONTAL SCALE
0 100 200 300 400 500

VERTICAL SCALE
0 10 20 30 40 50

NOTE -
DEPTHS SHOWN REFER TO ELEVATION 1.9 FEET
BELOW SANDY HOOK MEAN SEA LEVEL DATUM

and there have been no new developments since except increased deterioration of the jetty that was built by Mr. L. M. Haupt on the south or Point Pleasant side, with a view to providing a navigable channel.

To test the claims of interested parties the Board in November and December, 1922, and April, 1923, made a number of hydrographic surveys, the results of which are indicated on the maps annexed hereto.

Point Pleasant Beach Borough

Population, 1,575.
Net valuation taxable, $2,071,123.
Frontage, approximately 2 miles.

It has not been found necessary as yet to construct any coast protection works of any importance. Surveys for many years past show little change along this front, except in the immediate vicinity of Manasquan Inlet, but there was a considerable recession between the survey of 1839 and 1870.

Bay Head Borough

Population, 273.
Net valuation taxable, $1,353,261.
Ocean frontage of more than a mile.

Bay Head (head of Barnegat Bay) marks the northerly limit of the offshore bar or barrier beach which we have already described as extending southward to Cape May. A number of timber groynes have been constructed here and for years past have given good satisfaction. Certain private owners have improved their property very close to the outer limits and have found it necessary to build bulkheads. No damage has occurred, so far as is known, for several years past. Bay Head was the terminus of the original Inland Waterway project, and is the summer home of many boating enthusiasts who find the almost land locked bay and tributary rivers ideal for sailing and all aquatic sports. We have already referred to the chain of ponds and small waterways which indicate the line of a former connection between Barnegat Bay and Manasquan Inlet.

Mantoloking Borough

Population, 37.
Net valuation taxable, $369,835.
Approximately 2½ miles of ocean frontage.

The entire strip of beach between Bay Head and Mantoloking is very rapidly being built up. In the operation, as in other places along our beaches, sand dunes are being levelled and we shall watch with interest the result of the removal of these splendid natural protections against the sea.

Brick Township

Population, 2,084.
Net valuation taxable, $459,091.

By far the greater part of this township is on the mainland. Its beach frontage of approximately one mile and a half in length is not highly developed as yet. The same is true of

Dover Township

Population, 2,198.
Net valuation taxable, $2,713,077.00

with an ocean frontage of approximately one and three-quarter miles. Hence detailed descriptions of these two sections are not required at this time.

Lavallette Borough

Population, 117.
Net valuation taxable, $438,951.00.

This borough has approximately one and one-quarter miles of ocean frontage. It is in this vicinity that the old inlet known as Cranberry Inlet pierced the beach in the 1700's. We are told that one Michael Ortley expended relatively large sums in an unsuccessful endeavor to reopen this ancient inlet.

Seaside Heights Borough

Population, 154.
Net valuation taxable, $753,457.00.
Ocean frontage, approximately three-quarters of a mile.

Seaside Park Borough

Population, 179.
Net valuation taxable, $1,173,020.
Ocean frontage, approximately two miles in length.

The 1922 report describes the protection features in this locality.

The nine-mile strip of beach from Seaside Park to the north point of Barnegat Inlet is wholly undeveloped, having no rail or highway connections. It is located in Berkeley, Lacey and Ocean Townships.

Barnegat City Borough

Population, 69.
Net valuation taxable, $115,292.00.
Ocean frontage of over two miles.

Barnegat City, on the south point of Barnegat Inlet, is the site of Barnegat Lighthouse, for the

preservation of which this Board has made strong pleas to the Department of Commerce. A full description of Barnegat Inlet and its changes was given in the 1922 report and need not here be repeated.

Harvey Cedars Borough

Population, 65.
Net valuation taxable, $124,153.50.
Ocean frontage, approximately two miles.

The conditions here do not appear to call for any extended discussion in this connection.

Surf City Borough

Population, 43.
Net valuation taxable, $105,008.00.
Ocean frontage, approximately 1½ miles.

The conditions here are approximately the same as at Harvey Cedars.

The entire strip of beach from Little Egg Harbor or New Inlet to Barnegat Inlet is known as Long Beach, and the portions thereof not included within incorporated municipalities form part of

Long Beach Township

Population, 106.
Net valuation taxable, $1,329,991.00.

Beach Haven Borough

Population, 329.
Net valuation taxable, $1,290,757.00.

This borough and the protection works have been fully described in the 1922 report.

The changes in the vicinity of Beach Haven Inlet, very fully described in the 1922 report, are definitely indicated up to 1923 when the engineers of this Board and Commander Patton, of the United States Coast and Geodetic Survey, made a complete topographic and hydrographic survey of the Beach Haven Inlet.

The area between New Inlet and Brigantine Inlet is practically undeveloped and does not here require any extended treatment as erosion or accretion are not at this time of any great importance excepting to the Coast Guard:

Brigantine Borough

Population, 12.
Net valuation taxable, $916,025.00.

The population of this municipality, recently known as East Atlantic City, numbered 12 people in 1920. This beach has an ocean front of approximately six miles, extending between Absecon Inlet on the south and Brigantine Inlet on the north. The destruction in September, 1903, of the railroad bridge which connected this beach to the mainland was most unfortunate for this community. The ferry between Atlantic City and Brigantine was abandoned shortly thereafter.

A company is now engaged in developing portions of this beach, their first move being the undertaking of the construction of a highway bridge from Atlantic City. This work is now well advanced. Coast protection problems will therefore have more interest than has been hitherto the case. At present a ferry is maintained by this company between the beach and Atlantic City.

City of Atlantic City

Population, 50,707.
Net valuation taxable, $196,554,799.00.
Frontage of about 3½ miles.

Atlantic City is the most northerly municipality on the nine-mile strip of beach front known as Absecon Island, which extends from Absecon Inlet on the north to Great Egg Inlet on the south. Considerable space was devoted to this municipality in the 1922 Report and no new developments have taken place there since then which would render it necessary to re-describe the ocean front conditions in detail. No losses from the ocean have occurred for many years in which respect Atlantic City is highly fortunate. In fact, extensive accretions from the ocean have become highly valuable.

Plans have been laid for conducting elaborate observations of the velocity and direction of the waves approaching this beach, using the long piers from which to take the necessary measurements.

Ventnor City

Population, 2,193.
Net valuation taxable, $21,666,760.00.
Frontage, approximately 1¾ miles.

Conditions on the Ventnor ocean front are well in hand, and no losses worth mentioning have occurred for years. This section was also treated in sufficient detail in the 1922 Report.

Margate City

Population, 249.
Net valuation taxable, $6,502,208.00.
Frontage of approximately 1¾ miles.

Conditions at Margate are highly favorable, the beach during the past two years being in excellent

condition which some of the residents ascribe to the operation of the rock breakwater at 11th Avenue, Longport. It seems hardly probable that the influence of that structure can extend to so great a distance as this.

Longport Borough

Population, 100.
Net valuation taxable, $869,486.00
Frontage, about 2 miles.

It is unnecessary to enter into an extensive review of the history of coast protection works at Longport, as this is fully set forth as to structures then existing in the 1922 Report. However, the beach has built up very considerably since 1922 and especially following the repair and extension of the rock breakwater jetty at 11th Avenue, together with the placing of riprap in front of sections of the sea wall where excessive scouring had taken place, resulting, in the opinion of the Board, in greatly endangering the sea wall from being undermined. The building up of the beach to the north of the 11th Avenue breakwater has greatly encouraged the residents and property owners. Unfortunately, some erosion of the lower point has continued within the last two years. It is highly probable that adequate and permanent protection of Longport will require heavy works at the lower point and on the lagoon side at the lower end. The tidal currents pass through this inlet at high velocity with consequent pronounced effect on the shore line in the vicinity af the inlet. As long as either the flood or ebb tide currents are free to impinge upon this point, serious changes in the shore line are to be expected. Plate 5 in this report shows the position of the high water line at the time of various surveys. The first accurate survey is that of the United States Coast and Geodetic Survey of 1841, which shows the inlet with two branches with a peculiarly shaped island between. The survey of the Commissioners of 1854 shows a very different situation, the north point having pushed southwestward to almost its present limit, being much broader and extending hundreds of feet farther out to sea. At the time of the riparian survey of 1881 the Longport point had grown farther southwest to such an extent as to cover almost the entire site of the irregularly shaped island or sand bar which existed at the time of the 1841 survey. Comparing these two surveys of 1841 and 1881 indicates a growth of the Longport point to the southwestward of nearly one and a half miles; to date this point has receded from the extreme mark of 1881, approximately 3,800 feet. In addition, the southerly end of Longport is much narrower than was the south point as it existed in 1881, the loss of land between these two dates being approximately 184 acres.

It is most unfortunate that it required such losses as this to awaken the public to the necessity of taking general unified control of such situations. It is submitted that these losses were not at all unavoidable and could have been arrested in the early stages by the execution of a general plan. Longport is directly across Egg Harbor Inlet from

Ocean City

Population, 2,512.
Net valuation taxable, $22,002,119.00
Frontage, 7¾ miles.

Ocean City is on the south point of Egg Harbor Inlet and extends over the barrier beach formerly known as Peck's Beach. It was practically uninhabited in 1880. It has gained greatly in area as a result of accretion. Here as in Atlantic City the question of the ownership of the lands thus gained from the sea has been the subject of much litigation. This accretion, which is largely limited to the northerly end of the beach, has been accompanied of late years with more or less serious losses along the southerly ocean front of the city. We have in the 1922 Report referred to the very limited usefulness of Corson's Inlet from the standpoint of navigation and to its potency as an avenue for erosion of the southerly portion of Ocean City. It is believed that the closing off of this inlet entirely or at least to very restricted limits would aid greatly in maintaining the beach of the southerly portion of the municipality.

Real estate development has been very active for the past two years on the north point of Ocean City and this has resulted in the levelling and grading of the dunes in addition to the dredging of vast quantities of sand from Great Egg Harbor Bay for grading purposes. The question of erosion or accretion of this north point will be of greatly increased interest hereafter in view of the construction of roads and dwellings and the advance in the land values. It is hoped that the levelling of the dunes will not be accompanied by unfavorable tendencies toward erosion. There would be scant excuse for Ocean City's permitting any serious erosion should that tendency develop since the municipality is wealthy enough to provide adequate works and has the example of loss in other municipalities in the comparatively recent past. The 1922 Report described the type of structures employed on this beach.

Sea Isle City

Population, 564.
Net valuation taxable, $1,900,888.00.
Ocean frontage, approximately 6 miles.

The beach on which Sea Isle City is situated extends from Corson's Inlet on the north to Town-

send's Inlet on the south. No losses have occurred since the 1922 Report.

Seven Mile Beach extends from Townsend's Inlet on the north to Hereford Inlet on the south. It is the locus of the following municipalities:

Avalon Borough

Population, 197.
Net valuation taxable, $1,702,600.00.

Stone Harbor Borough

Population, 159.
Net valuation taxable, $1,941,665.00.
Frontage, approximately 3 miles.

This section was adequately treated in the 1922 Report and no new developments have taken place of sufficient importance to call for extended report at this time.

We covered very fully in the 1922 Report the shifting and general instability of Hereford Inlet.

Five Mile Beach is the locus of the following municipalities:

North Wildwood City (formerly Anglesea)

Population 807.
Net valuation taxable, $3,888,455.00.
Frontage, approximately 1½ miles.

Wildwood City

Population, 2,790.
Net valuation taxable, $12,025,555.00.
Frontage, 1 mile

Wildwood Crest Borough

Population, 161.
Net valuation taxable, $2,554,619.00.
Frontage, 2½ miles.

Portions of this beach have been subject to erosion in the past, but conditions for several years have been favorable, very considerable areas having been gained by accretion, particularly along the central and southerly end of this beach. This is ascribed by many to the influence of the long jetties constructed by the Government as a part of the improvement of Cold Spring Inlet. Another feature that has pronounced effect in the condition of this beach is the recent closing of Turtle Gut Inlet which formerly separated this beach from Two Mile Beach to the south. It is believed that the closing of this inlet will be beneficial from every standpoint. The County of Cape May, with some assistance from the State, first built the highway fill across this inlet and this is now supported by the Pennsylvania Railroad Company's fill adjoining the highway and lying just west thereof. This eliminates the dangers of erosion through this inlet which has possessed little or no value from the standpoint of navigation and gives rail and highway communication to a hitherto uninhabited and practically worthless two miles of shorefront known as Two Mile Beach. The railroad company's purpose in building the extension of its line across this inlet and down Two Mile Beach to Cold Spring is to establish extensive wharf and storage facilities near Cold Spring Inlet and thereby obtain a share of the fish shipments.

Cape May City

Population, 2,999.
Net valuation taxable, $7,409,841.00.
Frontage, 3½ miles.

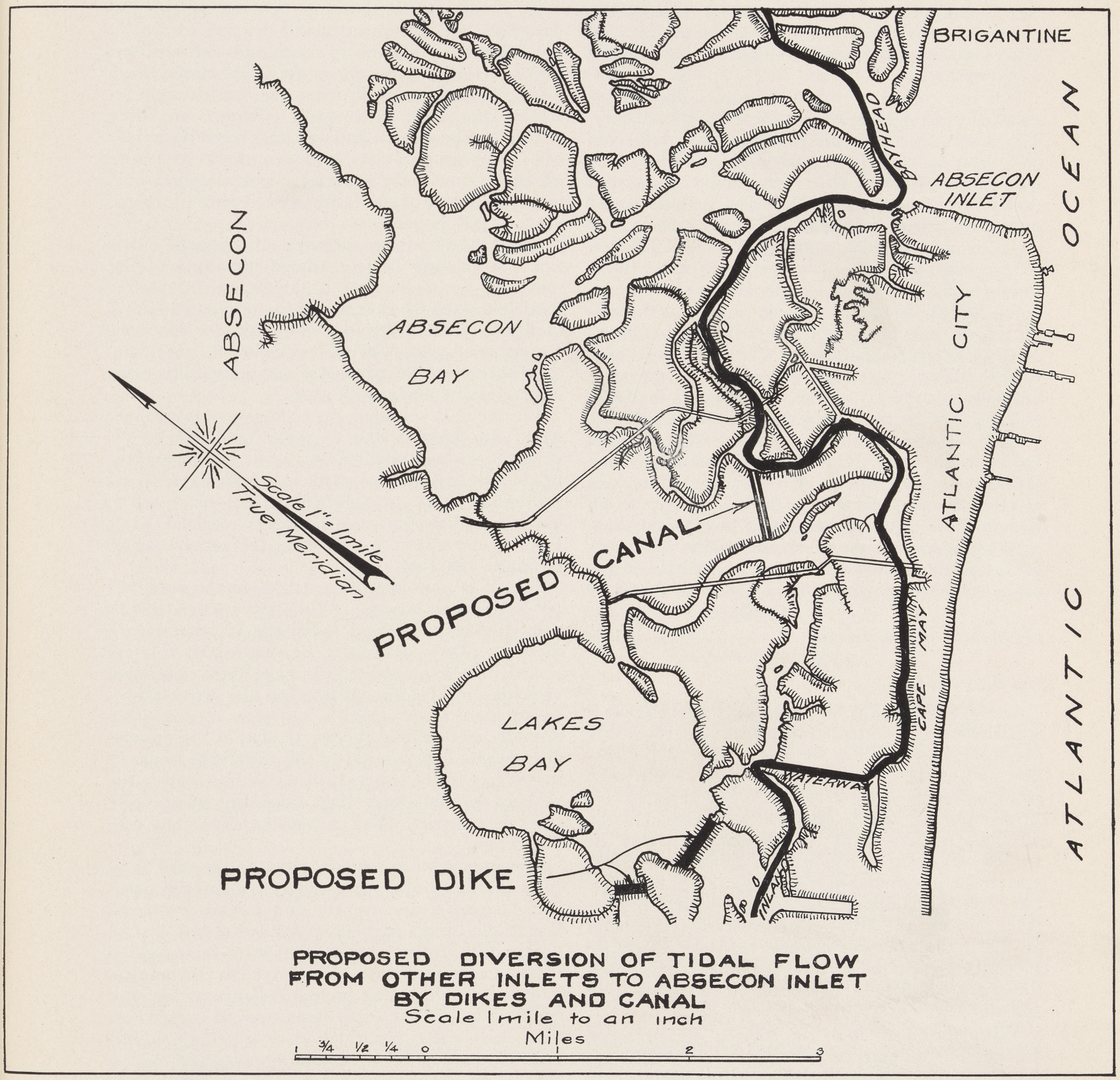
Cape May City marks the southerly limit of the lagoon and offshore bar of New Jersey. West Cape May and Cape May Point are always subject to more or less change owing to the degree of exposure and to the velocity of the tidal currents entering or ebbing from Delaware Bay. This section has been treated in sufficient detail in the 1922 Report and there have been no new developments which require extensive treatment.

TIDES AND TIDAL CURRENTS

It is of particular importance that the effects of the tidal forces upon the beaches be correctly evaluated. This is desirable, less because these forces are of major importance to the erosion of beaches remote from the inlets, than because there appears to be a tendency in some quarters to ascribe to them an importance they do not in fact possess.

The reason for that tendency is obvious. To the layman, one of the most striking phenomena visible to the observer at the beaches is the daily fluctuation in the water level. His knowledge of the nature of this fluctuation is vague and indefinite, and it is not unnatural for him to assume that this impressive vertical oscillation is accompanied by a horizontal movement of such magnitude as to be an effective agent in the erosion and transportation of the beach materials.

This element of mystery vanishes, however, when the tides are critically studied. They are known with a thoroughness far exceeding that of any of the other forces involved in the erosive processes. The same exact knowledge which enables the astronomer to predict the precise instant of an eclipse, makes it possible for him to foretell the time and



PROPOSED DIVERSION OF TIDAL FLOW
FROM OTHER INLETS TO ABSECON INLET
BY DIKES AND CANAL

Scale 1 mile to an inch

Miles

1 3/4 1/2 1/4 0 1 2 3

range of the tide. The Coast and Geodetic Survey of the Federal Government not only makes accurate predictions, a year or more in advance, of the tides for any port in the United States, and many in foreign countries, but does it almost entirely by machinery. Certainly this is possible only as a result of a thorough understanding of what the tide is and how it acts.

For the present we need offer only the briefest statement of the basic principles of the tidal theory. The tide is the result of the attractions of the sun and moon upon the individual water particles in the fluid envelope which covers the major portion of the earth's surface. That attraction is the force of gravity; it varies directly as the mass of the attracting body, and inversely as the square of its distance. The average intensity of attraction of either body for the earth as a whole is equivalent to that which would be exerted upon a particle situated at the center of the earth, and the effective tide-producing force is the component tangent to the earth's surface, of the difference between the attraction of the celestial body for the particle at the center of the earth and for one at the surface. The tide-producing force is therefore a differential of the force of gravity, and varies directly as the mass of the body, but inversely as the cube of its distance. Thus, the moon is the principal tide-producing agency, for although the sun has a mass about 26,000,000 times as great as that of the moon, the sun is 389 times as far away from the earth. Its tide-producing force compared to that of the moon is therefore represented by the fraction $\frac{26{,}000{,}000}{389^3}$, or a little less than one-half.

Let us now glance at the moon's effect upon a single particle of water. When the moon is directly overhead, its attraction for the particle at the surface and at the center of the earth lie in the same straight line. The moon's effect is then directed vertically upward, and is opposite in direction to the attraction of the earth for the particle. But the earth's attraction is 8½ million times as great as that of the moon, and in consequence, the latter cannot exercise any appreciable effect in lifting the particle. Finally the attractive force does not contain any horizontal component whose tendency is to move the particle along the surface. In other words, when the moon is directly overhead, its tide-producing force is zero.

When the moon is in the horizon, its attractive force upon the particle is horizontal. At that instant, however, the two particles at the surface and at the center of the earth are equidistant from the moon and its attraction for them is of the same magnitude. That is, the moon attracts the particle with just the same force that it attracts the earth as a whole. In consequence, there is no tendency toward a displacement in the position of the particle; in other words, here also the tide-producing force is zero.

At all intermediate positions between the two just described, the moon's attraction for the particle at the surface differs both in magnitude and in direction from that for the one at the center of the earth. This difference tends to move the particle with resect to the earth as a whole. The force, being oblique to the earth's surface, may be resolved into two components; one vertical, which tends ineffectually to lift the particle; the other horizontal, which is capable of producing a movement of limited velocity and extent.

Let us now consider the effect of the earth's rotation, the particle being assumed initially to be at rest. As the moon rises in the east it attracts the particle toward the east, and the latter tends to move in that direction. This eastward attraction continues for six hours, until the moon reaches the meridian, at which instant the particle is moving with its maximum velocity toward the east.

For the next six hours the attraction is toward the west. Its effect is first to retard, and then to reverse the eastward motion, so that as the moon sinks below the horizon the particle is moving with its maximum westward velocity. From moon-set to lower transit the eastward motion is repeated, while from lower transit to moonrise the particle again moves to the west.

It will be seen that all particles in the ocean do not oscillate in unison. While the particle at one point is moving with its maximum velocity toward the east, others six hours, or one-fourth rotation period distant on either side have their maximum velocities toward the west; and the particles between these two opposite extremes are passing through an infinitely minute gradation of intermediate phases. As a result of this difference in phase, the surface of the waters is distorted into waves, and we have the tide wave. High tide at any point represents the presence of the crest of the wave; low tide, the trough.

It is important to remember that in the tidal wave as in all other ocean waves, there is a radical difference between the movement of the wave form and that of the water particles contained at any instant within that form. While the form is travelling through a great distance at high velocity, the particle moves through a very limited distance at low velocity. Thus, if the earth were covered everywhere with deep water, the tidal wave would be 12,000 miles from crest to crest, and would travel with a velocity of 1,000 miles per hour. The lengths and velocities of the actual waves in the deep waters of the oceans are very great. Yet the water particles in mid-ocean move with a computed velocity of only about one-tenth mile per hour, with a total range of

translation during the tidal cycle of about one-half mile. Certainly there is nothing in a movement of this character remotely suggestive of a hidden but intensive onslaught of the ocean waters upon the land.

The preceding statement suggests, as briefly as possible, the character of the tide produced by a single celestial body which maintains a fixed position with respect to the earth. The actual tides of the ocean are far more complicated. These complexities result from the facts that the sun as well as the moon is a tide-producing body; that the inter-relations between sun, moon and earth are extremely complicated and constantly changing; and finally, that the effects produced by these celestial bodies are profoundly influenced by the extent and depth of the ocean basins on which the force is expended.

It is not necessary to discuss these complications. Those of celestial origin manifest themselves in such phenomena as the daily inequality of the high and low waters; variations in the monthly range of which the spring and neap tides are the extremes, and in numerous other variations of which the perigean and apogean tides are typical.

The modifying effect of terrestrial features is illustrated by the basically different type of tide in Long Island Sound or the Bay of Fundy, from those of our Atlantic Coast as a whole, or by the difference in range of tide along the Atlantic and Pacific Coasts of the United States.

While these tides of the oceans are only of indirect concern to the engineer, their brief consideration is pertinent to the studies to be made by this Board, by reason of the fact that they determine the character of the tide at the shores, which must be taken into account in all efforts at coast protection.

While it is not possible by actual observation to determine the velocities of the tidal currents in mid-ocean, the low velocities deduced from a mathematical analysis of the tidal phenomenom are confirmed by observations made adjacent to various coasts. Thus the Coast and Geodetic Survey has determined the velocity of the tidal currents at seventeen light vessels anchored at various vantage points from 5 to 40 miles off the Atlantic Coast. These observations show that in general, except where the tidal current is modified by a hydraulic element due to the presence of an adjacent body of inland water, its maximum velocity is from 0.2 to 0.4 miles per hour.

These velocities would be further diminished as the tide wave approached the coast. The 1922 report of the Board discussed the character of the tidal movement immediately adjacent to the coast, but beyond the influence of the inlets. Only the conclusion of that discussion need be restated here. It was shown that the tidal current near and normal to a coast is substantially that required to fill or empty the prisms between high and low water. A formula was given for computing this current. Solving this formula as applied to the actual range of tide and depth of water along the New Jersey coast, we find that at the curve of 18 feet depth, situated an average distance of one mile from shore, the velocity of the tidal current is only about 267 feet per hour. Such a current would not only have no appreciable effect of itself, it would not sensibly augment or diminish other currents.

In the vicinity of the inlets (and this term includes both New York Harbor and Delaware Bay) the tidal currents are of great importance. These inlet currents, however, are in a sense hydraulic; that is, the product of the flow of water necessary to fill or empty the enclosed lagoons in harmony with the rise and fall of the tide outside. Their character is determined therefore not only by the range of tide outside, which for this extent of coast is practically constant, but also by the cross section of the gorge through which they must pass, by the size of the body of inland water and by various other factors. These factors differ for each inlet and in consequence the current at each inlet presents its own distinctive problem, which must be studied in relation to all the local factors there obtaining.

These studies form one of the important items for further investigation by this Board. For it is a fact, however greatly to be regretted, that with respect to this, the most important element in the relation of the tide to coast protection, no attempt has heretofore been made at a comprehensive collection of the data necessary to the solution of this important and complex problem.

INLETS

In the report submitted by the Engineering Advisory Board on Erosion in 1922 to the Board of Commerce and Navigation, certain facts relating to and studies of inlets were mentioned. There was pointed out on pages 20 to 28, incl., and 42, 45, 49 and 52, of the printed report the detailed results of observation of the various inlets on the New Jersey Coast, with comments thereon, and an attempt made to deduce general laws therefrom.

In a general way, these laws are the laws of migration or shifting of the inlets laterally, of variability of line of deepest water, and of liability of shore lines at inlets to advance or retreat at rates greatly in excess of the rates at other portions of the shore lines. It was also pointed out that neighboring inlets have a reciprocal influence on each other, one sometimes increasing in size and influence, and the other correspondingly decreasing to the point of closure. There was also pointed out the influence which the direction of the line of approach of the interior channel has upon migration. Those considerations, together with a study of the effects obtained from such protective and regulating works as

have been undertaken on this coast at inlets led to certain conclusions being formulated with respect to the character of works that might be deemed suitable for their control. These conclusions are those numbered 16, 17 and 18 on page 16 of the Board's printed report.

Such additional study as has been given the matter of inlets and their influence on coast erosion, has tended to increase and magnify the Board's confidence that jetties of ample cross section and composed of stone varying from 3 to 12 tons, are necessary for such locations. No stone smaller than three tons should be used, and the shape of all stones should be such that the greatest dimension should not greatly exceed three times its smallest dimension. It further appears that twin jetties possess great superiority over a single jetty, whether straight or curved, and may be used with more confidence of favorable results.

In length, the jetties should always extend from high water line outward to such distance as may be required by the problem at hand. For navigation purposes they must necessarily extend out sufficiently far to obtain the low water depth sought. For fixation of location and beach protection purposes an extension to or only slightly beyond low water mark is necessary.

The best type of jetty thus far used on the Jersey Coast is the rubble mound, with a tight core of sheet piles. The south jetty at Shark Inlet is of the recommended type and cross section.

These conclusions are tentative and are subject to modification upon further study.

It is now proposed not only to extend the scope of study of inlets to include a more detailed investigation into these features of inlets but further to initiate studies not yet undertaken upon their complex physical and hydraulic characteristics.

The physical features worthy of more study are source and destination of sand and other detritus, both that moved along the shores, and that deposited inside, means of reducing deposits, determination of characteristics of inlets approaching closure, or increasing in magnitude, comparative study of charts of different surveys, study of interior and exterior deltas, and measurement of interior tidal basin and study of effect of the direction of approach to the inlet of the interior channels.

The hydraulic features to be studied are current velocities and volumes, the determination of those velocities conducive to erosion, and those conducive to deposit, the conditions of tidal propagation through the inlet, the determination of those values for ratios of cross section to depth most suitable at each inlet to assist in stabilizing it, a study of the applicability to these data of the usual hydraulic formulæ for flow of water in open channels, and the selection of a project for the improvement and fixation of each inlet, which will be an ultimate goal to which all works undertaken by the State or authorized by permit should conform.

Such a study would involve the collection of all available maps of an inlet, observations and measurements of littoral drift, detailed hydrographic surveys, current measurements, observations of tidal oscillation, both exterior and interior, the cubature of the tidal discharge, the measurement of the area of the tidal basin within the inlet, a study of the erosibility of the bed of the inlet, and the depth to which erosion can occur at moderate velocities, and a determination of the proper constants in hydraulic formulæ.

With these data at hand and a knowledge of hydraulics, a determination can be made of the area of cross-section and depth of channel most suitable to enable the inlet to perform its natural functions in a manner that would cause least damage to its shores. Its proper location with respect to its tidal basin can also be determined, and proper means taken to confine it to that location and cross-section. Suitable works for accomplishing the desired results will then be designed and filed for future guidance. It is anticipated that the time necessary for the Engineering Advisory Board to carry out this progress and to complete a full report thereon would be 5 to 10 years, depending upon the availability of funds. The cost of the study of each inlet would probably not exceed $5,000.00, and this sum would be needed only at the rate of about $1,000 per annum per inlet, if regularly provided. As a beginning, such studies need be undertaken only at those inlets where immediate operations are necessary to protect settled communities.

LONGPORT

Conditions and Operation of Protection Structures

The profound changes that have occurred at Longport and the variety of means that have been employed to arrest erosion pointed to this municipality as an especially good field for continuous detailed study. The presence of the concrete sea wall outside of the high water mark was from the beginning recognized as introducing a factor, the operation of which would probably lead to important deductions in the study of the subject.

It was believed that in situations like the New Jersey beaches, where the ordinary range of tide is only approximately four feet and the material of the beach is relatively fine sand, the construction of a sea wall below high water mark will cause serious changes in the effect of the waves upon the shore. It is common experience that northeast (onshore) storms on a sandy beach frequently pile up a ridge of sand above the ordinary high water mark, and at the same time scour out a gully parallel to the shore below high water mark. The tendency of the off-

shore winds is to rapidly change this condition and form a beach profile of smooth regular slope. It was believed that to avoid undue loss of material as a result of such modification of the slope of the beach during onshore storms, the dimensions of groynes or jetties should be such as to extend out to the bar lying outshore of the gully thus formed, and in that way preclude serious transportation of beach material through the slough or gully or beach channel, as it is variously termed, and into the inlet. It was believed that this tendency of the seas to form a gully and outshore bar during the abnormal onshore wind would be established as a prominent and permanent condition by the construction of a sea wall outshore of high water mark such as that at Longport, since the waves strike the wall with more energy than they would retain after rolling up a sandy beach on which there is no such obstruction. Comparison was made as far as possible between the new situation created by the construction of this wall and conditions at Sea Bright where the Central Railroad Company of New Jersey has for years maintained a riprap wall along the shore.

At Sea Bright a series of timber groynes extend outshore at right angles to the sea wall and there is normally a sand bar parallel to the shore a short distance seaward of the end of the groynes, thus leaving a gully or beach channel between the said bar and the outshore end of the groynes. It had been hoped in the design of the Sea Bright sea wall and groynes that the sand would be collected by the groynes sufficiently to form a good beach, but that hope has not been realized and the bar has not met the expectation that it would move inshore.

The Board made its first detailed survey of this Longport Waterfront in June, 1922. This was followed by survey in October, 1923, immediately following a severe northeast storm, and by surveys in March, 1924, and August, 1924. The conditions are indicated on the maps of these respective dates annexed to this report.

The October, 1923, survey followed, as we have stated, a severe northeaster and disclosed conditions that were highly disquieting. In the interval between this survey and that of June, 1922, the breakwater jetty at 11th Avenue had been repaired and extended oceanward and 1,276 tons of rock had been deposited at the toe of the concrete sea wall where scouring had been most pronounced, and a bulkhead had been constructed in the vicinity of 15th and 16th Avenues inshore of and opposite the breach in the concrete sea wall.

It was obvious that these devices had not yet begun to function to any encouraging degree. A bar had been formed parallel to the sea wall and some 400 feet offshore therefrom, and between this bar and the sea wall was a deep beach channel which extended to the 11th Avenue breakwater jetty and followed its northeasterly face to deep water. Here were conditions highly dangerous to the sea wall for the flood tide current especially coursed through this gully at high velocity. Floats placed at the inshore end of the northeast side of the 11th Avenue breakwater moved rapidly outshore and swung sharply around the outer end of the jetty toward the inlet.

The additional protective works adverted to in the two paragraphs immediately preceding were constructed with State Aid appropriated in 1922 under the Enabling Act of 1920 on the following terms:

> For the construction, repair or preservation of sea walls, bulkheads and jetties and other approved devices necessary and proper to protect the riparian lands of this State pursuant to Chapter 318, Laws of 1920, as follows:
>
> Longport Borough, Atlantic County $50,000.00

This act, as we have heretofore stated, contains the requirement, among others, that the municipality shall appropriate at least 50% of the cost of the works. It was agreed to apply the funds available to the following items:

1st. *Repairs and Extension to the Stone Breakwater Jetty at 11th Avenue.* This structure had been seriously damaged. Work began on January 2, 1923, and was completed September 29, 1923. The cost of the original jetty before State aid was obtained was $37,513.27. The cost of the repairs and extension amounted to $89,125.17, the unit cost of rock being $3.60 per ton. Contractor, E. J. Holland, of Atlantic City.

2d. *Construction of Timber Bulkhead Inshore of the Sea Wall Line in the Breach in the Vicinity of 15th and 16th Avenues.* This was begun January 2, 1923, and completed February 24, 1923. Total cost $4,955.00 at unit figure of $12.00 per lineal foot. Contractor, Frank E. Gandy, of Atlantic City.

3d. *Placing Rock at Toe of Sea Wall in Seriously Eroded Section.* Total cost $6,192.00 at $4.85 per ton. Contractor, L. J. Sieling, of Red Bank, N. J.

4th. *Placing Large Railroad Car Float as an Extension to the 11th Avenue Breakwater Jetty and Driving Piling to Hold Float in Place.* Cost of placing the float $1,950.00; 27 piling $891.00. Contractor, L. J. Sieling, of Red Bank, N. J.

The Board had stipulated that it would pay one-half of the State's contribution when the works were at least one-half completed, and the balance when the works had been entirely and satisfactorily completed. Pursuant to the arrangement, the Board paid the State's contribution in two installments as follows:

July 13, 1923, ...$25,000.00
Nov. 13, 1923, ...$25,000.00

The plan annexed to this report entitled "Plan Showing Operation of Coast Protection Devices at Longport, New Jersey," affords comparison of sec-

tions of the beach at the times of the various surveys. Section AA was taken at the lower point and indicates considerable erosion and shifting shoreward of deep water. This shows the conditions outshore of certain old bulkheads and groynes constructed by the Borough. Conditions inshore may be compared by referring to the surveys of 1922, 1923 and 1924. The Borough is at this time, December, 1924, engaged in the construction of a bulkhead designed to protect this point.

Section BB on the cross section plan affords a comparison of lines of soundings in 1923 and 1922 extending southward from a point near the outer end of the present jetty. This shows a very considerable improvement between those two dates on this particular line.

Section CC gives a comparison of lines of soundings in October, 1923, and June, 1922, in extension of the axis of the 11th Avenue breakwater jetty. This section shows strikingly the tendency of the tidal flow to scour out a deep channel at the outshore end of structures of this magnitude, necessitating provision for quantities of rock far in excess of what will be indicated by the first soundings taken before such a work is constructed. Of course this adverse factor would not be so effective if hardpan or other material that is not readily eroded is found at shallow depth below the sand; but this is not the case at Longport. Many expedients have been suggested to obviate this tendency, among which is that of placing a rock base first and extending this seaward as rapidly as possible, building the structure up to grade later. How successful this mode of procedure would be in precluding the scouring effect at the end of the jetty is a question to be determined by experiment. It would of course require the construction of a trestle if railroad cars or trucks were used in delivering the rock. There is no question that rapid prosecution of the work will minimize the formation of the deep channel at the end of the rock work, but some settlement is very probable anyhow in this material.

Section DD is taken normal to the sea wall south of 13th Avenue and approximately 500 feet northeast of the 11th Avenue breakwater jetty. The sections of August, 1924, show a very marked improvement in the condition of the beach since the surveys of 1922 and 1923. The beach was then in normal summer condition.

Section EE and Section FF indicate the serious condition that existed in October, 1923, and the very great improvement revealed by the survey of August, 1924. The taking of soundings close to the sea wall is attended with great difficulty and considerable danger. The remains of old structures constitute the chief hazard, as the broken piling, etc., are likely to punch holes in the sounding boat; and should the sounding boat sink the party would have great difficulty in reaching shore since the sea reaches the sea wall and the breakwater jetty.

The survey of March, 1924, of which a plan is annexed hereto, furnishes an interesting basis for study. The observations were taken immediately following several days of high northwest winds which had been preceded by a northwest storm of great intensity. The velocity and duration of the winds is indicated on the graph of this plan. The cross sections show how quickly the heavy northwest winds in their turn modify the profile of the beach even after a serious onshore storm.

It is interesting to study the conditions at the old low wooden groynes which were constructed coincidentally with the concrete sea wall. A very considerable section of the southermost jetty, just south of 12th Avenue is entirely covered with sand, as is the second jetty between 12th and 13th Avenues. The general tendency is for the sand to pile up on the northerly side of all these groynes. The movement of the water in these restricted areas is very complex. At low tide the waves follow along the northerly side of the groynes until their energy is dissipated. The water then flows northeastwardly along the sea wall. This action was particularly pronounced at the groyne just north of 13th Avenue and that at 14th Avenue. This plan also indicates very favorably the absolute necessity for a tight joint between the groyne and the foot of the sea wall.

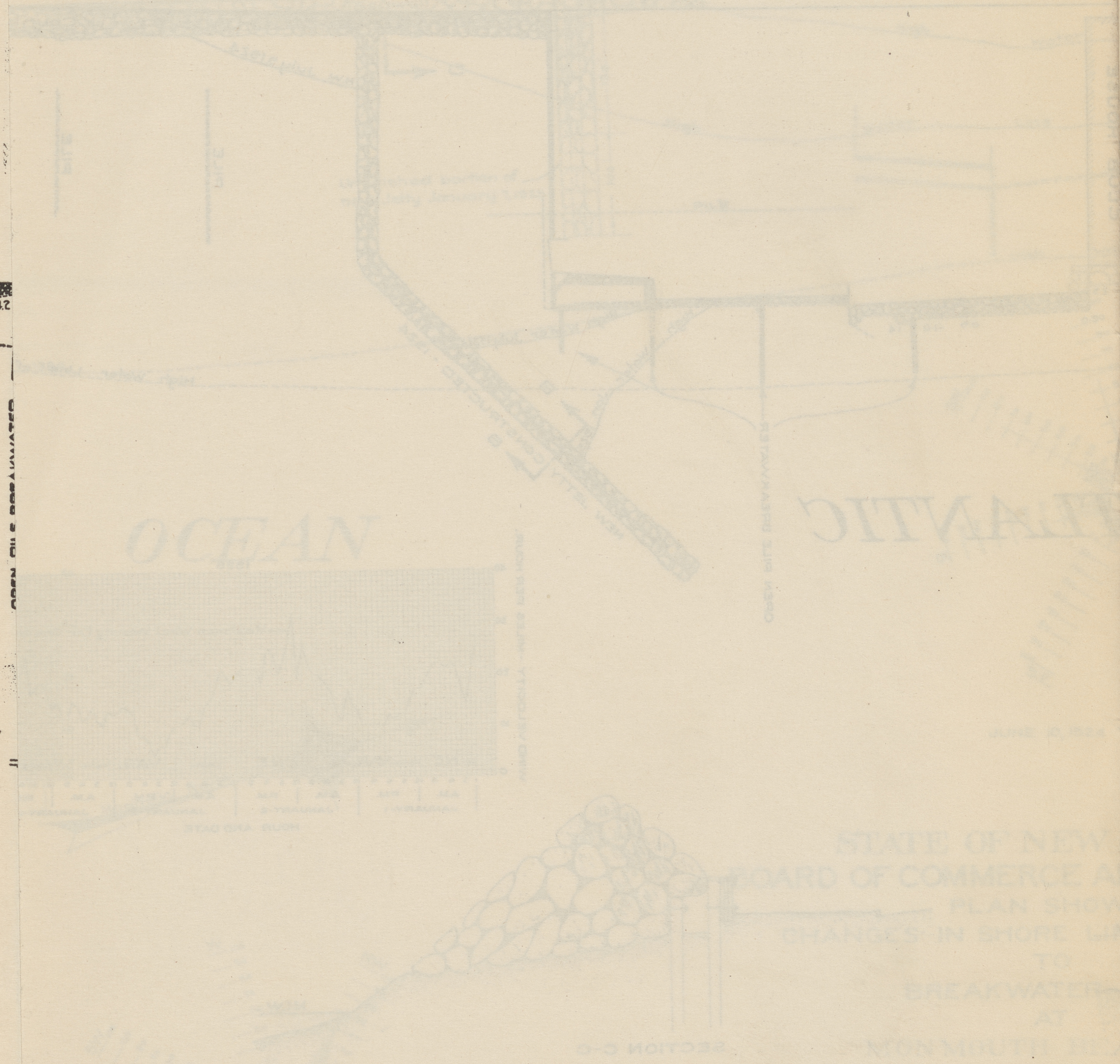
THE AIR BREAKWATER

Reference was made in the 1922 report to the Brasher Air Breakwater System. This is described as a patented device for protecting coffer dams, breakwaters and all marine construction work from damage by wave action.

The inventor of this device states that the air bubbles arising from a considerable depth will completely destroy the form of the waves and prevent their doing any damage. The plant is described as an air compresser of proper capacity with a suitable system of perforated pipe lying on the sea bottom, the air being conducted under high pressure to the outlets in the pipes offshore and released prior to the change of the form of wave from a wave of oscillation to a wave of translation. This type of protective device has been described in various publications, and is reported to be in use at several localities.

This Board has not had an opportunity to observe the operation of devices of this type.

42



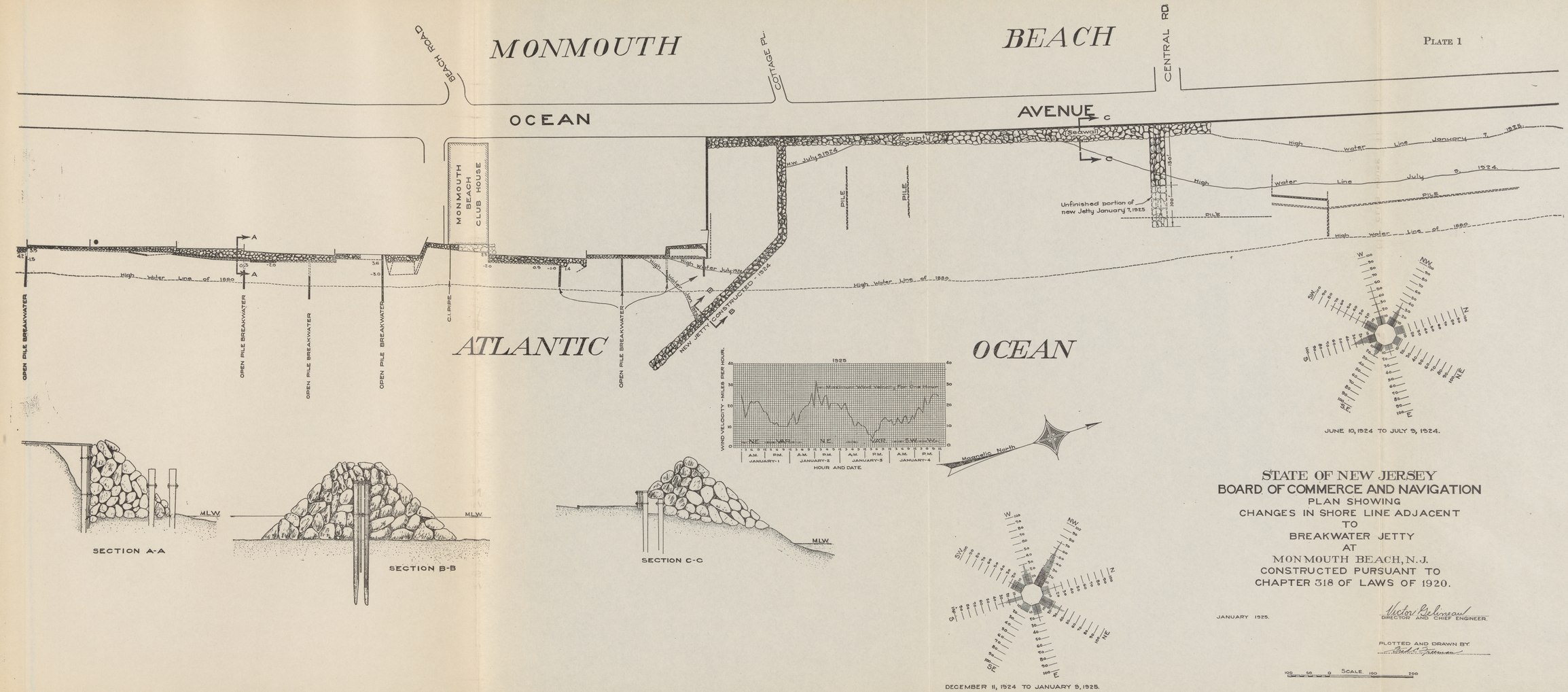
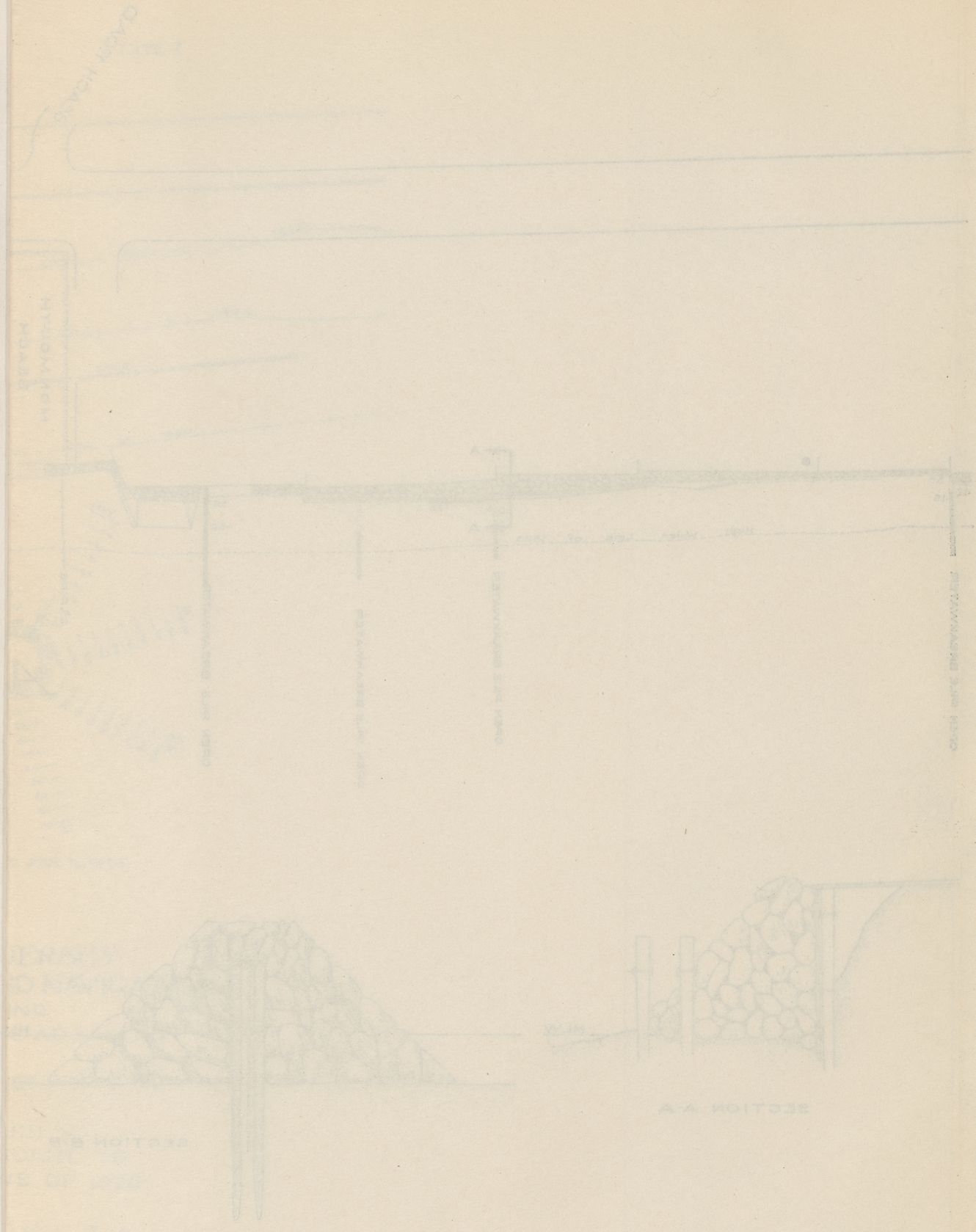


PLATE 1
MONMOUTH BEACH
BEACH ROAD
COTTAGE PL.
CENTRAL RD.
OCEAN AVENUE
County
Seawall
MONMOUTH BEACH CLUB HOUSE
H.W. July 9, 1924
PILE
Unfinished portion of new Jetty January 7, 1925
High Water Line January 7, 1925
High Water Line July 9, 1924
High Water Line of 1880
High Water Line of 1880
High Water July 1924
NEW JETTY CONSTRUCTED 1924
OPEN PILE BREAKWATER
C.I. PIPE
ATLANTIC OCEAN
1925
Maximum Wind Velocity For One Hour
WIND VELOCITY - MILES PER HOUR.
HOUR AND DATE
JANUARY-1
JANUARY-2
JANUARY-3
JANUARY-4
Magnetic North
JUNE 10, 1924 TO JULY 9, 1924.
SECTION A-A
SECTION B-B
SECTION C-C
M.L.W.
DECEMBER 11, 1924 TO JANUARY 9, 1925.
STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
PLAN SHOWING
CHANGES IN SHORE LINE ADJACENT
TO
BREAKWATER JETTY
AT
MONMOUTH BEACH, N.J.
CONSTRUCTED PURSUANT TO
CHAPTER 318 OF LAWS OF 1920.
JANUARY 1925.
Victor Gelineau
DIRECTOR AND CHIEF ENGINEER.
PLOTTED AND DRAWN BY
SCALE



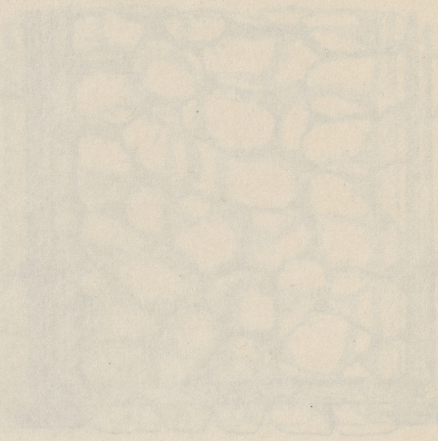
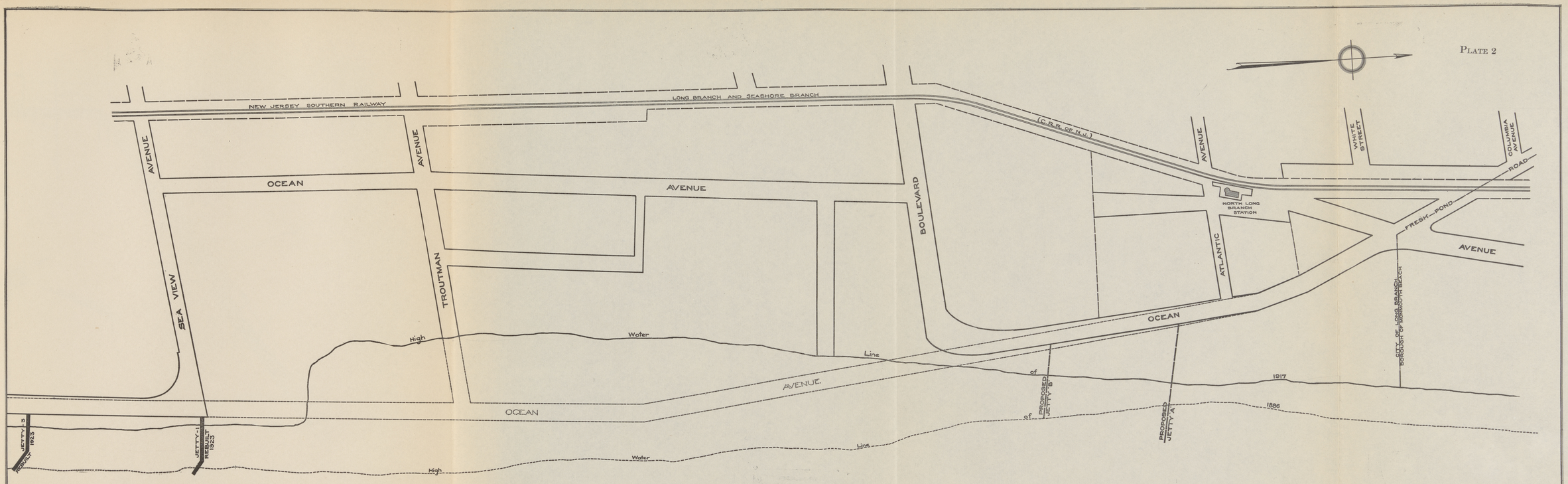
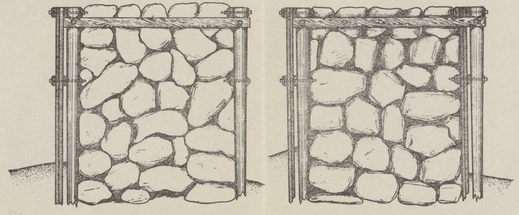


PLATE 2



ATLANTIC OCEAN



TYPICAL SECTION
JETTIES 1-3-5 & B

TYPICAL SECTION
JETTY-A

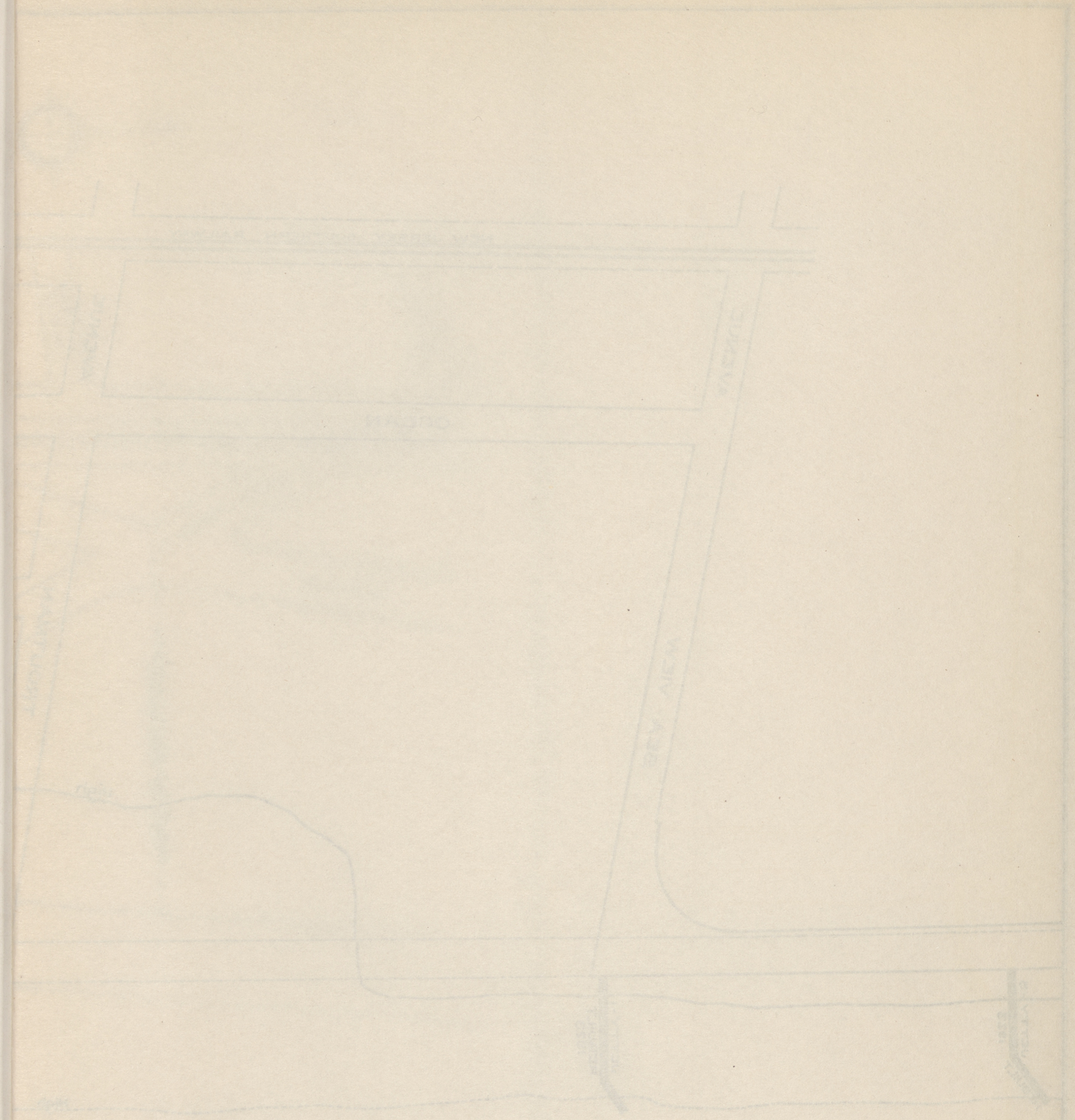
STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
MAP SHOWING
EROSION OF COAST LINE
VICINITY OF
TROUTMAN AVENUE-LONG BRANCH

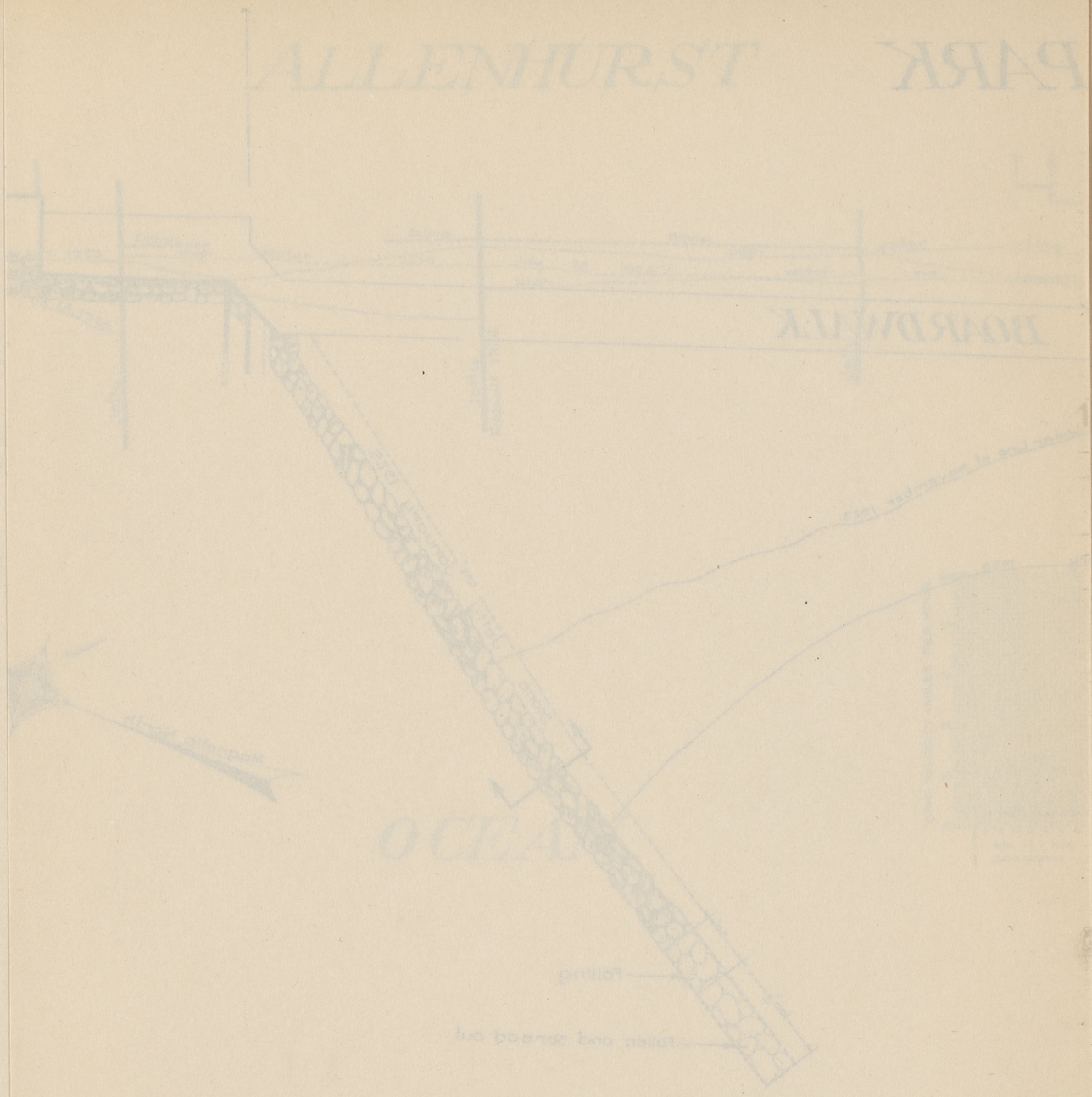
APRIL - 1924

Victor Gilinsky
DIRECTOR & CHIEF ENGINEER

SCALE
100 50 0 100 200 300 400 800

H.R. TOOKER, ASST. ENG.





ASBURY PARK

ALLENHURST

BOARDWALK

High Water Line of November 1923

High Water Line January 1925

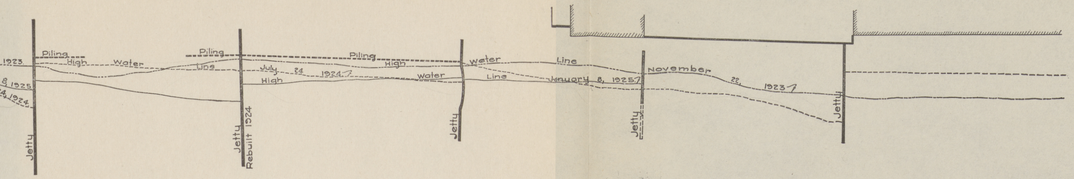
ATLANTIC OCEAN

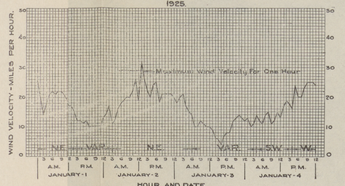
Stone Jetty as of January 1925

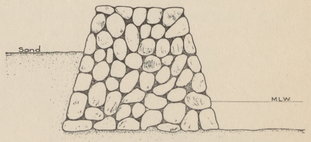
Magnetic North

Falling

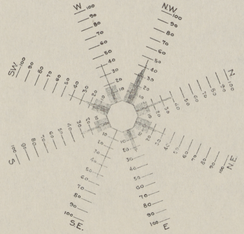
Fallen and spread out



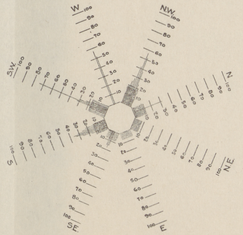




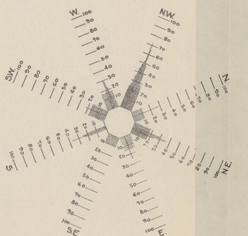
TYPICAL SECTION



OCTOBER 23, 1923 TO NOVEMBER 22, 1923.



JUNE 25, 1924 TO JULY 24, 1924.



DECEMBER 11 1924 TO JANUARY 9, 1925.

STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION

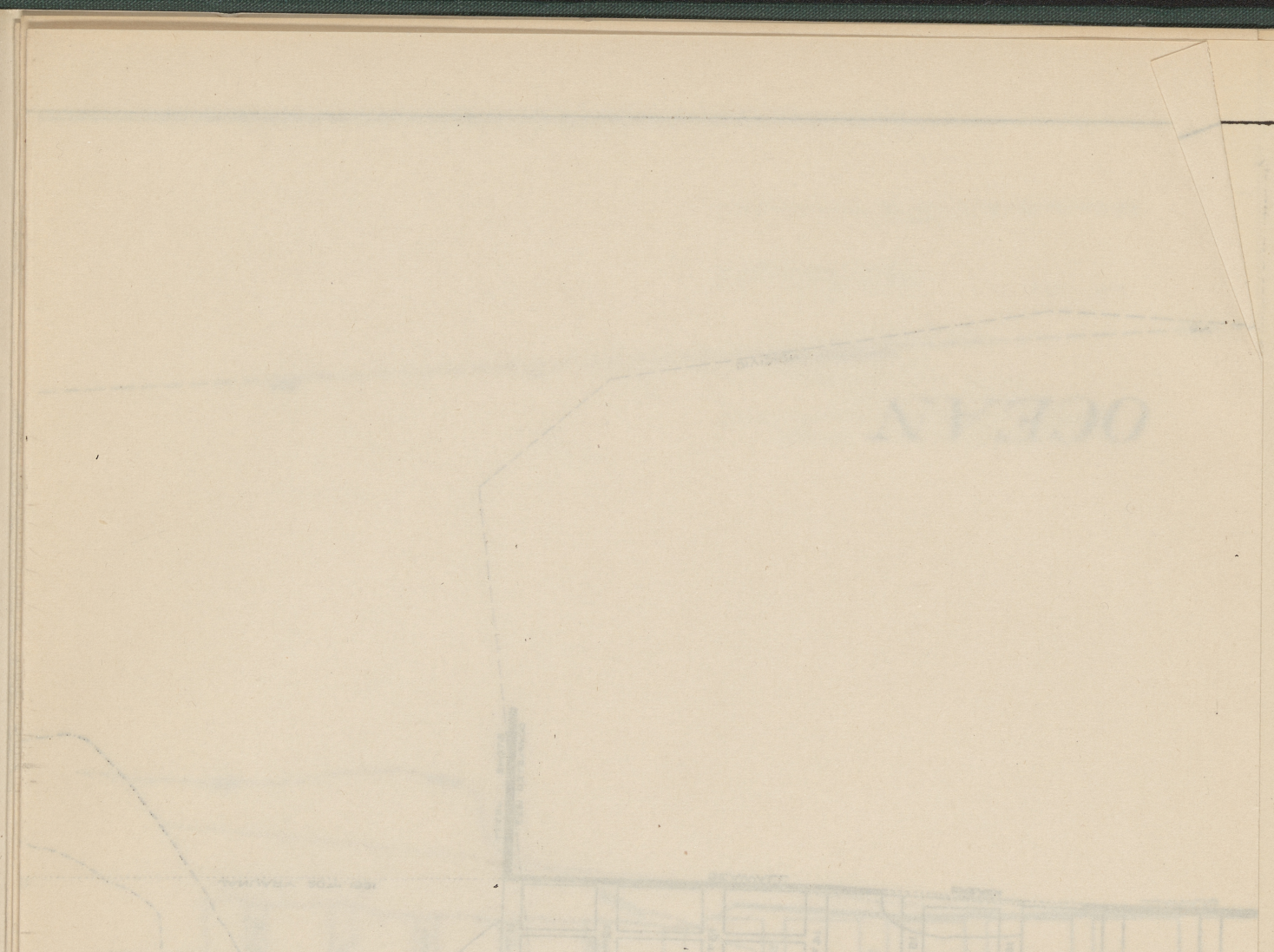
PLAN SHOWING
CHANGES IN SHORE AT
ASBURY PARK AND ALLENHURST, N.J.
ADJACENT TO BREAKWATER JETTY CONSTRUCTED
PURSUANT TO
CHAPTER 318 OF LAWS OF 1920.

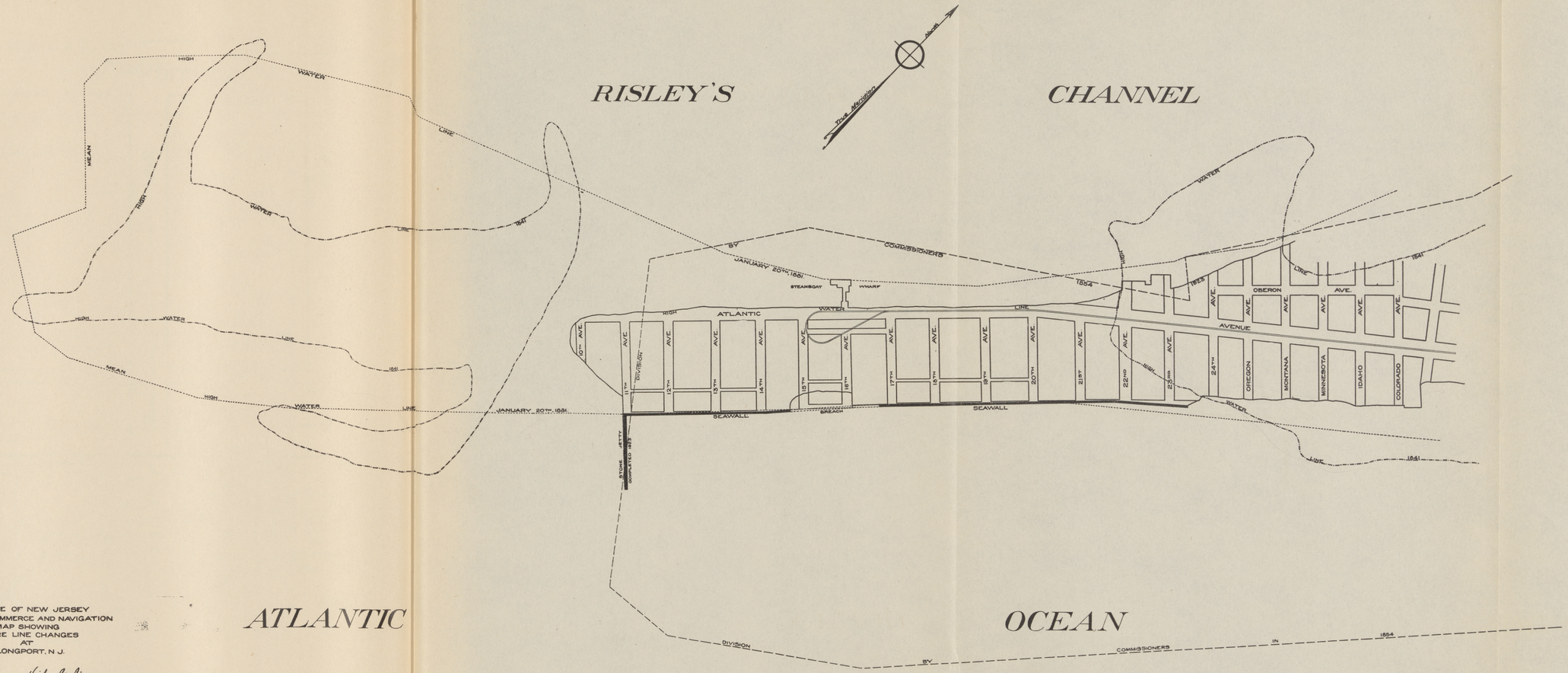
JANUARY 1925.

Victor Dolman
DIRECTOR AND CHIEF ENGINEER.

PLOTTED AND DRAWN BY.
Fred. E. Freeman

SCALE 100' 50' 0 100' 200'



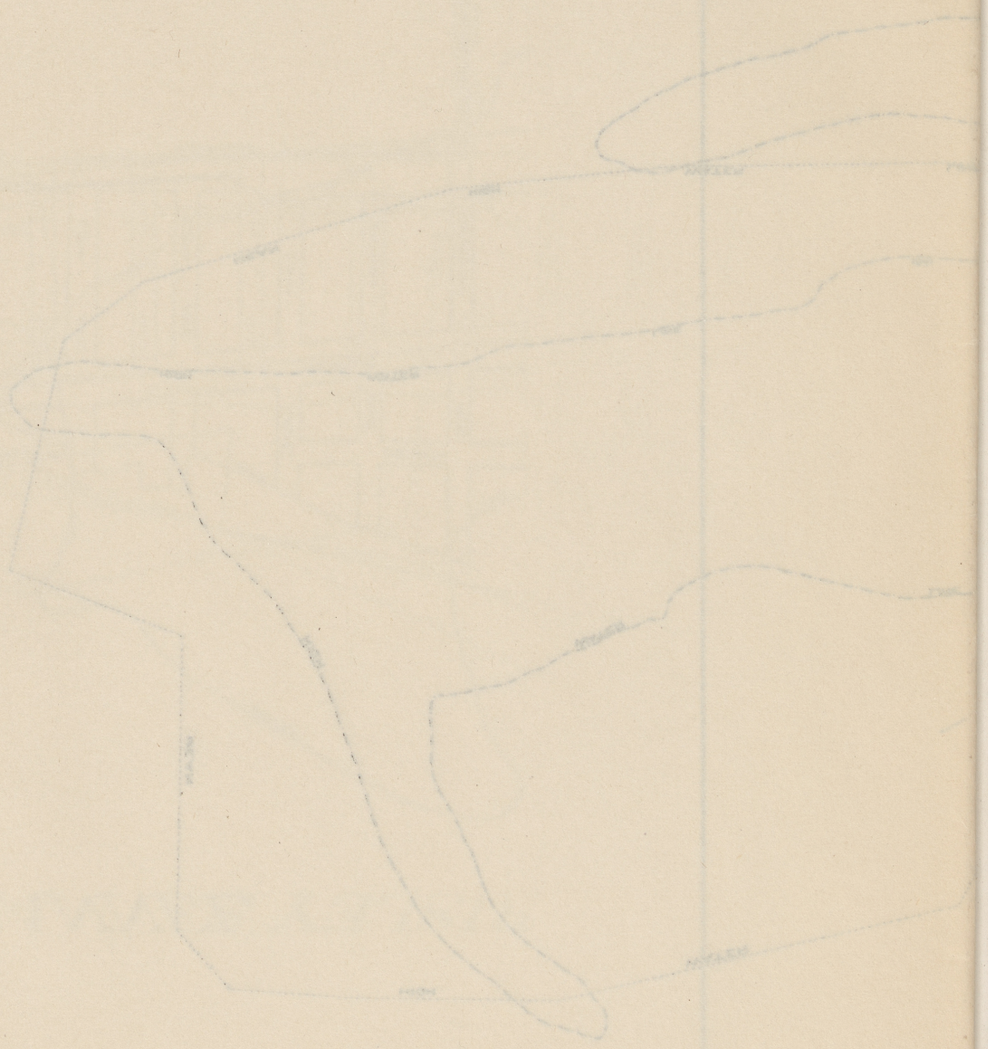


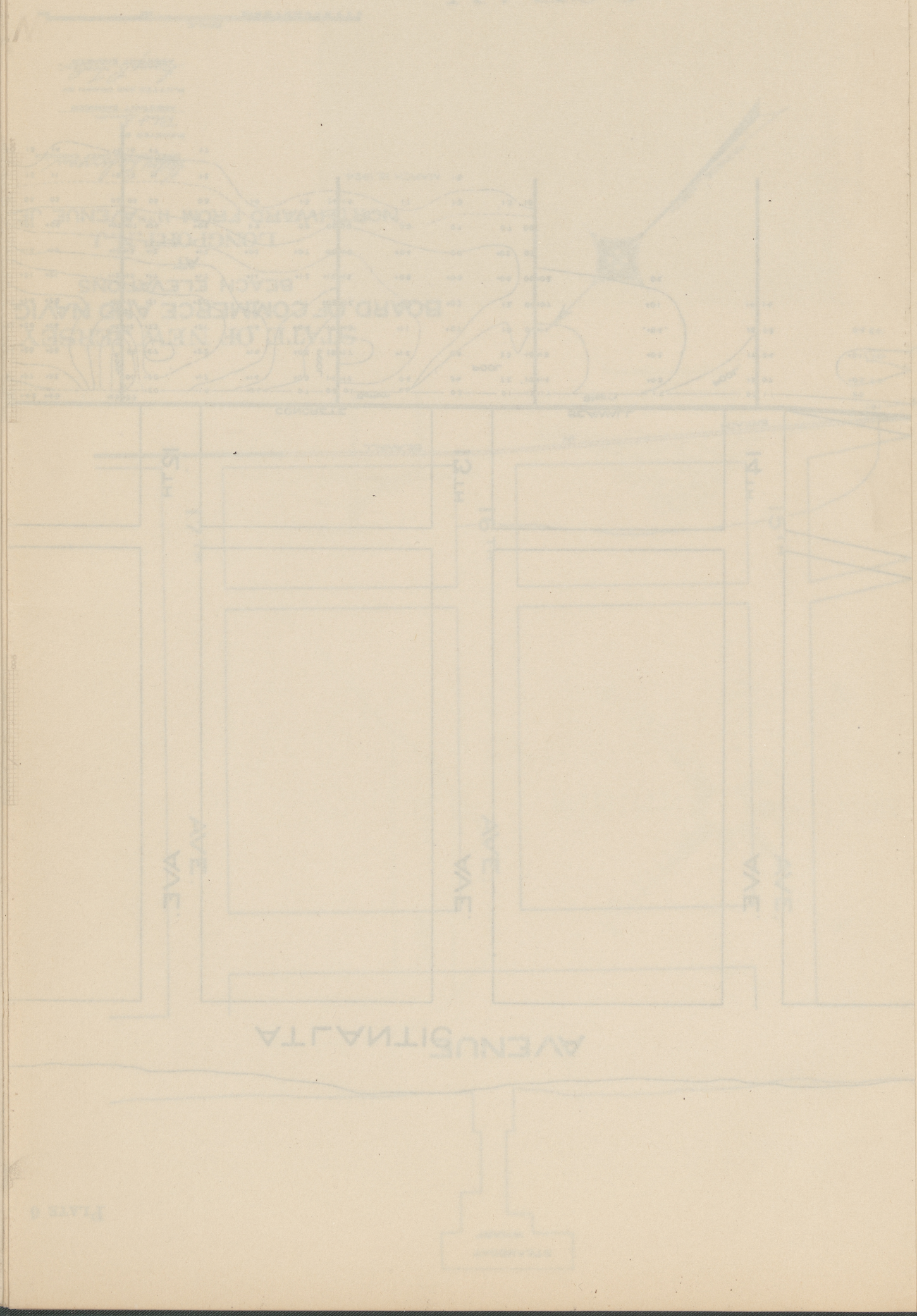
STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
MAP SHOWING
SHORE LINE CHANGES
AT
LONGPORT, N J.

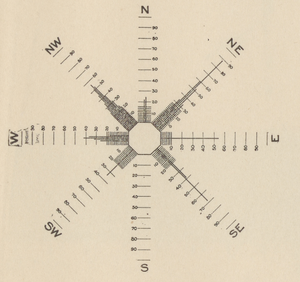
MAY - 1924

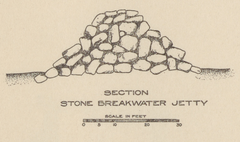
Victor Belleau
DIRECTOR & CHIEF ENGINEER

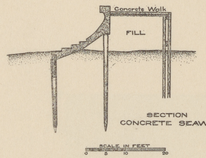
SCALE

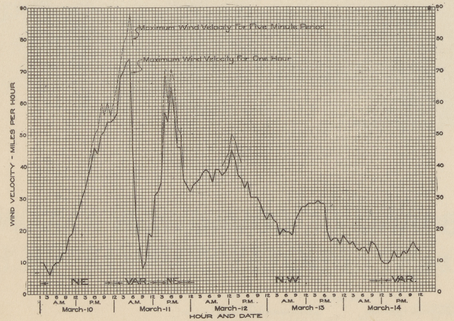












STATE OF NEW JERSEY
BOARD OF COMMERCE AND NAVIGATION
BEACH ELEVATIONS
AT
LONGPORT, N.J.
NORTHWARD FROM 11TH AVENUE JETTY

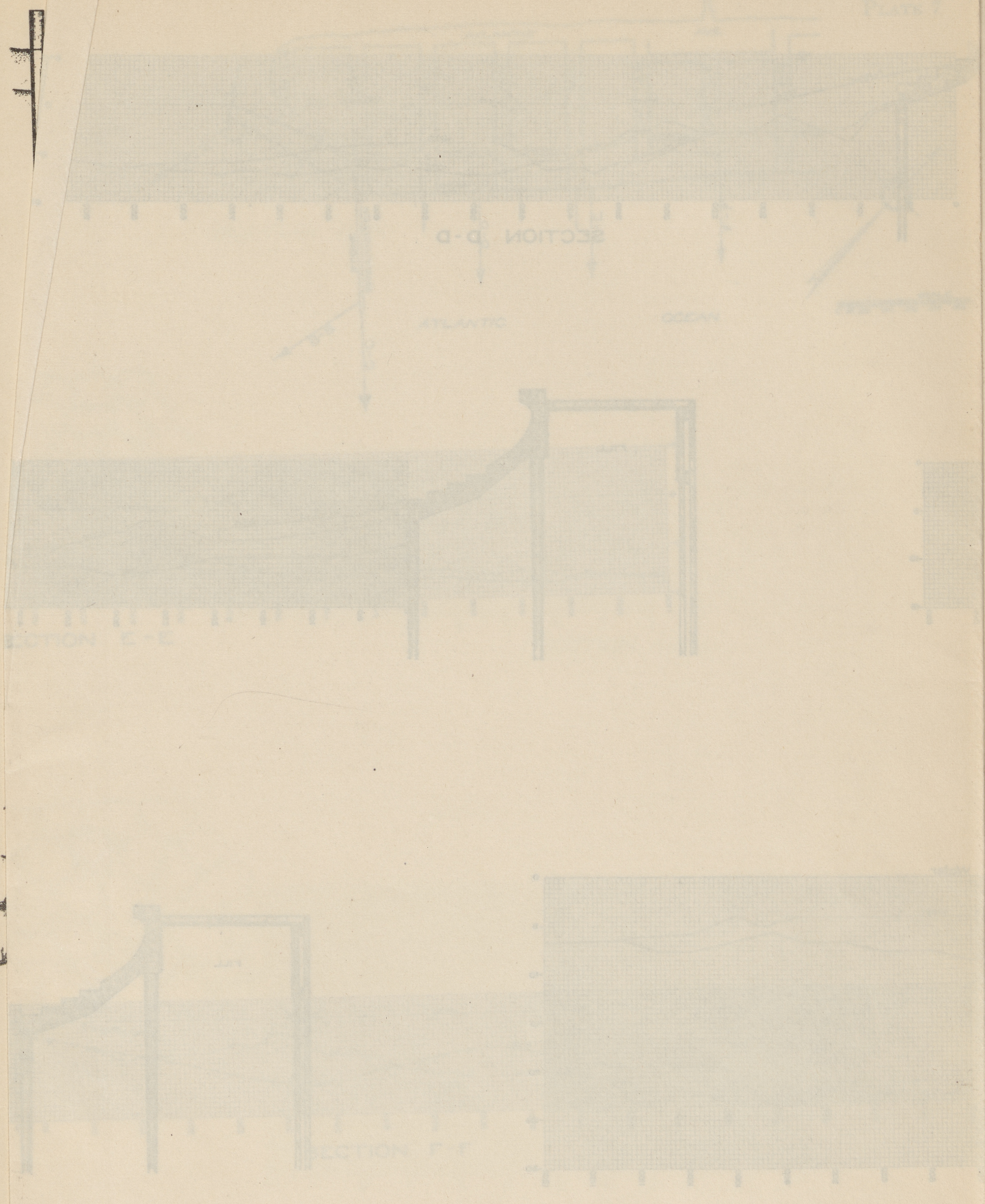
MARCH 16, 1924.

Walter G. Oliverson
DIRECTOR AND CHIEF ENGINEER

SURVEYED BY
Robert Simon
ASSISTANT ENGINEER

PLOTTED AND DRAWN BY
Kenneth R. Taylor
ASSISTANT ENGINEER

SCALE



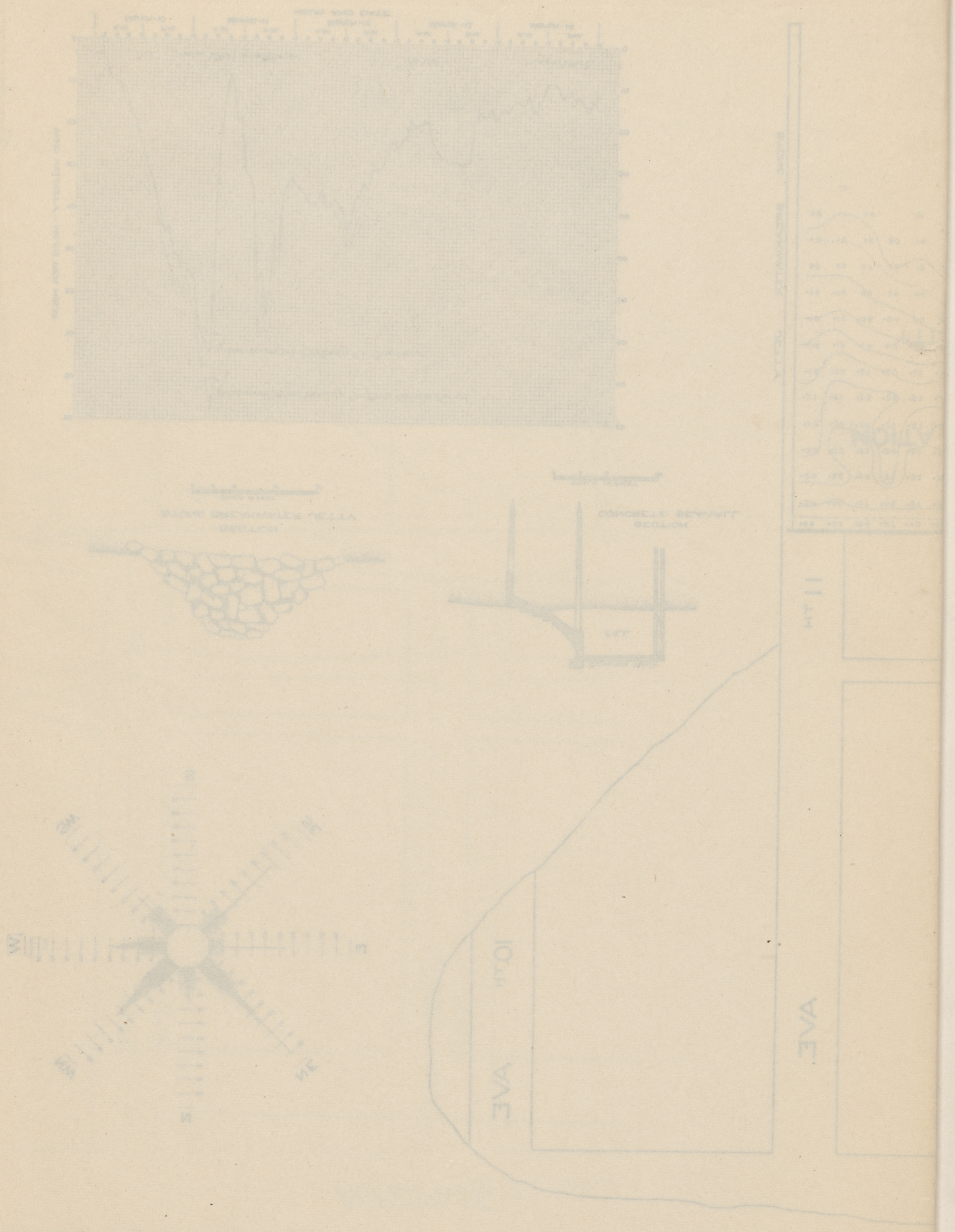
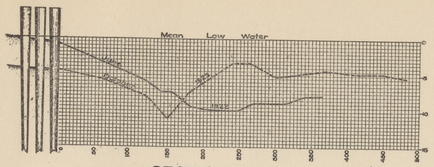
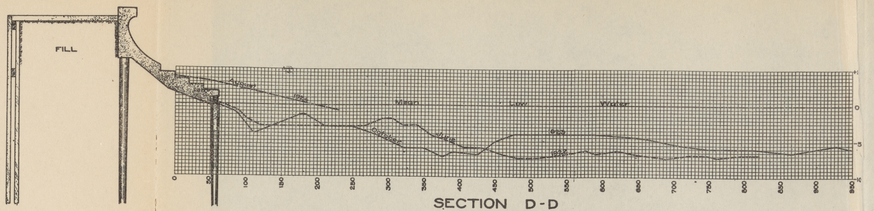


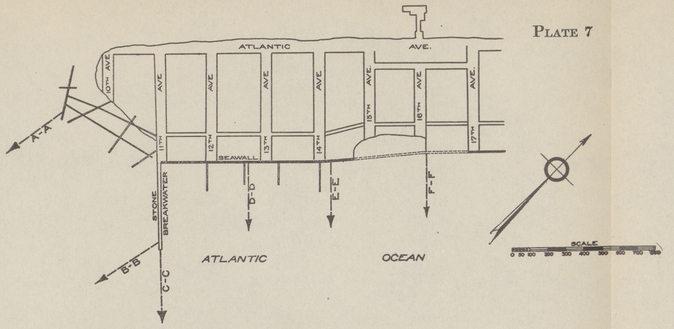
PLATE 7

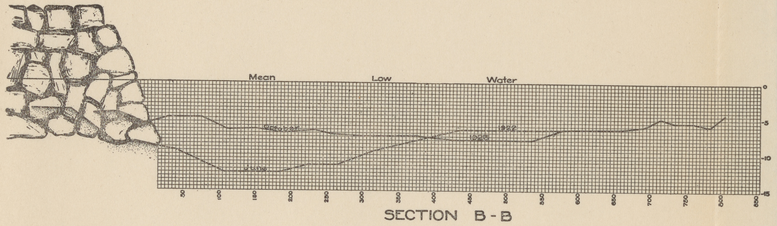


SECTION A-A

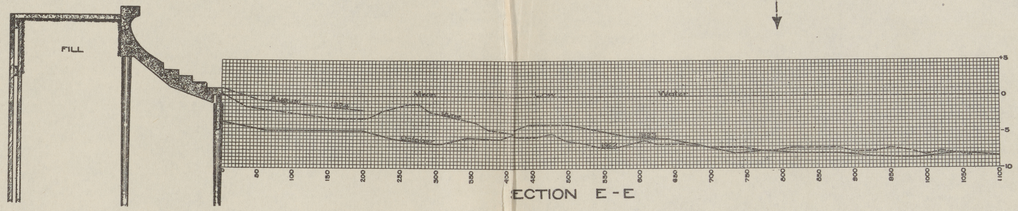


SECTION D-D

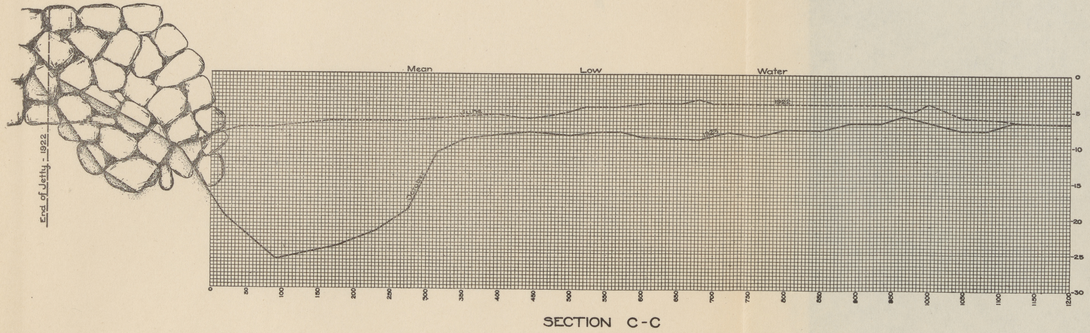




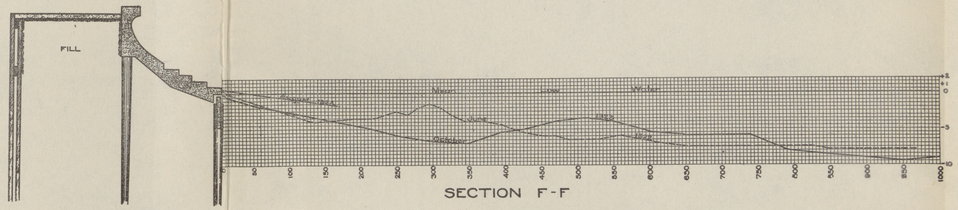
SECTION B-B



SECTION E-E



SECTION C-C



SECTION F-F

STATE OF NEW JERSEY ~ BOARD OF COMMERCE AND NAVIGATION
PLAN - SHOWING - OPERATION - OF - COAST - PROTECTION - DEVICES - AT - LONGPORT - N.J.

SCALES

HORIZONTAL 0 10 20 30 40 50 100 150 200

VERTICAL 0 1 2 3 4 5 10 15 20

Victor Dalmeau
DIRECTOR AND CHIEF ENGINEER

DRAWN BY
Raymond L. Tooker
ASSISTANT ENGINEER