GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 6.

Annual Administrative Report

OF THE

STATE GEOLOGIST

For the Year 1911

INCLUDING A REPORT ON

SHARK RIVER INLET

By C. C. Vermeule, Consulting Engineer

TRENTON, N. J.
MacCrellish & Quigley, Printers, Opposite Post Office.

1912.

The Geological Survey of New Jersey.

BOARD OF MANAGERS.

HIS EXCELLENCY WOODROW WILSON, Governor and *ex officio* President of the Board,...Trenton

Members at Large.

HARRISON VAN DUYNE,	Newark,	1912
JOHN C. SMOCK,	Trenton,	1913
ALFRED A. WOODHULL,	Princeton,	1914
FRANK VANDERPOEL,	Orange,	1914
T. FRANK APPLEBY,	Asbury Park,	1915
DAVID E. TITSWORTH,	Plainfield,	1916
WILLIAM LIBBEY,	Princeton,	1916

Congressional Districts.

I.	STEPHEN PFEIL,	Camden,	1916
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III.	HENRY S. WASHINGTON,	Locust,	1914
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IX.	JOSEPH D. BEDLE,	Jersey City,	1913
X.	CLARENCE G. MEEKS,	Weehawken,	1915

State Geologist,

HENRY B. KÜMMEL.

Letter of Transmittal.

TRENTON, N. J., February 13, 1912.

Hon. Woodrow Wilson, Governor, and ex officio President of the Board of Managers of the Geological Survey:

SIR--I have the honor to submit by Administrative Report summarizing the work of the Geogological for the year 1911. This report is made in accordance with Chapter 46 of the Laws of 1911. Later in the year I shall submit, for publication, scientific bulletins giving in detail the results of the Survey's investigations.

Yours respectfully,

HENRY B. KÜMMEL,

State Geologist.

Administrative Report.

HENRY B. KÜMMEL, STATE GEOLOGIST.

Contents.

ADMINISTRATION.

The lines of work prosecuted by the State Geological Survey do not differ greatly from year to year, so that there is little opportunity for anything new in the Annual Administrative Report which the State Geologist is by custom and by law required to present to the Legislature. Perusal of the following pages, however, will convince the reader that the activities of the Survey are manifold. For more detailed information regarding the results of the Survey's investigations, reference is made to the technical reports published from time to time as Bulletins and Final Reports. Copies of these can usually be obtained upon request, at no expense beyond the cost of transportation, except in the case of reports the remaining copies of which are less than 200. These are sold at cost of printing and binding.

Expenditures-The appropriation for the support of the Survey is voted annually by the Legislature in the regular appropriation bill. For the fiscal year ending October 31, 1911, it was $16,500. The expenditure of this sum is made under the direction of the State Geologist, subject to the general direction of the Board of Managers and the immediate audit of a committee of the Board, who examine and sign all bills before payment. A tentative budget covering the proposed expenditures was approved by the Board early in the year. It was recognized, however, that the best interests of the Survey might demand some modifications in detail as the work progressed, so that authority was given the State Geologist to make such changes as he deemed best. The disbursements were as follows:

Salaries of State Geologist and scientific staff,	$10,652 35
Salaries of clerical assistants,	1,801 05
Traveling expenses,	941 40
Office furniture,	81 00
Office supplies,	324 50
Laboratory equipment,	133 24
Laboratory supplies,	403 62
Library,	33 65
Museum supplies,	28 75
Postage,	308 04
Express,	111 67
Telegraph,	1 43
Telephone	36 25
Engraving and printing maps,	1,331 05
Sundries,	45 28
	$16,233 28
Lapsed to State Treasurer,	266 72
	$16,500 00

In addition to the money received from the Legislature, the Survey received and disbursed the following sums:

Balance on hand at beginning of fiscal year,	$77 85
Sale of maps, reports, etc.,	1,008 22
For analyses made at laboratory,	40 00
	$1,126 07
Paid State Treasurer	1,062 62
Balance on hand due State Treasurer, November 1,	$63 45

Organization.---Several changes were made during the year in the membership of the Board of Managers, in whom is vested the general oversight of the Survey. The following appointments were made by the Governor and confirmed by the Senate for terms ending April 21, 1916: Stephen Pfeil, Camden, First Congressional District, in place of Frederic R. Brace of Blackwood, deceased; George W. Wheeler, Hackensack, reappointed, Sixth Congressional District; David E. Titsworth, Plainfield, Member-at-Large, reappointed, and William Libbey, Princeton, Member-at-Large, in place of George W. Tennant, Jersey City, whose term had expired and whose other public duties were such that he could not serve longer on the Board.

Six members of the Survey staff are continuously employed; the others are on a per diem basis and are engaged upon Survey work as occasion demands. In addition to these, several employes of Mr. Vermeule were engaged on Survey work as in previous years, but under a ruling of the Civil Service Commission these are not regarded as on the Survey staff. The following persons were employed during the last fiscal year:

Henry B. Kümmel, State Geologist.
R. B. Gage, Chemist.
Laura Lee, Clerk and Stenographer.
S. Percy Jones, Geologist.
Howard M. Poland, Assistant in charge of collection of well data.
John S. Clark, General Assistant.
R. D. Salisbury, Geologist.
J. Volney Lewis, Geologist.
W. S. Bayley, Geologist.
E. W. Berry, Paleobotanist.
Henry S. Fowler, Paleontologist.
D. W. Johnson, Geographer.
C. C. Vermeule, Topographer and Consulting Engineer.
H. D. Leslie, Assistant on Soil Survey.
W. W. Oley, Assistant on Soil Survey.
I. V. Stone, Assistant on Soil Survey.
Ray Pinkel, Assistant on Soil Survey.
Theodore Van Winkle, Assistant on Soil Survey.

John G, Baumann, Janitor at Laboratory.

Publications.--During the year the Survey began a new series of publications designed to replace the "Annual Reports" previously published, which included not only an administrative report but also scientific papers on various topics. This action is in accord with the spirit of Chapter 46, Laws of 1910, which recognizes the difference between these classes of reports. Each paper is now published as a separate report and makes one of a series of bulletins, the first five of which have been published.

This modification of the plan of publication necessitated a rearrangement of the Survey mailing list in order that each person on the list might receive only those classes of reports in which he was interested. A circular letter was sent explaining the change and asking correspondents to indicate their wishes. The replies were then classified and stencil lists were prepared for each of the classes and an addressing machine purchased, so that now the bulletins can be distributed promptly and rapidly. Owing, however, to these changes in the mailing system it was necessary to defer the distribution of most of the reports until after the close of the fiscal year.

The publications of the year were as follows:

Map showing the distribution of the iron mines of the State and their geologic relations, in two sheets, to accompany Vol. VI, the Report on Iron Mines.

Sheets Nos. 30 and 34 of the one inch per mile topographical atlas, new and revised edition.

Bulletin I.-The Administrative Report of the State Geologist for 1910. In January.

Bulletin II.-A Report on the Approximate Cost of a Canal between Bay Head and the Shrewsbury River, Henry B. Kümmel. In February.

Bulletin III.-The Flora of the Raritan Formation, Edward W. Berry, In October.

Bulletin IV.-A Description of the Fossil Fish Remains of the Cretaceous, Eocene and Miocene Formations of New Jersey, Henry W. Fowler. In October.

Bulletin V.-The Mineral Industry of New Jersey for 1910, Henry B. Kümmel and S. Percy Jones. In October.

Distribution.--The demand for the maps and reports of the Survey continues with little variation. The topographic maps are sold at the uniform price of twenty-five cents per sheet which includes postage, while the geologic folios cost from twenty-five to fifty cents, postage extra. No charge is made for the reports of the Survey except in the case of some volumes of which only a few copies remain on hand for distribution. These are sold at cost price. Recipients are requested to pay the cost of transportation of certain of the larger volumes.

The following is a list of the reports which can be obtained only by purchase:

Annual Report for 1883, ...Price $0 50
Annual Report for 1892, ... Price 1 55
Annual Report for 1903, ... Price 40
Annual Report for 1905, ... Price 1 55
Paleontology, Vol. I-Brachiopoda and Lamellibranchiatia of the Raritan Clays and Greensand Marls of New Jersey. To residents of New Jersey, by express, charges collect; to non-residents, $1.50, charges prepaid.
Paleontology, Vol. II-Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey. To residents, by express, charges collect; to non-residents, $1.40, charges prepaid.
Paleontology, Vol. III-Paleozoic Paleontology, ... Price, $1 00
Paleontology, Vol. IV-Cretaceous Paleontology, ... " 2 70
Final Reports, Vol II, Pt. I-Mineralogy, Botany, bound, price $1.50; unbound, postage 25 cents.
Final Reports, Vol. IV-Report on the Physical Geography of New Jersey, paper cover, price $1.00; bound, price $1.35; photo-relief map, $1.50 extra.
Final Reports, Vol. V-Report on Clay Industry of New Jersey, bound $1.60.

The sale of maps by the Survey during the past three years has been as follows:

	Sheets sold.		
	1909	1910	1911
Maps on scale of 1 inch per mile,	1435	1485	1491
Maps on scale of 2½ inches per mile	2205	2039	2096
Geologic folios	246	150	65
	3886	3674	3652

Owing to the delay caused by the rearrangement of the mailing list and cutting stencils for use in an addressing machine, the distribution of bulletins issued during the year was delayed and most of them were not sent out until after the close of the year. The total number of reports distributed was, therefore, only 1,303, a number less than one-third as many as in previous years.

Library.----The Survey library continues to increase chiefly by exchange, but to some extent by purchase. It now numbers 1,006 bound volumes, 3,943 unbound volumes and pamphlets and 3,724 maps. During the year the accessions were 62 bound volumes, 207 paper-covered volumes and pamphlets and 126 maps and atlases.

Property Records.--In May the Board of Managers instructed the State Geologist to prepare an inventory of the property of the Survey and to recommend a plan for keeping property records which would show the property on hand and the person responsible for its keeping. Certain classes of property, as stationery, are consumed in the using; other kinds, although somewhat more permanent, within a short period wear out or are broken in use. This includes many classes of chemical apparatus; other kinds are permanent or nearly so and remain on hand indefinitely. It was essential that the system to be adopted take account of the different classes of property, that it be elastic enough to meet future demands, and that it be simple enough not to add greatly to the clerical work of any member of the office force, for manifestly it would not be good management to spend more money in keeping track of property than the value of the property that might be lost or improperly used through lack of such attention. Complicated systems applicable to large organizations may easily prove too cumbersome and expensive for smaller bodies, where the responsibility is divided among only a few persons at most.

The system finally adopted was to enter each article or class of articles (where there are several of one kind) on pages of a loose-leaf note book, measuring 5 x 8 inches. These are ruled so as to show date of purchase, number purchased, cost, name of person to whom charged, number charged, condition, and final disposition. The property of the Survey is regarded as expendable and non-expendable. Expendable property includes all articles which are perishable or which, when applied to official use, are consumed or are made an essential part of an article otherwise accounted for. Other classes of property are classed as non-expendable. Monthly abstracts will be made of all non-expendable property purchased, each article entered in the property book and charged to the proper person. Transfers, loss or destruction of property are to be reported in writing to the property clerk and, upon the approval of the State Geologist, are posted in the record. When this is done the person charged with them is relieved of responsibility therefor.

Note-Taking.--During the year much thought has been given to devising a system of note-taking for field observations by which the exact locality of the observation can be recorded precisely, briefly, and in such a way as to be intelligible to future workers in the same field. The common practice of a dot and arbitrary number on the field map, with a corresponding number in the note book fails completely if the field map becomes separated from the note book, or when the number of entries is so large that several figures have to be used on the map for each locality. Some method was needed by which it would always be possible to fix the location on any copy of the State Atlas, irrespective of whether it was the original field map or not. Museum specimens and well records thus labeled could always be referred back to their proper location if necessary. A modification of the system suggested several years ago by Prof. J. F. Kemp was finally adopted, and in the field work of the past season it was given a thorough test and found successful. In order that there may be a formal record of it for future reference it is here described in full.

The engraved atlas sheets on the scale of 1 inch per mile form the basis of the system. These sheets are numbered from 21 to 37, inclusive. Except No. 37, which overlaps parts of Nos. 35 and 36, they match edge to edge and there is no duplication of areas on different sheets. On these sheets lines of latitude and longitude are engraved at two-minute intervals, so the sheets are already divided into rectangles each representing two minutes of latitude and two minutes of longitude, and each measuring from east to west about 1 3/4 inches and from north to south about 2 1/4 inches. Since each of the atlas sheets comprises 26 degrees of longitude and 28 degrees of latitude, there are 13 of these rectangles from east to west and 14 from north to south.

Beginning at the upper left-hand corner every third engraved line of longitude and of latitude is over ruled in red ink. The effect of this is to divide the sheet into 16 rectangles each about 5 1/4 inches from east to vest and 6 3/4 inches from north to south, and each containing nine of the smaller 2-minute rectangles. These may be briefly called 6-minute rectangles, since they measure six minutes of latitude and longitude on a side. In addition to the 16 complete 6-minute rectangles there is along the right-hand side of the sheet a single row of the 2-minute rectangles and along the bottom a double row. Beginning in the upper left-hand corner these large rectangles are numbered across the sheet 1 to 5, inclusive, the incomplete one at the right being 5. Those of the second row are numbered 10 to 15, those of the third row 21 to 25, of the fourth row 31 to 35 and the

1	2	3	4	5
11	12	13	14	15
21	22	23	24	25
31	32	33	34	35
41	42	43	44	45

Figure 1.

incomplete rectangles at the bottom containing only six of the 2-minute rectangles, 51 to 55. Figure I illustrates on a small scale the arrangement and numbering of these squares which form the primary divisions of each atlas sheet. The nine 2-minute rectangles in each of these are numbered from 1 to 9 beginning in the upper left-hand corner, and numbering to the right, 4 being on the left under 1. The subdivisions of the incomplete rectangles at the right are numbered 1.4.7; of those at the bottom 1.2.3.4.5.6. and of that at the lower right corner 1.4. The manner of numbering these subdivisions is shown in Figure 2. The 2-minute rectangles constitute the secondary subdivisions of the atlas sheet. Each side of the 2-minute rectangles is then divided into three, making nine tertiary subdivisions each measuring about 5/8ths of an inch from east to west and 3/4ths of an inch from north to south and each representing

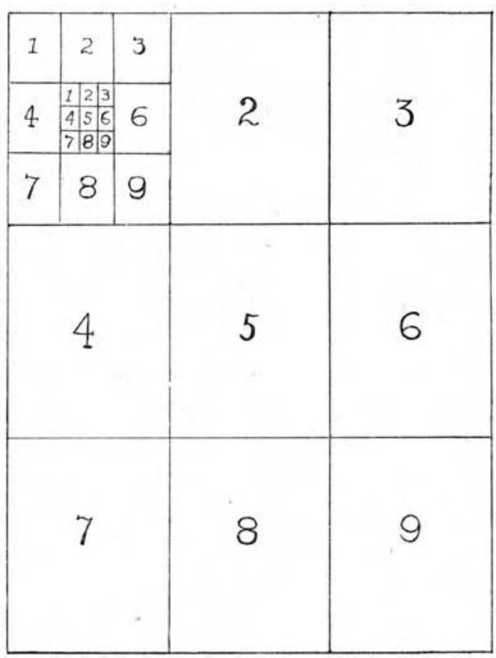


Figure 2.

an area 5/8ths by 3/4ths miles. These are numbered 1 to 9 the same as the secondary divisions.

A further subdivision of each of these rectangles is necessary in order to fix locations accurately and these are likewise numbered from 1 to 9. By this process the atlas sheet is divided into small rectangles each representing an area about 330 yards from east to west and 440 yards from north to south. Figure 2 represents a 6-minute rectangle divided into the 2-minute rectangles, with the tertiary subdivisions of one numbered and one of these again divided into the still smaller rectangles. By writing first the number of the atlas sheet, and then the number of each of the rectangles in order of magnitude, it is possible to give to each of these smallest divisions a number of its own, different from that of any other area in the State. This number can he applied to it quickly and without difficulty, or given a number, the corresponding area can be located quickly on any atlas sheet. In actual practice it has not been found necessary to rule upon the field maps any lines subdividing the 2-minute rectangles. The smaller divisions can be more conveniently ruled and numbered upon a small piece of tracing cloth or of transparent celluloid, which can be laid upon the map in the desired position and from which the smaller numbers can be read. When not in use this is conveniently carried in a pocket in the cover of the note book. In practice a dot is made on the field map at the point of observation, the number of the atlas sheet, of the 6-minute rectangle and of the 2-minute rectangle is entered in the note book from the map. The transparent guide is laid on the map and fitted to the boundaries of the 2-minute rectangle, then the numbers of the two smaller divisions are read off.

If the entry were 32.1.3.9.9. the locality would be on Atlas Sheet No. 32 in the 6-minute rectangle No. 1 (in the upper left-hand corner), in 2-minute rectangle No. 3 (in the upper right-hand corner), and again in subdivision 9 (in the extreme south-eastern part). The actual locality is about 1 mile east by south of Pemberton, Burlington County.

If still greater accuracy is required a small rectangle, the size of the smallest subdivision can be drawn in the note book following the numerical entry and in this a dot placed showing the actual location.

If on the field map it is desirable to make reference to the note book, the number of the note book and the page can be written as a fraction as, for instance, 3/4 close to the dot indicating the locality, the numerator giving the note book number, the denominator the page.

Since the boundaries of the 2-minute rectangles are already engraved on the map and the smaller rectangles are not in practice shown, it is necessary only to outline the 6-minute rectangles by strengthening certain engraved lines. While this is convenient, it can be omitted, and with a little extra care localities can be given their proper number without it. The transparent guides, however, are essential to correct work.

Inasmuch as the lines of longitudes converge northward, the 2-minute rectangles are not quite so wide along the northern tier of the State as at the south end of Cape May. The difference, however, is but slight, and if the guides are ruled to fit rectangles midway of the State from north to south the error is barely noticeable. In fact, it may be more than compensated for by changes in the paper with changing weather.

A complication arises in the case of Sheet 37 which overlaps the two sheets north of it--Nos. 35 and 36. This is met by giving the repeated sections of No. 37 the numbers they have as parts of Atlas Sheets 35 and 36, and regarding Sheet 37 as beginning at latitude 39° 04', the southern limit of Nos. 35 and 36.

A great advantage of this system is the fact that it can be applied when copies of the original projection sheets are used as field maps, as is often the case. Since these copies are on a scale of three inches per mile, or three times the engraved sheets, the 2-minute rectangle on the larger scale is exactly the same size as the 6-minute rectangle on the engraved sheets, and the smallest subdivision (330 by 440 yards) is the same size as the next largest division of the engraved map. Hence the same transparent guides can be used, only in that case their smallest divisions are ignored. The field map is ruled in 2-minute rectangles, which are numbered to correspond to the engraved sheets of the same area.

This plan was given a thorough test during the past season by several persons in field work and was found to be far superior to any other heretofore used. The fact that all members of the Survey staff are using the same system is in itself a great advantage.

TOPOGRAPHIC WORK.

Mr. C. C. Vermeule has continued in charge of the topographic work of the Survey. Mr. P. D. Staats has been his chief assistant.

Leveling.-Late in the autumn a line of exact levels was run in the southern part of the State under Mr. Vernleule's direction. The purpose of this work was to determine if possible whether or not any appreciable warping of the earth's crust had occurred in that region since the lines of levels were first run, about twenty-five years ago. Mr. Vermeule's report is as follows:

"NEW YORK, December 14. 1911.

"Dr. H. B. Kümmel, State Geologist, Trenton, N.J.:

"DEAR SIR-I beg to report as follows concerning the leveling operations in the southern part of the State executed during the past autumn:

"Mr. Peter D. Staats, assisted by a competent and careful rodman, Mr. Joseph H. Smith, began leveling at Cape May Court House October 4th and completed the field work November 6th. The levels ran from Cape May Court House along or near the line of the West Jersey Railroad, through Sea Isle Junction and Millville to Vineland and Newfield Junction; thence returning along or near the line of the West Jersey and Atlantic Railroad through Mays Landing to Absecon and Atlantic City. There was also a branch line run from Sea Isle Junction to Sea Isle City, 6 miles, which, together with the 84 miles included in the line first described, made a total distance of 90 miles. Of this, 19 miles was run over a second time in order to check possible errors, making the whole distance leveled 109 miles. The whole period covered 39 working days, of which 5 days were lost through rain or high winds, leaving 34 working days, so that the actual rate of leveling was 3.2 miles per day.

"The instrument used was a 15-inch Gurley Y level, being a duplicate of the level used for the original work of primary leveling executed in 1885 and 1886. The instrument was carefully adjusted, and care was taken to equalize, so far as possible, the fore and back sights and to check each reading as made. In all respects the methods adopted and precautions taken were identical with those adopted when the original line of primary levels were run over this same route in 1886. The original levels were run along the railroad lines, but the traffic at present is much more frequent than in 1886, owing to the introduction of electricity over the larger part of the route, and also working along the railroad line is now more dangerous because of the third rail. Furthermore, the improvement of the highways along and near the route made it much more feasible to use these; consequently the levels were not confined closely to the railroad lines, but in many cases they diverged to highways parallel with and near to the railroads.

"A complete list of the primary bench marks along this route will be found in Volume IV, The Physical Geography of New Jersey, 1898, under Cape May County, page 43; Cumberland County, page 44, and Atlantic County, page 33. The primary purpose of the recent work was to compare the present elevations of these primary bench marks with the elevations as determined in 1886. However, readings were taken at a number of secondary bench marks, mainly on the head of the rail, at various crossings and stations, but these proved of little value for comarison, owing to the fact that regrading and reballasting of the railroad had changed the bench mark in practically every case. For this reason the figures on these secondary bench marks are not given, as they may create confusion and interfere with the primary purpose of the leveling.

"The following table gives the comparative elevations as determined from the levels of 1886 and the levels taken in the present year:

Bench Mark	Elevation 1886.	Elevation 1911.	Difference.
Cape May Court House	19.498	....	....
Sea Isle City	9.151	9.033	-0.118
Millville National Bank	33.450	33.453	+0.003
Vineland--West Jersey Station	108.10	108.082	-0.018
Mays Landing--Court House	19.89	19.790	-0.100
Absecon--M. E. Church	30.660	30.638	-0.022
Atlantic City--Absecon Light House	8.954	8.931	-0.023

"Of the foregoing bench marks, those at Cape May Court House and Sea Isle City are each stone posts set in concrete, as described particularly in the Annual Report for 1885, page 15. The Sea Isle City bench mark, however, had to be moved some years after the original levels were run, in order to make way for improvements on the lighthouse lot, and at that time its elevation was redetermined from the elevation at the original location. The other bench marks are all on buildings, and the last one at Atlantic City is a bench mark of the U. S. Coast and Geodetic Survey, cut on the northwest side of the base of the Absecon lighthouse. All of these bench marks are in satisfactory condition and may be considered not to have changed appreciably since the running of the original levels.

"It will be seen that the agreement between the levels of the present year and the original levels of 1886 is extremely close and entirely within the probable error of the observations.

"The agreement throughout is such that, it may be assumed that there has been no important relative change of elevation between these several bench marks during the interval from 1886 to 1911.

"It appears timely and pertinent in this connection to call your attention to the fact that, owing to the conditions of strict economy enforced upon the Survey during the prosecution of the original topographic work, for the control of which these primary levels were originally executed, it was impossible to expend any large sum of money in setting bench marks. Eighteen substantial bench marks were set along the seashore between Sandy Hook and Cape May, but elsewhere we were forced to depend upon the more permanent structures, such as bridges and buildings which were available along the route of our primary levels. A far smaller number of such permanent structures existed twenty-five years ago, when the work was done, than are available at the present time, and the primary bench marks for this reason were not as numerous as it is now possible and perhaps desirable to make them. A considerable percentage of the bench marks originally established have either disappeared or become unreliable, owing to the removal or settlement of the structures.

It would, therefore, appear that it might be desirable at the present time to establish a very considerable number of additional bench marks upon the larger number of durable structures now available for that purpose. If this is done at the present time, we shall be able to utilize all of the primary bench marks which now continue in existence. If it is deferred for any considerable period, you can appreciate that the number of these bench marks available will continually decrease, and an increasing percentage of the value to be derived from the original primary levels will disappear.

"I am not convinced by experience that the setting of special permanent bench marks is likely to give substantially better results than the utilizing of existing structures. Of the eighteen bench marks originally set, we have already found it necessary to re-establish two, and it is very difficult to find locations for such marks which will be secure against possible future interference through grading operations or the using of the location for buildings or other structures. It does not seem that such bench marks will be substantially more permanent than bench marks on the more durable bridges and public buildings, whereas they will be very considerably more expensive.

"Respectfully submitted,

"C. C. VERMEULE."

GEOLOGIC WORK.

Report on plant remains of the Raritan clays.--For several years a small allotment was made to Mr. E. W. Berry, of Johns Hopkins University, to enable him to collect and study the plant remains which are found in the Raritan clay deposits.

The Raritan formation appears at the surface in a narrow belt extending across the State from Woodbridge and South Ambov on Raritan Bay, to Trenton and thence along Delaware River to Salem County. Over much of this distance it is covered by a layer of yellow gravel of variable thickness and very much younger in age, so that even within this belt it is exposed only at intervals in clay pits or in natural sections along stream banks. The best exposures are in Middlesex County where it is extensively mined in enormous pits. It is also shown in numerous pits near Trenton and at various points in the bluffs along Delaware River and its tributaries south of Trenton.

The Raritan formation is made up for the most part of alternating beds of clay and sand with local lignitic deposits and gravel. The clays are of variable kinds, some sandy, some containing lignite and iron pyrite, some fat; some are suitable only for the manufacture of fireproofing, hollow brick or common building brick: others are available for architectural terra cotta and some are white high-grade fire clays. These clays have been fully described and their occurrence shown in the Report on Clays, Volume VI, of the Survey Reports.

Borings have shown that the Raritan formation continues southeast from the narrow belt along which it outcrops and that in this direction it is overlain by other beds of clay and sand which were deposited at successively later periods. Since these formations all slant gently to the southeast the Raritan beds occur at constantly greater depths in that direction until along the oceanward side of the State, as at Atlantic City, they are approximately 2,300 below sea level.

Certain layers of this formation have long been known to contain plant remains, the first fossil plant from it having been described by Conrad from the banks of South River in 1869. The leaf impressions in the clays early attracted the attention of Dr. George H. Cook, then State Geologist, and collections were made. In the Clay Report of the State Survey, issued in 1878, a certain layer of clay in the vicinity of Woodbridge was called the "leaf bed" and a list of species identified by Professor Lesquereaux was published in that report. In 1896, the U. S. Geological Survey published an elaborate posthumous work by Professor Newberry on the Flora of the Amboy Clays, which included, however, some species outside the Raritan formation. The interval of time since the termination of Newberry's active work upon these plant remains and the prodigious progress in this country both in geology and paleobotany in the last two decades has made it possible for Mr. Berry by his recent studies to add much to our knowledge of this subject. In these studies he had access to all of Professor Newberry's types, as well as to much other material, some of it collected by himself.

In his report, Mr. Berry, after describing the Raritan formation and giving a brief sketch of previous investigations, discusses its place in the geological column and its correlation with European formations as indicated by the plant remains. He regards it as equivalent to a part of the upper Cenomanian of Europe. The present enumeration of Raritan plants embraces between 160 and 170 species, the botanical relations of a few of which are unknown. The balance belong to the following great botanical families. One fungus and one alga are recognized, although probably many others existed. There are nine species of fern plants (pteridophytes). The great bulk of them belong to the seed plants (spermatophytae), and of these 24 to the gymnospermae or naked seed plants, which is almost twice as many as are present in the recent flora of the State. During the period when the Raritan clay was being formed, the gymnosperms were therefore relatively much more abundant both in individuals and in species than in recent floras. Two of these belonged to that very singular order whose sole surviving represenative is the Maidenhair tree, indigenous in eastern Asia, but not infrequently cultivated as an ornamental tree in our parks. There were also two or three species of the Sequoia which are now represented by the giant redwoods of the Pacific coast. The angiosperms, usually called "flowering plants," make up the balance of the flora, all of them being dicotyledons except a single species. Among these were represented the figs, magnolias, tulip trees, laurel, cinnamon and other forms referred to modern genera, but not to modern species.

While the flora as a whole differs from any modern American flora with which it may he compared, it is distinctly suggestive of existing floras. That is the same plant groups which dominate in the present flora of the globe are largely represented. Of the 78 known genera from the Raritan only 32 are extinct. and 11 of these are gymnosperms or lower plants. Not a few genera, however, although not extinct, are not now found in New Jersey. In fact, some of them found here in Raritan time are now restricted to the Southern hemisphere.

Mr. Berry points out that species identical with those found in New Jersey occurred also as far north as Greenland and as far south as Alabama. From this it can be safely inferred that the climate of that period was very different as a whole from the present one. It was certainly more uniform than at present, both as regards seasonable changes and zonal differentiation.

One of the most interesting of the author's suggestions is that this flora originated in the Arctic area and spread thence to North America, Europe and Asia, so that we may tentatively picture successive waves of plant migration sweeping southward from the polar regions.

The greater portion of the report is taken up with a detailed description of the plant remains, the more characteristic species or the forms never before described or figured being illustrated. The report was published as Bulletin III.

Report on the fish remains of the Cretaceous, Eocene and Miocene formations of New Jersey.--The greensand marl beds of southern New Jersey have been the prolific source of fish remains as well as of other fossils. Shark's teeth ranging in size from a small fraction of an inch to huge affairs 5 inches or more in length were preserved in great numbers and are now found in many collections. No shark of modern times approached in size the giant *Carcharodon polygurus* which swam the seas then covering the southern portion of our State. Its length is estimated to have been between 85 and 90 feet, or over twice the length of the largest known existing fish. The cutting edges of its teeth were serrated and often very sharp. This monster was widely distributed in the Cretaceous and Tertiary seas of long ago, and its fierce search for food must have rendered incessant the butchery of the majority of aquatic animals. Besides this giant, twenty-eight other species of sharks have been recognized from the remains found in the marl pits of the State, but no one of these is known to exist at the present day, although in many instances they are represented to-day by closely allied forms.

Sharks, however, are not the only fish whose remains have been found in these deposits. Rays, with their broad, flat, disk-like bodies and slender tails, swam along the ocean bottom, and with their large grinding teeth crushed the thick-shelled mollusks whose shells we also find in innumerable numbers in the marl beds. The existing species, about 15, are large sting-rays, which are found in most all warm seas, but about 80 extinct species have been described, of which 10 are known to have lived in this region and have been identified by their dental plates. One of the largest of these plates, measuring 61/2 inches in length and 4 inches in width, from the Shiloh marl of Cumberland County, was sent to the Survey in 1880 by Isaac Smalley. For thirty years it remained in the collections unidentified until examined last year by Mr. Fowler. He was unable to correlate it with any species heretofore recognized and therefore it was described as a new species of the genus Myliobatis.

Teeth of an allied form were recently found in boring a well at Fortesque Beach, on Delaware Bay, at a depth of 214 feet, showing that since the lifetime of the fish at least that amount of sediment had accumulated in that vicinity. In fact, beds to a much greater thickness than 200 feet have been formed, for since these remains were deposited there have been long periods of erosion as well as deposition, and the depth of sediments in which they are now interred indicates not the total deposition since that period, but the difference between deposition and erosion.

Other fish are represented by fragments of bones--vertebrae or jaw bones chiefly-and a few by spines, or scales. In no case have any complete skeletons nor impressions of the body been preserved, as was the case with the earlier fish found at Boonton in the shale beds of the Newark or red sandstone formation. The great difference in this respect will be seen by a comparison of the illustrations accompanying the report by Dr. Eastman on the Triassic Fishes, published in the Annual Report of the State Geologist for 1904, and those accompanying Mr. Fowler's paper on the Cretaceous and Tertiary fish, recently published as Bulletin 4. In the former case the remains were interred in sediment which was soon consolidated into hard rock and in which the outlines of the body, fins, scales, etc., were perfectly preserved, in some instances the most delicate markings being now clearly visible. The later deposits, on the contrary, have never been consolidated into rock, but have remained soft and incoherent. Near the surface they have been subject to the leaching action of underground waters, which have largely carried away much of the soluble compounds. Only the more indestructible portions of the skeletons, such as teeth with their coating of enamel, have commonly been preserved.

In the preparation of his report, Mr. Fowler had access to the collections of the Academy of Sciences of Philadelphia, where much of the material collected from the marl beds has been preserved. Some is in the Geological Survey Museum. His report gives a descriptive summary of the fish remains, many of which had not before been studied. In most cases each species has been illustrated and described from the specimens, although in some cases it was necessary to use the original accounts by other workers. While the report is quite technical and, perhaps, of not great interest to the general reader, it is a valuable work of reference and a summary description of these remains as now known from New Jersey.

Mineral production.--New Jersey is not commonly regarded as a State of great mineral wealth. Neither gold, silver, lead, copper, coal, oil nor gas are mined within her borders in commercial quantities. Nevertheless, the value of her mineral products as shown by statistics collected jointly by the Federal and State Surveys amounted to $35,184,692 in 1910, or $4,278 per square mile of territory. The mineral production per square mile of Pennsylvania in 1909 was about $12,254; of New York, about $1,324; of Ohio, $4,704; of Illinois, $2,525; of California, $505; of Colorado, $569; of Alabama, $803, and of West Virginia, $3,598. The above comparison favors New Jersey slightly in that the production of 1910 was used for this State and of 1909 for the others. Returns for 1910 would probably show slightly larger production in the case of the States cited and so raise their per mile production slightly, but it would not affect the general result. Of all the States in the Union only two--Pennsylvania and Ohio--exceed New Jersey in value of their mineral production per square mile. On this basis many of the great western commonwealths, like Colorado, California, Utah, which we are wont to consider as the great mining States, are found to have a production of only one-eighth or one-tenth that of New Jersey. In the face of these figures it may be well to revise our opinion and recognize the position New Jersey in reality holds.

It is true that these figures of mineral production relate in some instances not to the raw material but to the first manufactured product, and in a comparison between States it sometimes happens that one State is credited with a manufactured product, the raw material of which comes from another State. Thus in the figures cited Pennsylvania gets credit for $179,000,000 of pig iron, the ore of which came chiefly from Minnesota and Michigan. Some of the raw materials contributing to New Jersey's clay industry which totaled upwards of $18,400,000 were not mined here. In spite, however, of these limitations the comparison is an instructive one and shows that New Jersey ranks very high among the States in mineral wealth.

Well records.--The collection of data regarding the underground water of the State has been continued by H. M. Poland. Ninety-seven new well records and 42 sets of samples have been obtained through the courtesy of the well drillers. In addition to these the Survey has been fortunate in receiving from the U. S. Engineer's office of the War Department a complete set of specimens from the borings along the route of the proposed ship canal across New Jersey from Delaware River to Raritan Bay. These borings were located at an average distance of every half mile and were carried to a depth of 23 feet below low tide.

Wells at State Institutions.--Within the past few years appropriations have been made by the Legislature to a number of State institutions for the purpose of sinking deep wells to obtain purer, more abundant, or cheaper water supplies. The State Home for Boys at Jamesburg, the Rahway Reformatory, the Glen Gardner Sanitarium, the State Hospital for Insane at Trenton, and the State Prison, are some of those to which such appropriations were made. In some of these cases the results have not warranted the outlay involved, from failure to obtain either the desired quantity or quality. In one or two instances the advice of the State Geological Survey was requested by the Management of the Institution in advance of the application to the Legislature, but in more cases it was not. In at least one instance an adverse opinion did not deter the management from asking and obtaining an appropriation and drilling a well which was at first a failure through an insufficient supply and later when a greater supply had been obtained, was a failure because of surface contamination. Since in not one instance, but in several, have efforts of this kind been unsatisfactory, the suggestion is made that questions of this character might properly be referred to the Geological Survey for a report on the probable occurrence of ground water of the quantity and quality desired. In consequence of the investigations of the survey, which have extended over a period of more than fifty years, much information has been secured regarding the occurrence of underground water. Records of several thousand wells are on file in the Survey office, and the State Geologist is in a position to advise regarding the probable occurrence of ground water in any given locality, and the probable success or failure of wells. It is, of course, not possible always to predict with absolute certainty the amount to be found, or the depth, or the quality, but every geologist knows that some geologic conditions are much more favorable to its occurrence than others. It may also be said that the geologic structure of the State is so well known that there can be little question of the character of the rock to be found in drilling at any point. It would seem, therefore, that conservation of resources and economy of expenditure should demand that all the knowledge of the Survey be utilized before any project for sinking wells for State institutions be sanctioned by the Legislature. A request from the chairman of the Appropriations Committee for information on any proposed boring could in all ordinary circumstances be answered within a few days, before the next meeting of the committee, so that there need be no delay in this procedure.

Report to the Managers of the Woman's Reformatory.--In September, at the request of Mrs. C. B. Alexander, President of the Board of Managers of the Woman's Reformatory, I made an examination of a tract of land near Clinton, Hunterdon County, which they had under consideration as a site for the proposed reformatory. The purpose of the investigation was to determine the probability that an adequate supply of water might be obtained. The report was as follows:

"TRENTON, N.J., September 6, 1911.

"Mrs. C. B. Alexander, President, Board of Managers, Women's Reformatory, Bernardsville, N. J.:

"DEAR MADAM--Pursuant to your request I have made an inspection of the George Smith farm, near Clinton, and beg leave to submit the following memorandum:

"The farm contains something over 300 acres lying in the angle between the Easton and Amboy turnpike and the Clinton-Pittstown road, with a frontage of over a mile along the former road.

"The general elevation is about 360 feet above sea level, but the farm is traversed from north to south by an open valley sunk about 80 feet below the general level. This valley is drained by a small brook, fed, except in wet weather, exclusively by springs arising on the farm. In wet weather it receives at its head the surface drainage of fields lying on the north side of the Amboy-Easton turnpike.

"The underlying rock on the farm is chiefly a red, black and yellow shale, but on the west side of the brook limestone is exposed in a small quarry and so far as surface indications are a guide the limestone underlies the southwest corner of the farm. On the higher levels and upper slope the rock seemingly lies within three or four feet of the surface, as was shown by numerous post holes. On lower slopes and along the flat valley bottom it probably lies much deeper.

"Water Supply.--As above stated, numerous springs issue along the valley bottom to form the small brook which drains it. Most of these manifest themselves as small swampy places along the valley bottom. The largest is at the old milk house on the west side of the brook near the southern boundary of the property. This spring has a good flow although nothing unusual.

Owing to the Way in which most of the water is now escaping, *i.e.*, seeping out in many boggy places, it is very difficult to make an estimate as to the total flow of these springs. My own experience in estimating stream flow is so limited that I prefer not to give any figures, but I am of the impression that by properly developing all the springs along the valley bottom connecting them by subterranean galleries, and conducting the water by gravity to a receiving well, a considerable supply could be developed.

"*Water from deep wells.*--Statistics show that about ninety per cent. of the wells drilled in shale and slate similar to that underlying most of the Smith farm are successful in obtaining water, *i.e.*, water enough for a single family. This may, however, be only one or two gallons per minute, Of one hundred wells, forty-three yielded 1 to 5 gallons per minute, while only six yielded more than 50 gallons. Five gallons per minute is 7,200 per day (24 hours). Assuming that you would ultimately need 25,000 gallons per day (50 gallons per capita for 500 persons--a low estimate) you would need about 18 gallons per minute, and judging from results elsewhere there would be one chance in three of obtaining this amount from a single well. A flowing well is not probable, although not impossible if drilled in the valley bottom.

"*Quality.*--I have made no analysis of the water as that is a matter for the State Board of Health. The large spring at the milk house issues from limestone and is hard water (carbonate of lime and magnesia). The water from the shale and slate would be softer. If proper care was taken regarding the disposal of sewage and other wastes from the institution, I believe there would be no danger of contamination of the springs. Since, however, some at least of this spring water has traversed crevices in the rock, perhaps for some distance, there is more chance for the transmission of pollution than if the water filtered through a sand bed.

"Yours truly,

HENRY B. KÜMMEL,

"State Geologist."

Coastal Stability versus Coastal Subsidence.--In the Annual Report of the State Geologist for 1885, Dr. George H. Cook described in great detail many changes which had been observed within historical times along the New Jersey coast. From a study of these facts it was concluded, "That there is a change in the relative level of the sea and the land going on now; the sea rising upon the land. The marshes now cover land which since the first settlement of the country has been above tide level and cultivated in farm crops. Trees formerly grew where the salt-marsh now covers the surface, and only salt-grass or other marsh vegetation can grow, * * * *. In many places, too, Indian shell heaps are found in the marsh, and, going down to hard ground, the marsh has evidently grown up around them since they were begun, Marsh sods are found under the beaches and along the strand, which, though in their places of growth, are several feet below tide level. The storms and waves of the sea appear to have greater effect in wearing away and changing the shore line than they had in former times. This would naturally occur if the sea rises higher on the land than it formerly did." (Loc. cit., pp. 57, 58.)

Again speaking of the tide meadows, Cook said: "As these meadows are of such recent date we might expect to obtain from them abundant evidence of any change of level which may have occurred during their formation, and in this expectation we are not disappointed. We find, in fact, conclusive evidence of a general subsidence of the coast or rise of the water level to an extent of from ten to twenty feet within a short period of geological time, but at a rate which is not yet quite definitely established."

The points of evidence alluded to are as follows:

"1st. The encroachment within the present generation of the salt-meadow on the upland, in many places killing timber along the border and rendering arable land unfit for cultivation.

"2d. The stumps of trees in the mud, with their roots imbedded in hard bottom, many feet below high-water mark, and at a level where they could not possibly have grown previous to the formation of the marsh.

"3d. The occurrence of Indian or aboriginal shell beds resting on hard bottom and partly or wholly submerged in the meadow to the depth of some feet. These were unquestionably formed on knolls of upland which projected above the surface, and have since become buried by the rise of the meadow.

"4th. The existence of old bridges and crossways of poles or corduroy roads several feet below the surface of the marsh. The time of their construction is unknown to the present generation of inhabitants, and there seems to be no authentic record of any bridges, built within the memory of the inhabitants on the shore, having settled or sunk in the marsh to an appreciable extent; so we may, with justice, conclude that they have been buried by the upward growth of the meadow.

"5th. The occurrence * * * of the meadow-sod below low-water mark on the outer shore [of the beaches], at a level where experience and observation show the grass could never have grown." (Loc. cit., pp. 62, 63.)

Nearly thirty years previous, Prof. Cook, in a paper before the American Association for the Advancement of Science, in 1857, had cited many facts indicating, in his opinion, that the coast was sinking at the rate of two feet per century. His conclusions were accepted apparently without much question and the rate given found its way into several standard text-books on Geology (Dana, Le Conte, et al.) and has been widely quoted, until it has come to be regarded as an established fact. It is interesting to note, however, that Cook in 1857 himself stated that the rate of subsidence, although based on observations by various persons, which were in surprising accord, was not substantiated by so large a body of fact as to make it beyond question. In fact, he expressly stated that other data which would probably be found might show very different rates. It is also worthy of note that writing in 1885, after reviewing all the data, he expressly states the subsidence is "at a rate which is not yet quite definitely established" and nowhere in his later paper (1885) does he allude to the rate in any definite terms. It may be fairly inferred therefore that Cook, although holding firmly to his early belief in subsidence, was not disposed to regard the two feet per century rate as established.

Since 1885 the study of coast lines has made great progress and the criteria for distinguishing stationary from sinking coasts have been carefully worked out. It has been recognized also that other factors than coast subsidence may at certain localities cause the high tides to encroach upon the land. In other words, more careful study of tides and the factors which determine their height in bays, lagoons, and tidal streams has completely demonstrated that at many localities the average high tide level does not remain constant, but that changes in the shape of inlets, filling up of lagoons, recession of the mouths of tidal streams with resulting shortening of their courses, may cause the high tide at any given locality to rise higher than formerly and the tide marsh, whose level is determined by the high tide, to encroach upon the main land. Recognition of these facts with others, the importance of which does not seem to have been fully considered by most of the earlier workers, has led some geologists to question these conclusions, and to re-examine the facts to determine whether or not they were susceptible of another interpretation.

A year ago, Prof. D. W. Johnson, of Cambridge, Mass., began the study of this problem as related to the Atlantic coast from Nova Scotia to Florida, under the auspices of the Shaler Memorial Fund of Harvard University. With the consent of the Harvard authorities, it was possible for the State Survey to co-operate in this work so far as it concerned New Jersey. Prof. Johnson and party accordingly spent two weeks or more along both the Delaware Bay and Atlantic shores in a critical examination of this problem. Fortunately the Survey already had a vast amount of data directly applicable to the work, regarding the height of the tide marsh and of high tides, as well as the detailed statements of conditions as observed by Prof. Cook. This greatly facilitated the work and rendered it possible to make much greater progress in a limited time than in a region less well known.

In the investigation under Prof. Johnson's direction, the tide marsh was sounded at many points to determine its depth, and samples of the buried marsh vegetation taken for botanical study.

Synchronous observations were made on the height of a high tide in the ocean, the lagoon and far up the tidal streams, all measurements being referred to the same absolute datum plane. Observations were also made regarding many other matters which had a bearing upon possible changes of level. The State Geologist was with the party during a portion of its work. The results of Prof. Johnson's investigations so far as they relate to New Jersey will be presented in a special report to the State Geologist and will be published as a Bulletin of the Survey as soon as possible. His summary of his conclusions is as follows: "* * * there has been no appreciable subsidence of this coast within the last few thousand years. The phenomena which seem to indicate recent subsidence appear to fall into three groups: (1) Ficticious appearances of subsidence which are produced by wave action on a retrograding shore line without any change in the level of land or sea; to this group belong many instances of submerged stumps, peat exposed at low water on the seaward side of harrier beaches, erect trees recently killed by the invasion of salt water, etc. (2) Phenomena produced by a local rise in the high tide surface, due to a local change in the form of the shore line, unaccompanied by any general change in the relative level of land and sea; in this group may be found examples of practically all phenomena ordinarily attributed to a recent subsidence of the land. (3) Phenomena produced by an actual subsidence of the land or rise of the sea level which occurred some thousands of years ago: in this group belong many of the deeply buried peat deposits and submerged stumps. The evidence of coastal stability [in recent times] consists of (1) the form and position of successive beach ridges, the oldest of which were built by the waves thousands of years ago, yet later than the deeply buried peat deposits; (2) the position of abandoned marine cliffs on which the waves cannot have worked in recent time; and (3) the absence of a fringe of dead trees on those portions of the coast which are exposed neither to direct wave attack nor to local fluctuations of the high tide surface. It is concluded with reference to the Atlantic coast, that the land cannot have subsided as much as a foot within the last century;

that there can have been no long-continued, progressive subsidence at so high a rate as one foot per century, within the last few thousand years; and that no evidence thus far available can be regarded as satisfactory proof of any degree of recent subsidence, either spasmodic or progressive."

Professor Johnson's full report will probably be somewhat delayed in submission owing to his absence in Europe in the continuation of these studies, but when published it will be an extremely interesting one which will appeal to large numbers of our citizens, particularly those familiar with the phenomena with which he deals. So far as the edition warrants it will be distributed without charge to all who request it.

Green Pond Mountain Belt.--In the Annual Report for 1901 there was published a map and discussion of the geology of the Green Pond Mountain region. This is a narrow belt of conglomerate, sandstone, shale and limestone of Paleozoic age infolded and down faulted in the much more ancient pre-Cambrian crystalline rocks. It includes Copperas, Kanouse, Green Pond and Bearfort mountains and intervening valleys, and extends from near Flanders, in Morris County, northeast into New York. Green Pond and Greenwood Lake occupy portions of the valleys and the rugged cliffs and peculiar reddish conglomerate studded with white quartz pebbles are more or less familiar to all visitors to these lakes.

This belt is a region in which the tremendous forces within the earth's crust have been exercised in a highly effective manner in folding the rock strata and in causing great dislocations, along which the strata have been shoved past one another. One effect of these dislocations or faults is to bring into contact with each other strata which may normally be widely separated. In some instances where the plane of dislocation is inclined strata of greater age may be overthrust upon beds much younger, so that the apparent order of succession is reversed. In regions of great dynamic activities instances are known where the overthrust mass has been moved horizontally several miles.

As has already been said the Green Pond Mountain region is one of close folding and faulting. It is bounded on the west by a great dislocation separating the Devonian beds of Bearfort Mountain from the pre-Cambrian crystallines of Wawayanda Mountain. A similar fracture follows the well-known Longwood Valley, famous in the earlier days of iron-making for its line of forges. In both these cases the beds on the east have been depressed hundreds and probably several thousand feet, as compared to those on the west. These geologic features were described in the report issued in 1901 and may be familiar to many of my present readers. They are referred to here for several reasons. The southern portion of this belt lies within the area of the Raritan quadrangle of the geologic atlas of the State. The geologic folio covering this area will, it is hoped, soon be issued in co-operation with the United States Geological Survey. The maps have been in the hands of the engravers for a long time and most of the proofs have been corrected. The folio when published will be uniform with the Passaic, Franklin Furnace and other geologic folios already published and will be sold at a nominal price. The major portion of the region, however, lies within the territory of the Ramapo-Greenwood Lake quadrangle. Preparation of manuscript and maps for this folio occupied considerable of my time during the early part of the year. It is hoped that they will be ready for the engraver in the near future, but the folio will not be ready for distribution for a year or more.

The Green Pond Mountain belt does not terminate at the New York-New Jersey State line but extends northeastward nearly to Cornwall-on-the-Hudson, New York. Through the courtesy and co-operation of Dr. John M. Clarke, State Geologist of New York, I was able during the past season to extend my studies through the whole of the New York area. In this region the structure is more complicated than in New Jersey and the evidence of overthrust faults is more conclusive. In particular a series of high hills northeast of Warwick, N. Y., known as Brimstone Mountain, Sugar Loaf, Goose Pond Mountain. and several smaller unnamed elevations were found to be masses of pre-Cambrian gneiss overthrust from the east and resting upon crushed and contorted beds of black slate of Hudson River age, a formation very much younger than the gneiss and, where the succession of strata are normal, separated from it by 3,000 feet more or less of limestone and sandstone.

As a result of these studies in New York it was possible to come to a better understanding of the sequence of strata for the whole region and to reconcile some doubtful points regarding their correlation. A detailed report will be prepared as soon as press of other duties will permit.

SOIL INVESTIGATIONS.

Field Work.--The co-operative work in the examination and mapping of the soils of the State undertaken several years ago in conjunction with the Bureau of Soils at Washington, D. C., and the State Experiment Station at New Brunswick continued during 1911. Mr. Henry Jennings of the Bureau of Soils was in the field chiefly in Passaic, Morris and Warren counties from early in the spring until late in October or early November. During July and most of August he was assisted by I. V. Stone, whose services and expenses were paid by the State Geological Survey. Mr. Stone resigned near the close of August.

During July and August, Ray Pinkle, of Sussex, and Theodore Van Winkle, of Rutherford, were employed by the Survey in the agricultural canvass, which is carried on synchronously with the soil survey. These men visited each farm within the territory covered by the soil survey, and obtained from the occupant a great variety of information regarding the crops, methods of culture, fertilizers used, yield per acre, etc. Each farm was located on the sheets of the State Atlas by a system, of numbers which fixes its place permanently in the records of the Survey and will permit its relocation at any time on any copy of the State Atlas, even although the original field maps used in the canvass are lost.

The soil survey and the agricultural canvass have now covered the areas shown on Atlas Sheets 21 and 22, about 850 square miles. These comprise practically all of Sussex County, the northern part of Warren County, the western part of Passaic and the northern part of Morris. Upon the completion of the field work in this area Mr. Jennings was transferred by the Bureau of Soils to western Tennessee for the balance of the field season. The preparation and printing of the soil map is to be done under the direction of the Bureau of Soils at Washington, and it is expected that the preliminary steps to publication will be taken at once. The compilation of the statistics gathered in the farm canvass is being made by the experts at the State Experiment Station and will be completed as soon as possible.

Analysis of Soils.--In the progress of the work all types of soils which have been differentiated were carefully sampled by Mr. Jennings and his assistants. These have been analyzed both chemically and physically, the former work being done largely by Mr. Gage in the laboratory of the State Survey. During the year he analyzed about 100 samples, making an average of sixteen determinations on each sample. Not infrequently the work is checked over in order to avoid errors, so that the number of determinations has been much increased. In this work Mr. Gage has had the assistance of Fred Baumann for a portion of the time. Under the terms of co-operation a portion of Mr. Gage's salary which was properly chargeable to the analyses of soils was paid by the State Experiment Station.

TESTING OF OIL AND BITUMEN FOR ROAD MAKING.

The Survey has continued to co-operate with the State Road Department in the examination and testing of materials used in road construction, particularly oil and bitumen used as a binder. Every car of oil before use has been sampled, the sample being sent to the Survey laboratory to determine whether or not it conformed to specifications. Over 100 samples of these materials have been received and examined. In addition to this work twenty-five pavements already laid were sampled by cutting blocks from them, and the percentage of bitumen used determined by analysis. Mr. Gage also did considerable experimental work with various road materials from which much valuable information was obtained. Had some of these results been sooner determined many times the cost of the investigations would have been saved in the construction of roads.

Besides the laboratory work Mr. Gage spent more or less time in the field in the examination of bituminous pavements and oiled roads which had become defective or were showing signs of deterioration by weathering or wear, for it is necessary to supplement the laboratory tests by such study. The behavior of the material under the trying tests and severe conditions imposed by actual use must be observed.

That the co-operation between the Survey and the Road Commissioner's Department has been of value to the State is shown by an extract from a letter of Col. Stevens, the Road Commissioner, in which lie says: "Referring to the relations between this department and yours, and especially to Mr. Gage's services, I want in the first place to express my appreciation of the kindness of your Board in allowing Mr. Gage to continue work for us. His services have been of inestimable value; in fact, I do not know how we could have gotten along without him." Inasmuch as a portion of Mr. Gage's salary has been paid from the appropriation for the Road Department, the co-operative work has not cost the Geological Survey a large sum, and by it the State has been saved the expense of establishing and maintaining two laboratories.

CO-OPERATIVE WORK.

In addition to the co-operative soil investigations with the U. S. Bureau of Soils and the State Experiment Station to which allusion has already been made, the Survey continued its joint work with the U. S. Geological Survey; in the collection of mineral statistics; the collection of well data, and the preparation and publication of geologic folios. The progress made in these lines has already been described.

MEETINGS AND CONVENTIONS.

In accordance with the policy of the Board of Managers that the State Geologist should attend in an official capacity the meetings of other State Geologists, Geological societies and conventions dealing with subjects pertinent to the work of this department, and at which the State Survey might properly be represented, he was present at the following meetings:

In December, 1910, at Pittsburgh, meetings of the Association of American State Geologists; of the Geological Society of America; of the Paleontological Society and of the American Geographers, three days.

In April, 1911, at Washington, a conference of the State Geologists of the country with the Director of the U. S. Geological Survey, the Director of the Mines Bureau and the Director of the Bureau of Soils. These conferences lasted three days.

In October, at Chicago, the meeting of the American Mining Congress, four days and immediately after--

In Pittsburgh, the first National Mine Safety Demonstration Meeting, two days.

Association of State Geologists--At the meeting in Pittsburgh of the State Geologists' Association, problems relating to the administration of State Surveys were discussed, with a free interchange of ideas regarding methods of office management, record keeping, and making known to the public the results of the Survey investigations. These meetings, which have been held at least once a year for several years, have been found to be extremely helpful to those participating in them.

The meetings of the Geological and other societies were taken up with the presentation and discussion of scientific papers relating to geology, paleontology and geography.

At the Washington meeting in April the State Geologists met with the Directors of several Bureaus of the Federal Government to consider plans for co-operative work during the year and to avoid the duplication of effort which might otherwise occur where State and National Bureaus are working in the same field. At a meeting of the same character held the previous year arrangements had been made for the preparation and publication of a bulletin giving the history, organization and work of the various State Surveys. The editing and publication of this bulletin was undertaken by the U. S. Geological Survey after each State Geologist had prepared and forwarded the manuscript regarding his own State. This bulletin, No. 465 in the series of

U. S. Geological Survey publications, was issued in April. It gives the history and work of thirty-four State Surveys and of three State Bureaus of engineering or hydrology. It is a mine of information for anyone desiring knowledge regarding the Geological Survey of any State. In presenting in a comprehensive and compact form the facts regarding the State Surveys, it emphasizes the importance of this work and the degree to which the various States through their Legislatures have recognized its value and by appropriations given it support.

It is interesting to know that with the possible exception of New York, New Jersey has maintained a State Geological Survey without interruption of support for a longer period than any other State. The present organization was established in 1864 and has been supported without a break since that time. Previous to 1864 there were the Rogers Survey from 1835 to 1840 and the Kitchell Survey from 1854 to 1856. In New York the Survey was established in 1836, but there were one or more lapses in the State appropriations extending over considerable periods during which time the work was carried on and kept alive by the devotion of James Hall, whose labors in behalf of American Geology will never be forgotten so long as the science lives. Many of the other States besides New York and New Jersey established surveys in the decade between 1830 and 1840; in fact, in 1838 a larger percentage of States were supporting Geological Surveys than in any subsequent year until 1898, but this early era of geological investigation declined almost as rapidly as it rose and many of the surveys established in 1830 to 1840 were abandoned in the years immediately succeeding, not to be reorganized until the later years of the century. In New Jersey, however, a second Survey was maintained for a few years in the decade 1850 to 1860, and under the inspiration of Prof. George H. Cook the work was renewed in 1864 and has not since been interrupted.

Meeting of the American Mining Congress--The American Mining Congress is an association of men and organizations interested or engaged in mining. Its purposes are, among other things, to bring about safety and efficiency in mining operations, intelligent conservation of our mineral resources, uniformity in State laws governing mining operations carried on under like conditions, federal co-operation through research and investigation and improvement of the economic conditions underlying the coal industry. The Fourteenth Annual Session was held in Chicago and was devoted largely to consideration of problems relating to coal mining and to Alaska. President Taft was present at one session of the Congress and at another Secretary Fisher of the Department of the Interior delivered a memorable address setting forth with great detail and admirable skill the conditions surrounding mining in Alaska, and announcing the Administration's policy in regard to opening up the coal lands of the territory. This address was the first public announcement of this policy after the visit to Alaska of the Secretary and his assistants and their investigations on the ground.

Mine Safety Demonstration Meeting.--Immediately following the sessions of the American Mining Congress at Chicago were the demonstrations at Pittsburgh under the auspices of the National Bureau of Mines to make public the progress being made in securing a greater degree of safety in mine work. The Bureau of Mines maintains at Pittsburgh a testing laboratory where these problems are continually under investigation and also in the suburbs of the city operates a coal mine in which tests and observations can be made under actual mining conditions. That coal gas in mines is the source of many explosions has long been known; that coal dust in bituminous mines is more insidious, threatening to the miner and highly explosive has been demonstrated by the work of the Bureau of Mines. A practical demonstration of this on a large scale was arranged for this meeting. Seven hundred pounds of coal dust were placed on shelves along the gangways of the experimental mine, after it had been thoroughly inspected by hundreds of practical miners and others. That there was no coal gas in the mine was agreed by all. Then, after the mine had been cleared, and all spectators driven back to a safe distance, a shot of black powder burning with a long flame and so placed in the breast of the mine as to "blow out" was fired by electricity. The result was a terrific explosion which fairly shook the earth. Flames of burning coal dust and gas generated by the explosion rolled out of the entrances of the mine for a hundred feet or more, setting fire to the trees and grass on the hillside. A loaded mine car standing near the entrance of the mine was hurled from the tracks and one or more small buildings near the entrance were demolished. The noise of the explosion was reported by the papers to have been heard to a distance of six miles. Three thousand people or more witnessed this test and all were convinced that the explosive power of coal dust was established beyond all question.

Other events at this meeting were less spectacular but no less significant. The extent to which the coal mining companies have put in practice "first aid to the injured" was shown by the participation of between thirty and forty "first aid" squads in a tournament held on Forbes Field in the presence of President Taft and a large crowd of spectators including hundreds of miners. The first-aid squads were each composed of mine workmen and represented separate mines. Two squads came from distances as great as New Mexico and the State of Washington. Ten events, each embracing the treatment of an "injury" common in coal mining were run through. The skill and deftness with which the hypothetical injuries were dressed and bandaged spoke volumes for the efficiency of the training squads had received. Medals and prizes were distributed to the winning teams.

Another interesting event was the demonstration by a member of the Bureau of Mines of the practicability of using birds to detect in mines after an explosition the presence of the deadly gas called by miners white damp, or carbon monoxide. Rescue parties penetrating mines have often been overcome by this gas before its presence was suspected. It has been found that birds and small animals succumb to its deadly influence before it effects human beings, so that by carrying cages of English sparrows, or other small birds, into the mines and watching them the rescue party will have time to retreat in safety after the birds have been overcome by the deadly gas. The practical working of this was demonstrated at the meeting by a member of the Mines Bureau entering an air-tight glass box into which a small amount of this gas had been forced, taking a cage containing several birds. After five or ten minutes all the birds having become insensible, apparently lifeless, they were then passed out and the man remained in the box for several minutes longer with no feelings of injury. The birds were afterwards resuscitated by being placed in a jar of oxygen.

Demonstrations were also given of the use of various forms of oxygen helmets, equipped with which and breathing oxygen artificially supplied, men are able to enter mines immediately after explosions in spite of the presence of smoke and deadly gases.

The value of this meeting in demonstrating what was being accomplished in making coal mining more safe can hardly be overestimated. Many miners who had disputed the explosive nature of coal dust and scoffed at the laboratory tests which had demonstrated its true nature, were convinced beyond all question by the terrific results of the explosion in the experimental mine. The friendly rivalry evoked among the first-aid squads by the tournament could not fail to be productive of good in the spread of this movement and to the public was a convincing demonstration of the attention given by the mining companies to the conservation of our greatest asset--human life.

It is true that there are no coal mines in New Jersey and never will be and that the metal mines of the State are not subject to the dangers which beset the coal-mining industry. The lessons taught were, therefore, less important to the State Geologists of New Jersey than to the officials of some other States. Nevertheless, it was an instructive and valuable experience, particularly in its demonstration of what a closely allied department, the U. S. Bureau of Mines, is doing to render mining more safe.

January 30, 1912.

Report of the Board of Managers and its Engineer

ON THE

Improvement of Shark River Inlet

AS

Ordered by Act of Legislature, May 1, 1911

Report of the Board of Managers.

"To the Hon. Woodrow Wilson, Governor of New Jersey:

SIR—In behalf of the Board of Managers of the Geological Survey, I have the honor to submit for your consideration the report of its special committee and its engineer for the emprovement of Shark River Inlet, Monmouth County. This report was prepared in accordance with the following act of the Legislature, approved May 1, 1911:

"BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

"1. The sum of one thousand dollars or so much thereof as may be necessary, be and the same is hereby appropriated out of the State fund for the use and purpose of making a survey of the mouth of Shark river and the drawing of plans and securing estimates of the cost and expense of making and securing a permanent mouth or inlet thereto, said sum to be used for the purpose of defraying the expenses of the engineer in making the survey and the estimates of the cost of said work and the manner in which it shall be done; the said survey to be under the control and supervision of the board of managers of the geological survey, this appropriation to be available at the same time and the same manner as the usual appropriations are made and available for the fiscal year, and that upon the completion of the said survey and estimates the report of the engineer selected by the said board shall be forthwith made to the said board, and the said board shall transmit said report with such recommendations as it may see fit, looking towards the construction of said permanent mouth or inlet, in the annual report of said board to the Governor of the State of New Jersey.

"2. This act shall take effect immediately."

From the report of its engineer and from other data in its possession the Board believes that the plan proposed is feasible, and if carried out as herein proposed will result in the permanent betterment of conditions at the inlet. If, therefore, the improvement of Shark River Inlet be deemed by the Legislature to be of public importance, the Board of Managers of the Geological Survey recommends that this plan be adopted.

Respectfully submitted,

HENRY B. KÜMMEL

State Geologist.

February 14, 1912.

Chairman's Report.

TRENTON, N. J. February 13, 1912.

To the Members of the Board of Managers of the Geological Survey of New Jersey:

GENTLEMEN—Your Committee on the Improvement of Shark River Inlet submits the following statement of its operations together with the report of C. C. Vermeule, Consulting Engineer:

The committee was organized by the appointment of Messrs. Clarence G. Meeks and T. Frank Appleby to act with Mr. Harrison Van Duyne as chairman. Owing to the fact that the appropriation for the work was not available until the present fiscal year, nothing could be done until after November 1, 1911. Since that time the problems have been given careful consideration by the Committee, the State Geologist and Mr. Vermeule, who, as Consulting Engineer, was authorized by the Committee to make the detailed studies and prepare the plans and estimates called for by law. As a preliminary, a compass survey of the inlet was made and a map prepared on a scale of 100 feet per mile showing its condition on November 22, 1911, and the lines of former jetties now partly destroyed. Members of the Committee or the State Geologist had conferences with the U. S. Army Engineers at New York, contractors of experience in riparian work and with engineers regarding the problems involved. Mr Appleby of the Committee and the State Geologist, in company with Jesse A. Howland, of Sea Bright, made an inspection of the inlet, and at their request Mr. Howland submitted to them drawings and specifications for two lines of reinforced, tongue and groove concrete piling, a type of construction which seems to have certain advantages. Conferences were also had with Mr. Vermeule, to whom were referred the plans prepared by Mr. Howland.

It was recognized that it would be impossible to prepare final plans and estimates without borings to determine the nature of the foundations obtainable. Since, however, it was impracticable owing to the inclemency of the weather to make them at this time, and since the appropriation available was insufficient for this purpose, even had the weather permitted, it was decided to ask Mr. Vermeule to prepare, as quickly a possible, a plan and estimates based on such data as were available and with such reservations as were necessary in the absence of definite information in regard to the foundations. Mr. Vermeule has done this and his report is submitted herewith.

He recommends a curved jetty on the north side of the inlet to prevent its northward shifting and to hold the current to the southeast, its normal direction. This jetty in its location and curvature conforms to what seems to be the most stable position of the inlet. He further recommends a short curved jetty on the south side to prevent southward cutting at a threatened point. Reinforced concrete construction is recommended, three types to be used according to the exposure to waves and currents. The total length of jetty to be constructed is 2,175 feet and the total estimated cost is $58,000. He points out that experience or further study of the currents may show the necessity of extending the north jetty 350 feet out to sea at an additional expense of $13,500, but the necessity for this is at present in doubt. The plan is tentative in that borings may show such foundations as may necessitate a modification of the style of construction and dimensions of the piling, but it is not believed the estimate of cost will be greatly changed. Twelve hundred and fifty dollars over and above the balance of the present appropriation must he provided if the necessary borings, survey and final plans and specifications are to be made. The total expense of the work to date has been $630.50.

Respectfully submitted,

HARRISON VANDUYNE,

Chairman.

Engineer's Report.

Contents.

Illustrations.

NEW YORK, February 5, 1912.

Dr. H. B. Kümmel, State Geologist:

SIR—Since receiving your instructions concerning a report with estimates for the improvement of Shark River Inlet, while we have been continuously employed in collecting data, the weather has been too inclement to enable us to prosecute speedily the necessary surveys and soundings to such an extent as will be necessary for a full final report with definite plans. The money available is also insufficient to make the necessary borings and complete plans. Nevertheless, the data collected have enabled me to arrive at a definite conclusion as to the proper method of improvement and to give a sufficient close estimate for present purposes. I am also able to report definitely the following recommendations:

RECOMMENDATIONS AND CONCLUSIONS.

Shark River Bay is a most attractive pleasure ground and the only important considerable body of salt water for this purpose lying accessible to Asbury Park, Ocean Grove, Bradley Beach, Avon, Belmar, Lake Como and Spring Lake, with their large summer population. The bay also affords opportunities for fine oyster grounds about one thousand acres in extent. In order to preserve it in suitable condition for the raising of oysters and clams and other marine life, and to preserve its attractiveness as a pleasure ground, the inlet must be kept open so as to admit the tides freely. This inlet is also the first opportunity afforded south of Sandy Hook, twenty miles distant, where a haven is possible as a refuge for small sailing vessels and motor boats. For these several reasons, the expenditure necessary to maintain the inlet appears to be abundantly justified.

The jetties which have been heretofore constructed in an effort to maintain the inlet, have not been located on lines which accord with the natural tendency of the channel through the beach and off shore. The lines of these jetties are so placed that at present they seriously jeopardize the inlet and recently they have been the cause of a threatened closing of the same. These jetties have also been of entirely too light construction to be serviceable against the action of the sea.

The natural tendency of the channel is clearly indicated and is briefly, first, to deflect northward in a curve just inside the beach, and then deflect eastward and southeasterly through the beach and off shore. This tendency is due mainly to the influence of the prevailing winds and other well-defined natural forces. Channels occasionally open in a northeasterly or easterly direction due to the action of storms, but such channels are unreliable and more or less transient, and the works should be planned with a view to preventing such opening and with the purpose of maintaining the channel in its natural southeasterly course through the beach and offshore.

The construction of light and cheap works is not economical. Whatever is to be done in the nature of improvement, must be thoroughly substantial, otherwise the money spent will be wasted. My studies indicate that jetties on the convex side of a curving channel are unnecessary and that the southerly jetty through the beach has usually proven an obstruction and worse than useless. This conclusion leads me to put almost the entire expense in a jetty at the northerly side through the beach, and enables me to build much more substantially, without increase of the total cost. Tentatively I have adopted the types of construction shown in the accompanying plans, varying the strength and cost per foot with the exposure of the jetty. The exact type of construction to be followed, ultimately, must be adopted after the necessary borings have been obtained, and the offshore depths and direction of the currents more accurately ascertained than has thus far been possible.

The estimates hereinafter detailed show that adequate works cannot be constructed for less than $58,000, and if, after trial, further extension seaward shall prove desirable, $13,476 additional will be needed. Any reduction of this amount will be likely to jeopardize the entire investment.

The foregoing conclusions are based upon the facts which I shall hereinafter set forth more in detail.

INFLUENCES DETERMINING DIRECTION OF CHANNEL.

The principal influence which determines the direction of the channel off shore and through the beach is the wind. It is generally well known that during the summer months the wind from about 11 A. M. until sunset is southeasterly. It is not southeasterly during the entire summer as many suppose, and indeed it is in this direction not more than one-third of the whole time during the six months from April to September, inclusive. In order to determine more accurately the direction of the wind, I have taken the reports of the U. S. Weather Service for the eight years from 1903 to 1910, inclusive, and determined how many months during that time the prevailing wind stood in each quarter. This, I believe, is a fair measure of the relative importance of the winds from different directions. The record at Long Branch, being incomplete, has been completed by using the record of Oceanic which usually shows the wind to be in the same direction as at Long Branch. I have also taken Asbury Park, and, for purposes of general comparison, Atlantic City, with the following result:

NUMBER OF MONTHS IN WHICH THE PREVAILING WIND IS IN THE DIRECTION GIVEN DURING THE EIGHT YEARS FROM 1903 TO 1910, INCLUSIVE.

	Long Branch— Oceanic.	*Asbury Park.*	*Atlantic City.*
North,	1	0	3
Northeast,	2	10	7
East,	3	8	1
Southeast,	11	25	0
South,	3	5	7
Southwest,	33	1	40
West,	9	34	1
Northwest,	34	13	37
Total,	96	96	96

October to March.

	Long Branch— Oceanic.	*Asbury Park.*	*Atlantic City.*
North,	1	0	3
Northeast,	1	5	4
East,	2	1	0
Southeast,	3	3	0
South,	0	1	0
Southwest,	9	1	6
West,	5	26	1
Northwest,	27	11	34
Total,	48	48	48

April to September.

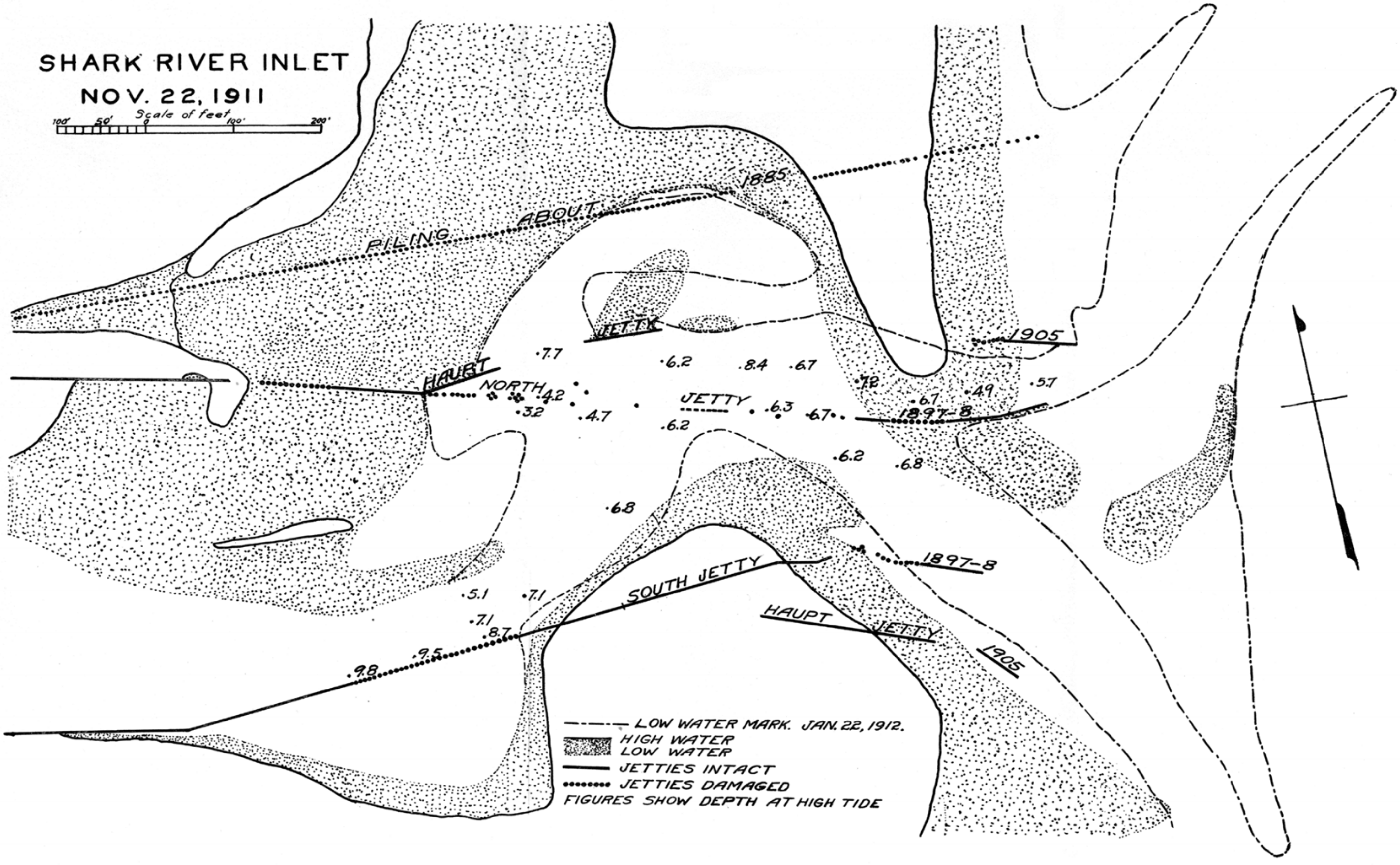
	Long Branch— Oceanic.	*Asbury Park.*	*Atlantic City.*
North,	0	0	0
Northeast,	1	5	3
East,	1	7	1
Southeast,	8	22	0
South,	3	4	7
Southwest,	24	0	34
West,	4	8	0
Northwest,	7	2	3
Total,	48	48	48

The winds at Atlantic City are more frequently southwest apparently than at the points nearer Shark River. Since there may be sometimes only a few points difference between a wind indicated as west and one indicated as northwest, for instance, it may be helpful if we average the above results for Long Branch-Oceanic and Asbury Park. This is done in the following table:

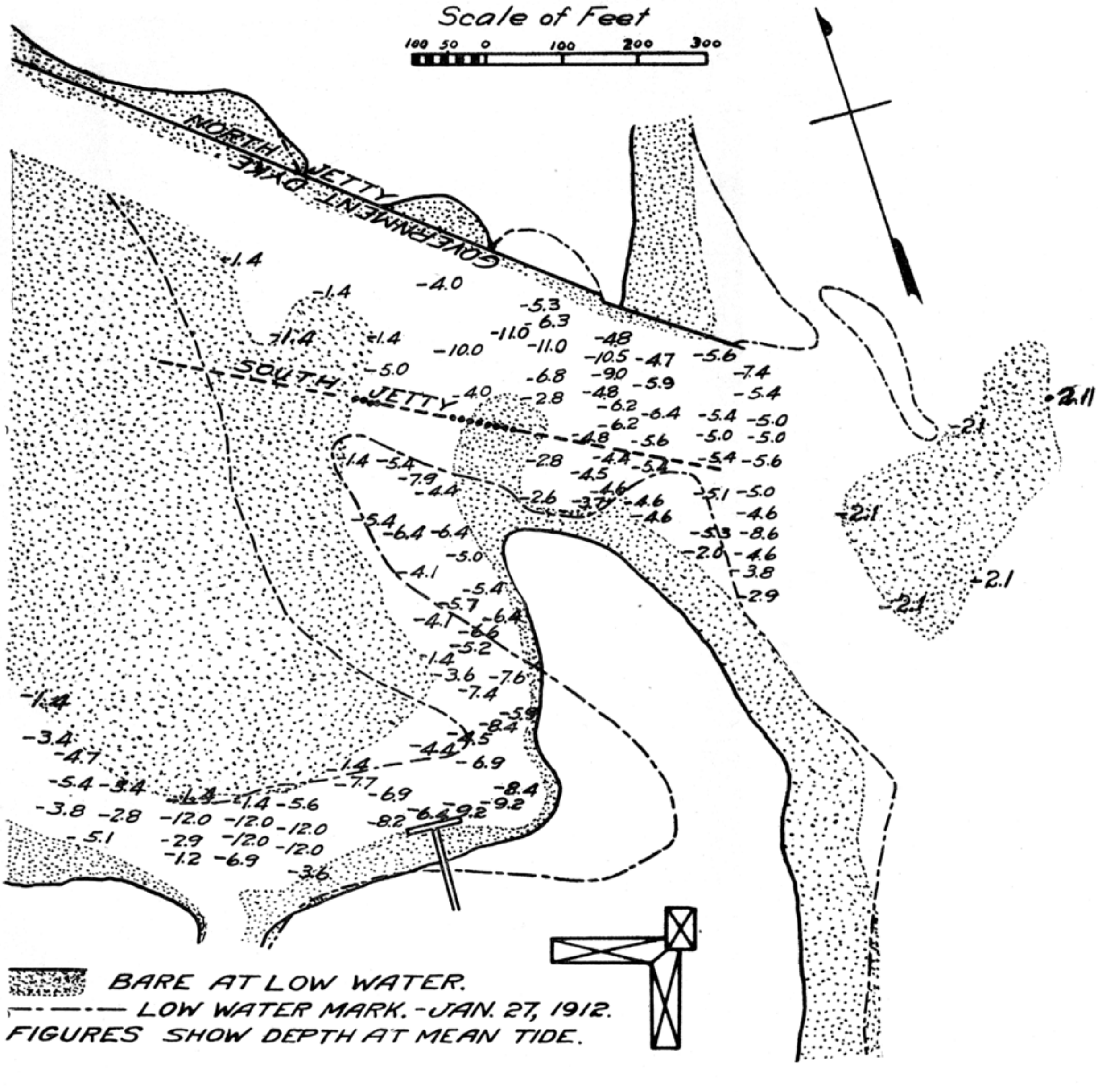
Direction of Wind.	*Year.*	*October-March.*	*April-September.*
North,	½	½	0
Northeast,	6	3	3
East,	5 ½	1 ½	4
Southeast,	18	3	15
South,	4	½	3 ½
Southwest,	17	5	12
West,	21 ½	15 ½	6
Northwest,	23 ½	19	4 ½
Total,	96	48	48

In the last table the relative prevalence of winds from different quarters is apparently correctly indicated. For instance, during the six months from April to September, if we assume that the southeast wind blows an average seven hours out of the twenty-four, which is about in accordance with ordinary experience, its relative prevalence would be 7/24, whereas the table shows 15/48, or 7½/24 as the relative prevalence of the southeast wind. It is true that the winds from different quarters may not be of equal velocity, and that the northeast and easterly winds, especially, are on this account more important than the table makes apparent, but this probably does not seriously vitiate the result.

The northeast, east, southeast and south winds are the on-shore winds, and are those which are important in the movement of the sand on the beaches. Of these the relative importance of the southeast wind is as 18 to a total of 33½, being about 54% of the whole, consequently, it follows that a current approaching Shark River Inlet on the flood tide is most likely to take a north-westerly direction, being influenced mainly by the wind. Once the current and the channel is established in this direction so that it clings to the beach at the south of the inlet, it will be held in this direction by the northeast and east winds, provided that these storm winds do not cut some other channel through the beach as they often do to the northward of the inlet. Should this cutting through northward be prevented, it becomes apparent that all of the onshore winds except the south wind have a tendency to hold the current and the channel in a southeasterly direction. This tendency is also aided materially by the very prevalent northwest wind. Although this is an offshore wind, it nevertheless is potent in influencing the current to take a southeasterly direction through the beach and offshore on the ebb tide. The prevailing tendency of all the winds, therefore, is to direct the current and the channel in a southeasterly direction through the beach and offshore. The accompanying map of Shark River Inlet shows that this was the direction taken by that inlet November 22, 1911. I also attach to this report a map of Manasquan Inlet made under my own direction in 1903, during the prosecution of the surveys for the Bay Head and Manasquan tidewater canal. This survey of Manasquan Inlet shows the same tendency of the channel to take a southeasterly direction, and that this is the prevailing trend of that channel is further indicated from a study of the map showing changes at Manasquan Inlet, being Plate IX of the Annual Report of the State Geologist for 1907. The same tendency is well shown in the map of Little Egg Harbor Inlet following page 80, Annual Report of the State Geologist for 1905, and it is also known to the writer to be the prevailing direction of Barnegat Inlet and Absecon Inlet. It is true that at times a channel breaks through in an easterly or northeasterly direction, but as is well known to the pilots of these inlets, such channels are of a shifting nature and far less reliable and stable than the southeasterly channel. Such breaches are illustrated in the sketches of Manasquan Inlet already referred to, and one such breach has occurred in the Shark River Inlet during the progress of these investigations and is shown by broken lines on Plate I. The present condition of Manasquan Inlet is also shown by broken lines on Plate II. The channel in this case is still southeasterly, although there is a very small subsidiary channel leading northeast.


SHARK RIVER INLET
NOV. 22, 1911
Scale of feet
100' 50' 0 100' 200'
PILING ABOUT 1885
JETTY
HAUPT NORTH JETTY
1905
1897-8
SOUTH JETTY
HAUPT JETTY
1897-8
1905
7.7
6.2
8.4
6.7
7.2
5.7
4.9
6.7
4.2
3.2
4.7
6.3
6.7
6.2
6.2
6.8
6.8
5.1
7.1
7.1
8.7
9.5
9.8
LOW WATER MARK. JAN. 22, 1912.
HIGH WATER
LOW WATER
JETTIES INTACT
JETTIES DAMAGED
FIGURES SHOW DEPTH AT HIGH TIDE

MANASQUAN INLET 1903



Shark River and Manasquan Inlets both show similar tendencies to the formation of an S-shape bend just inside the line of the beach. The channel approaches the beach and then turns by a curve northeasterly and then in its best condition almost immediately turns again to the southeast, passing through the beach. This is well shown in the preceding maps of the two inlets. This tendency is due largely to the drift of the beach sand northeasterly during the prevailing southeasterly or southerly winds. However, it is well known that no running stream remains in a stable condition with its channel in a straight line. The natural tendency is always to curve and only in a curved shape does it preserve anything like real stability. The reason is that the current is deflected to the outside of the curve or the concave bank and the channel tends to assume a permanent position somewhere between the middle of the stream and said concave bank. For this reason, it appears to me that this tendency as well as the southeasterly trend of the channel through the beach and off shore should be respected and any proposed jetties should conform to said tendency.

MALFORMATION OF CHANNEL AND CLOSING OF INLET.

The studies of both Shark River Inlet and Manasquan Inlet show similar tendencies toward deformation of the foregoing type of channel, which type appears to most nearly approach natural stability. First, the channel cuts into both of its concave banks. At the southerly bend of the S it will be noted that at both inlets there is a tendency to cut into the beach in a southeasterly or easterly direction, while at the northerly bend there is a similar tendency to cut in a direction parallel with the beach northerly and sometimes northeasterly toward the beach. Both of these tendencies are injurious to stability for the reason that the channel is broadened unduly by such cutting and bars form, which increase the instability of the main channel. Furthermore, the northeasterly bay frequently cuts to such a depth that a northeasterly storm will drive entirely over the beach into the channel, cutting away the beach and opening a new inlet. This sometimes opens almost as far north as the line of Garfield avenue, at Avon, and the opening of such a second inlet so divides the volume of water passing out to sea, that it is insufficient to keep either inlet open and both ultimately close, causing the evils which we are now attempting to remedy. These tendencies immediately suggest the adoption of protection works at the concave banks of the inlet, which will prevent the cutting southeasterly at the southerly curve and the cutting northeasterly at the northerly curve of the S.

MISLOCATION OF FORMER JETTIES.

The foregoing explanation of the natural tendencies of the inlet will, I think, make clear one of the reasons for the failure of works heretofore constructed. Both the jetties of 1897 and 1898 at Shark River and the jetties at Manasquan Inlet have attempted to direct the channel in a direction nearly east, or a little south of east. The jetties have been wide apart inshore and have converged uniformly toward the inlet at the line of the beach. Two jetties have been built in all cases. The inlet has not conformed to these jetties for the reason that they did not adapt themselves to its natural tendencies, or to any condition which would enable it to adopt a stable course. An examination of the accompanying maps will show that the southerly bulkhead has usually obtruded itself more or less directly across the path of the southeasterly channel on the line of the beach, and has proven a real obstruction rather than a help. At Shark River Inlet it has been an obstruction in this respect, and has been of no service whatever. Inshore, at the southerly bend of the S, it was not substantial enough to prevent the stream following its natural tendencies, washing under the line of the jetty and carrying away the planking. Through the line of the beach it offered no protection whatever for the reason that the natural tendency of the beach is to move northward, and, therefore, it needs no protection against the scour of the channel. Further east the bulkhead has, as I said before, obtruded itself into the channel and proven itself a serious obstruction. The north jetty at Shark River was also too unsubstantial to prevent the inlet from following its natural tendency to cut northward. Furthermore, the jetty was not on proper lines to enable the stream to follow it smoothly and harmlessly, consequently, the part of the jetty just inshore for some five hundred feet, is totally wrecked. The portion of the north jetty which remains standing through the beach, has become a menace as will be noted by reference to the broken lines which show that this part of the jetty really aided the cutting through of the new channel during January, 1912. It is also true that the jetty of 1905, or such small parts of it as still remain, likewise aided this cutting through of the beach.

At Manasquan Inlet, the main channel refused entirely to remain within the converging jetties and followed its natural tendency to an S-shape bend as already described, as well as its natural tendency to proceed through the beach and offshore in a southeasterly direction. The result has been that the south jetty has been totally wrecked and only small traces of it remain. The north jetty has proven to be of considerable value at Manasquan, although an examination of the changes shows that the shifting of the S-shape bend is very great and often results in practically closing the inlet. A study of this inlet makes it perfectly clear that the jetty work would have been far more serviceable if it had conformed to the natural tendencies of the channel as hereinbefore described.

NORMAL MOVEMENT OF THE SAND.

We have seen that the prevailing onshore winds are southeasterly and these winds result in driving the waves diagonally onto the beach with a general northerly direction and set the sand steadily toward the north, up the beach. So long as these winds prevail, therefore, the sand on the beach at the southerly side of the inlet is steadily creeping toward the inlet and on the flood tide, this sand from the south side is carried in the inlet until it is deposited where the current slackens. On the ebb tide, this sand is again carried out, but as soon as it reaches the ocean, it is deposited at the northeasterly side of the inlet, where it continues its northerly movement along the beach, although the deposit from the inlet usually forms a more or less extended bar immediately at the northeast side. Northeasterly storms may at times drive part of this sand back into the inlet, but if the latter is confined to a fixed location, it is hoped that this difficulty will be speedily overcome when the wind veers again to the southeast, northwest, or west. If not, then the jetty must be extended some 300 feet further into the ocean, or beyond the edge of the present bar, so that the increased depth and current will move the sand more rapidly northward. The necessity for this extension must be determined either by further soundings and current observations, or by experiment. The slow movement of the sand from the southerly beach toward the inlet will be counteracted by the natural scour of the inlet, bearing in mind that the northerly jetty will prevent any bodily movement of the inlet northward.

TIDAL PRISM.

Our ability to maintain a sufficient inlet depends in large measure upon the volume of water passing through it at each tide. By computing this volume, and comparing it with Manasquan Inlet at times of approximate stability, we should be able to estimate approximately the width and depth of the resulting inlet through the beach. Our levels show that, adopting mean tide at Sandy Hook as our datum, the comparative levels of ordinary high and low water are as follows:

	-Elevation in Feet.-	
	High Tide.	*Low Tide.*
Ocean,	2.35	-2.35
Inside of beach,	1.96	-1.04
Upper bay,	1.70	-0.70

These levels show that the mean range of the tide in the ocean is 4.70 feet, while just inside the beach it is 3.00 feet, and in the upper bay 2.40 feet. They also show that while high tide in the upper bay is .65 feet lower than in the ocean, low tide is 1.65 feet higher in the upper bay than in the ocean. As a result, the tide flows out about one and one-quarter to one and one-half hours longer than it flows inward to the bay. In other words, flood tide continues about three-quarters of an hour after high tide in the ocean and the outflow continues about two hours after low tide in the ocean. Inasmuch as an equal amount of water goes in and comes out, or practically so, the result is that the flood tide into the bay runs stronger than the ebb tide, as it must necessarily do in order to pass in the same quantity of water in a shorter period of time. The velocity at flood tide is said to be as much as five miles per hour, but I believe much of the time it materially exceeds this.

The following figures for Manasquan River and Shark River show the relative volume of the tidal prism for each, together with the average volume of the fresh-water outflow. It will be seen that the latter is comparatively insignificant as against the volume of water due to the tides.

	Manasquan River.	*Shark River.*
Water surface, acres,	1,216	1,018
Range of tide, feet,	2.50	2.40
Tidal prism, acre-feet,	3,040	2,443
Mean discharge of fresh water per tide, acre-feet,	135	30
Total average outflow each tide, acre-feet,	3,175	2,473

The foregoing table shows that the volume of water passing through Shark River Inlet is practically eighty per cent, of that passing through Manasquan Inlet. Manasquan Inlet was shown by our surveys to be 320 feet wide at mean tide, with a depth ranging from 4.4 to 6.4 feet, and a cross-sectional area of 1,380 square feet. By analogy, Shark River Inlet should have an area of cross section of 1,104 square feet at mean tide and if properly confined to one location as is proposed, I estimate its probable width to be 200 feet, and mean depth 5 feet 6 inches. Its width at times may be reduced to 150 feet and its depth near the proposed jetty will probably be about 7 feet at mean tide, and 5 feet at low tide. It appears, therefore, that the tidal prism should be sufficient to maintain an adequate channel through the beach. If this channel is maintained in a stable condition, the tidal prism is likely to increase somewhat, which will be favorable to increased width and depth of the inlet.

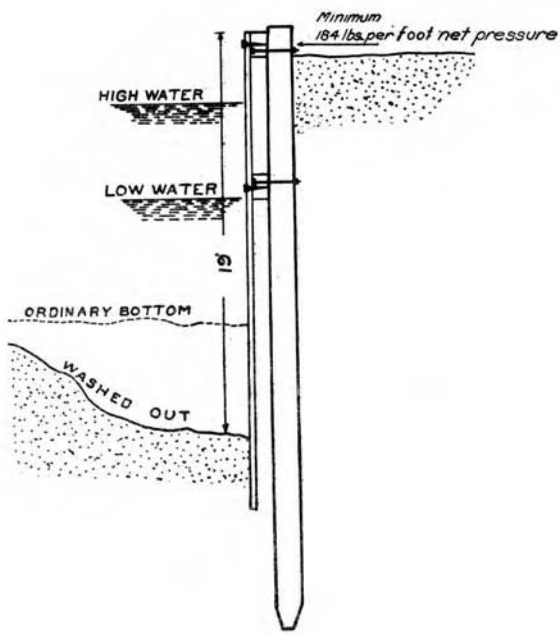
MATERIALS FOR JETTIES.

My estimates show that there will not be any great difference in cost between proper, substantial jetties built of timber and filled with stone, and jetties built of reinforced concrete amply braced. If hard wood could be obtained for piling and sheet piling, its lasting properties would be entirely satisfactory. There is a considerable amount of piling at present in place at Shark River Inlet, which was put down more than twenty-five years ago, and which is still in fairly good condition. However, hard wood is extremely scarce, and if any of the softer wood are used it becomes absolutely necessary that they shall be treated with creosote. With such treatment, we may expect sufficient durability for practical purposes from the timber itself. A serious difficulty arises, however, in the case of timber structures, from the corrosion of iron spikes and bolts, which are indispensable for their construction. Such iron fastenings corrode rapidly in sea water and such corrosion eventually leads to their destruction. Inasmuch as there is no substantial difference in economy, therefore, I am at present of the opinion that reinforced concrete is the better material. Timber might be used by driving two lines of piling with sheet piling, pumping out the sand between, and running into the enclosed space a solid wall of concrete of a thickness of not less than four feet. In this case the timber would be temporary, and its entire destruction would leave the concrete amply strong to answer the purpose. Further investigation may prove that for a part of the work a construction along these lines will be useful and effective, and it may be adopted without changing the estimates. The present estimates, however, are based upon the use of reinforced concrete piling, intended to be cast in wooden molds and transported to and used on the work after setting sufficiently to be handled.

I am emphatically of the opinion that only a rich mixture of cement and sand should be used in this work. My own experience in hydraulic work has convinced me of the great superiority of mixtures of one part cement and two parts sand, in density, imperviousness to water and general resistence to disintegration Elaborate experiments conducted by a committee appointed by the Scandinavian Portland Cement Manufacturers convinced said committee that a mixture of one part cement to three parts sand would disintegrate in sea water, and a mixture of one part cement to two parts sand was recommended. In view of all experience at hand, therefore, I should consider it unwise to adopt a mixture less rich than one to two, especially for reinforced concrete work. I have also investigated the possibility of getting gravel for the concrete from the gravel pits within hauling distance of Shark River Inlet, and it appears to be possible to get gravel of a proper size and quality to be used for this purpose at a cost of not exceeding $1.50 per cubic yard delivered on the work. The cost of crushed trap rock will he considerably higher and will probably not be much less than $2.75 per cubic yard on the work. Since the gravel is not only cheaper, but has less voids, and therefore calls for a less volume of sand and cement mortar, its use will result in a very considerable economy in the cost of concrete, and this will be true whether it is used alone or mixed with broken stone. The beach sand which is found in abundance immediately at hand, will be suitable for use in the concrete, and since the cost of cement at present is low, conditions are favorable to concrete of low cost even though it be made as rich in cement as one to two. Results from the use of suitable gravel have been entirely satisfactory, and I should not hesitate to permit its use in this case.

SINGLE LINES OF PILING INSUFFICIENT.

Why the light pile jetties heretofore adopted have proven insufficient is illustrated by the drawing inserted herewith. In this case, I have assumed piling 25 feet long with walling pieces of timber bolted on above low tide, and sheet piling 20 feet long driven along the face and spiked to the aforesaid walling pieces. I have also assumed the usual condition, namely, a channel about five feet deep at low tide normally, but which has been washed out by the eddies and currents along the face of the jetty to a depth of nine feet at low tide. This gives at low tide nine feet depth of water on the channel side with the jetty extending seven feet above water level and the piling extending eight feet below the bed of the channel, while the sheet piling is only three feet below. Under these conditions, if we assume the sand on the opposite side of the jetty to be within one foot of the top, and to be practically dry, the pressure of the sand on the back will be greater than the pressure of water in front by an amount



WHY SINGLE LINES OF PILING
WILL NOT STAND
Figure 3.

which would be equivalent to 184 pounds per running foot of jetty applied at the top of the piling and tending to push the jetty toward the channel. This is the most favorable condition which can be suggested, and means a total pressure against the back of the jetty of about one ton for each eleven feet of length. If we assume, however, that the sand back of the jetty is saturated with water, then the pressure may run as high as two tons per running foot of jetty, and with the corrosion of the spikes, soon becomes sufficient to force the planking or sheet piling off of the jetty, and indeed to force the piling out and destroy the structure. Destruction sometimes occurs also by the washing out of the bed of the channel below the bottom of the sheet piling, and this, combined with the pressure of the saturated sand at the back, quickly strips off the sheet piling and destroys the jetty. Where the jetty is exposed to the action of the waves of the sea, destruction is, of course, much more rapid. Such structures are entirely inadequate, and are, for the purpose, by no means worth the money which it cost to construct them. Even with the substantial jetties which I propose, I consider it to be important to protect the jetty on the channel side from unusual scour by placing stone or riprap in the bottom of the channel for about eight feet out from the face of the jetty, first taking the precaution to pump out the sand so that the top of the stone will be at a depth of not less than five feet at low tide. This riprap protection will add materially to the durability and stability of the structure.

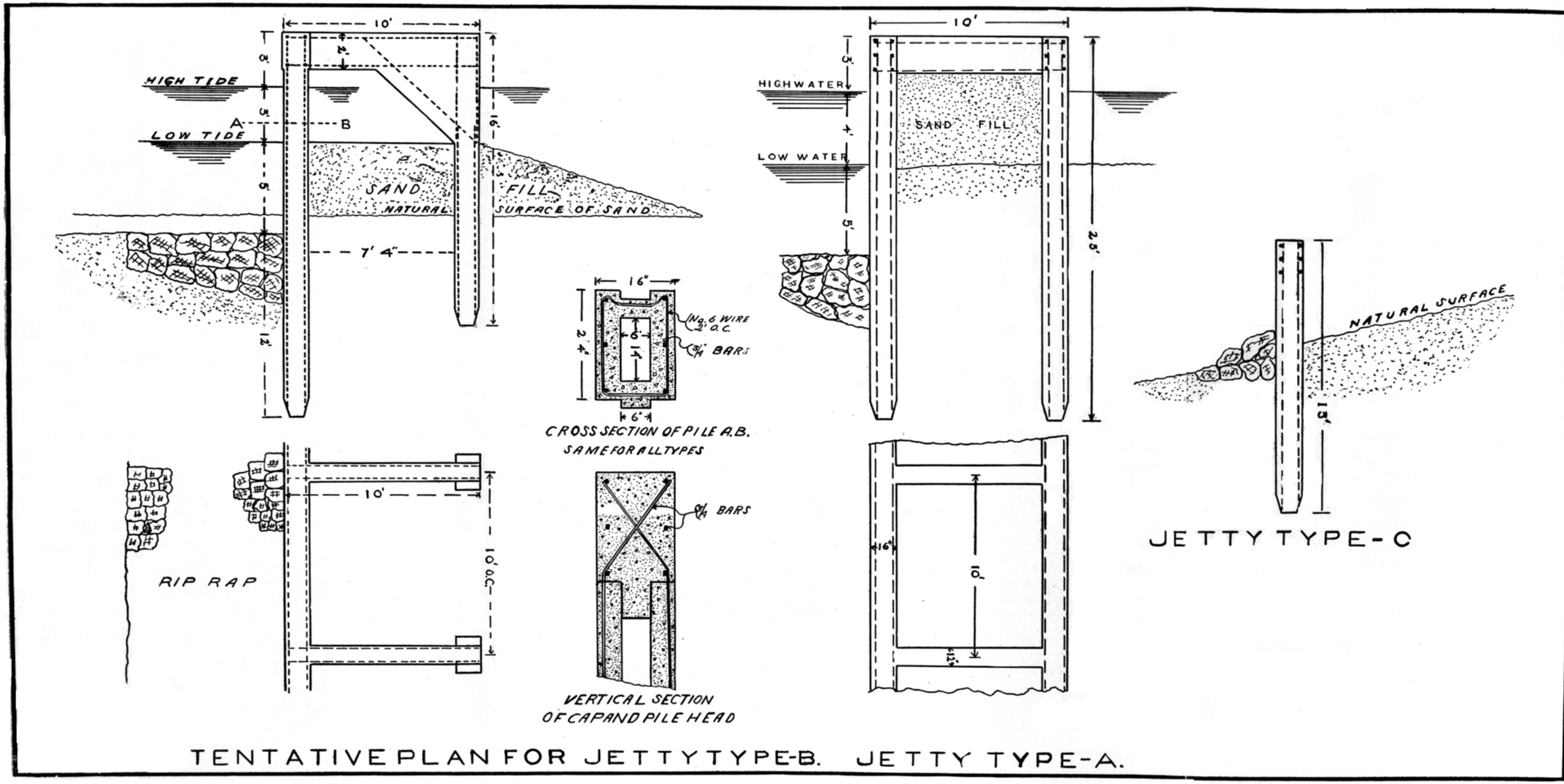
TYPES OF JETTIES PROPOSED.

After due consideration, I have tentatively adopted three types of concrete jetties for the purposes of this estimate. These are shown in the accompanying drawings, and will be referred to as types A, B and C, respectively. Further surveys and especially borings, which are imperatively necessary in order to locate the depth of the sand and the nature of the underlying material, said to be hard pan, but which more probably consists of clay-marl, may lead to some modification of these types. The types are all based on the use of a reinforced concrete sheet pile, measuring sixteen inches thick by twenty-four inches wide, and containing a tongue and a groove for the purposes of holding it in line with the adjoining pile. In the absence of borings, I have been compelled to assume an average length for the piling, in type A and type B jetties, of twenty-five feet. The piles will be cast hollow in order to reduce the weight, as shown by the cross-section. They will be reinforced longitudinally by three-quarter inch steel rods, and traversely with number six wire. It is intended that they shall be cast in suitable molds, allowed to set, and then transported to the work and sunk by means of a jet of water, in which operation the hollow form will probably prove very convenient. The mixture used in making concrete for these piles will consist of one part cement, two parts beach sand, and either four parts of broken trap rock, or five parts of gravel and trap rock or gravel alone.

Type A jetty will consist of two lines of these concrete sheet piles, placed about ten feet apart. After the piles are driven, reinforced concrete caps or string pieces will be cast in place, including a cross beam or tie every ten feet to tie the two lines of piling together. After completion, sand will be pumped in from the channel to fill the space between the piling to the top in order to increase the weight and stability. The sand will be pumped out on the channel side as previously suggested, and stone or riprap will be placed to the amount of one cubic yard to each running foot of jetty, the surface of the stone being kept five feet below low-water mark. Type A jetty is intended to be used for about 200 feet on the end of the north jetty, where it projects through and beyond the line of the beach and is considerably exposed to the pounding of the waves.

Type B is to be adopted for the jetties along the northerly and southerly curves of the S formed by the channel just inside the beach, where considerable strength and solidity is required, but where the jetty is less exposed than is the case with Type A.

Type B consists of a single line of the previously described concrete sheet piling, driven as previously described and supplemented by similar brace piles driven ten feet distant from the sheet piling. The tops of these brace piles will be at about the level of low tide. A cap or string piece will be cast along the tops of the sheet piling and at the same time a cross piece or brace of the form shown by the drawings will be cast, reaching from this string backward to the brace piles, the whole suitably reinforced with steel rods. As there will be no circulation of water permitted at the rear of these jetties, it is expected that the rear space will naturally within a short time fill up with sand, but in order to add stability to the jetty before this filling takes


10'
HIGH TIDE
LOW TIDE
A
B
SAND FILL
NATURAL SURFACE OF SAND
7' 4"
16'
12'
16"
No. 6 WIRE 2' O.C.
3/4" BARS
6"
CROSS SECTION OF PILE A.B.
SAME FOR ALL TYPES
RIP RAP
10' O.C.
VERTICAL SECTION
OF CAP AND PILE HEAD
HIGHWATER
LOW WATER
SAND FILL
25'
NATURAL SURFACE
13'
JETTY TYPE-C
TENTATIVE PLAN FOR JETTY TYPE-B.
JETTY TYPE-A.

place, it is intended that sand shall be pumped from the channel over to the rear of the jetty, filling it up to about the level of low tide. Riprap will be placed along the channel side of the jetty as described in the case of type A.

Type C is a lighter form of jetty which will extend along the northerly bank of the inlet from the end of the heavier jetty at the S bend, westerly to the line of Second Avenue in Avon. Since this is the convex side of the channel throughout, it is not expected that there will be any scour along the face of this jetty, and its principal purpose is to prevent the water from breaking over back of the north jetty and washing away the sand during times of unusual high tides.

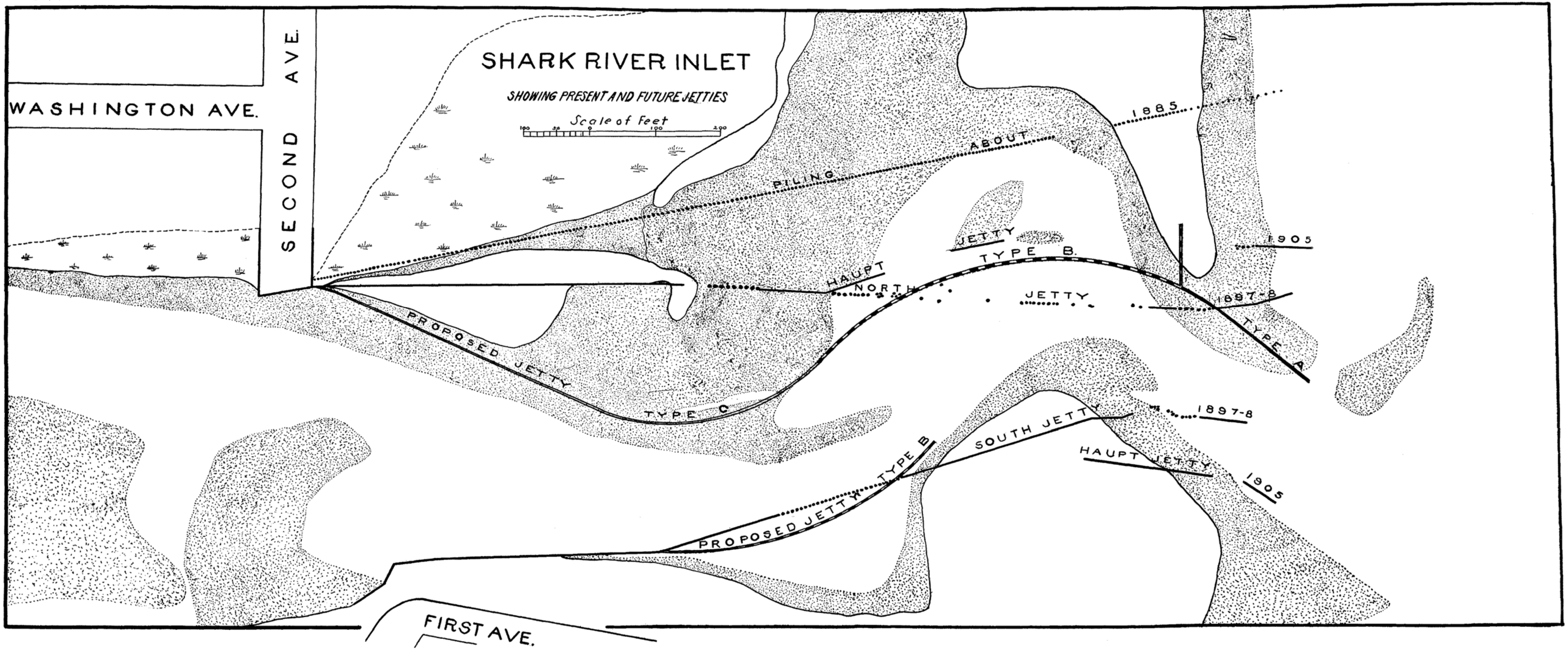
SEA WALL AT AVON.

In order to prevent the channeling out of the sand on the rear or northerly side of the jetty, I propose a short spur jetty running about 200 feet up the beach from the line of the north jetty. It will add considerably to the stability of this beach between the north jetty and the fast land in Avon, if a sea wall of some kind can be built reaching from the north jetty northward to the line of Garfield Avenue, at the boardwalk. This beach is low and there is a chance that at times it may be cut out by the action of northeasterly or easterly storms. Such storms will not be able to make a permanent breach so long as the inlet is controlled by the jetties, and is not allowed to cut northerly inside of the beach as it has done heretofore; but if such inroads of the waves from the ocean can be prevented entirely, the stability of the whole work will he materially increased. It has been suggested that the construction of the proposed ocean boulevard, which would naturally traverse about the same line as the suggested bulkhead or sea wall, will give all of the protection necessary at this point. I believe this to be true and have not included the cost of such a sea wall in my present estimates. Indeed, I do not believe that an expensive structure will be necessary.

LOCATION OF PROPOSED JETTIES.

As is shown by the accompanying sketch, the northerly jetty starts at the line of Second Avenue and runs along the northerly bank of the inlet nearly straight for the first 475 feet, thence by a curve to the left with a radius of 300 feet to a total distance of 850 feet from Second Avenue. This portion is all of type C. The north jetty thence continues by a curve of 450 feet radius to the right, a distance of 600 feet to the beach, this portion being of type B and being joined at its easterly end by the spur jetty previously alluded to. From the line of this spur jetty the main jetty continues southeasterly 250 feet, being of type A and extending some 200 feet into the ocean beyond the line of the beach.

The south jetty starts at the angle of the present bulkhead at Belmar, at the south side of the inlet and just to the west of the continuation of A Street. Thence it continues easterly by a curve to the left with a radius of 500 feet for a distance of 475 feet. This is all of the south jetty which it is intended to construct, and its purpose is to overcome the tendency of the inlet to cut southeasterly into the beach and also to confine it to a position consistent with stability. This south jetty will be entirely of type B. As heretofore stated, it is not continued around the northerly end of the beach at Belmar, for the reason that the natural tendency of this beach is to move northward, so that it suffers no probable danger from cutting away. Furthermore, it is my purpose to permit the inlet at this point to assume its own natural cross section, simply confining it in location by the northerly jetty. If a south jetty is built, it is impossible at the present time to foresee accurately just what its distance shall be from the north jetty. If it is built too far distant from the north jetty, the sand will accumulate beyond it to the north and the jetty will, therefore, become absolutely useless. On the other hand, if it is built too close to the north jetty, and the waterway thereby abnormally contracted, the range of tide in the bay is likely to be materially decreased so that the volume of water passing in and out at each tide will be diminished and the size and


SHARK RIVER INLET
SHOWING PRESENT AND FUTURE JETTIES
Scale of Feet
100 50 0 100 200
WASHINGTON AVE.
SECOND AVE.
FIRST AVE.
PILING ABOUT 1885
HAUPT NORTH JETTY 1897-8
JETTY TYPE B.
1905
TYPE A
PROPOSED JETTY TYPE C
SOUTH JETTY 1897-8
HAUPT JETTY 1905
PROPOSED JETTY TYPE B

depth of the inlet will be correspondingly reduced. Consequently, I can see nothing but harm to come from the construction of the southerly jetty, and I believe that the money which it would cost would serve a much more useful purpose if applied to increasing the strength and stability of the northerly jetty.

The current in the inlet will be naturally driven toward the north-curved jetty by the action of the prevailing southeasterly wind as well as by the encroachment of the sand of the beach at the south, and will, therefore, naturally assume a width and depth most conducive to stability, and I believe will result in maintaining a better opening of inlet than any other system which can be devised.

REMOVAL OF PRESENT JETTIES.

I have already referred to the harmful tendencies of the present jetties, due to the fact that they are out of alignment with the natural tendency of the channel. These jetties, therefore, should be entirely removed where they are between the lines of the jetties now proposed, and the ends of the southerly jetties where they now- extend beyond low-water mark should also be removed.

ESTIMATES.

I estimate that the cost of concrete in the molds, using broken trap rock and a mixture of one, two and four, will be $5.73 per cubic yard net, allowing no profit to the contractor. The cost of concrete using gravel and a mixture of one, two and five, will be $4.50 per cubic yard net, and the cost of a concrete composed of a mixture of gravel and broken stone and proportions one, two and five, will be $5.2o per cubic yard, net. Making some allowance for incidentals, I have called the net cost 20c. per cubic foot, or $5.40 per cubic yard, which does not include the cost of forms or molds, or the cost of steel reinforcement.

The cost of a concrete pile 1 foot 4 inches x 2 feet x 25 feet containing 53 cubic feet will be as follows:

53 cu. ft. of concrete in place @ 20c.,		$10 60
Cost of mold used 12 times, per pile,		1 50
Steel rods and wire, 350 lbs. @ 2c.,		7 00
Interior mold,		2 00
Placing steel reinforcement,		40
Net cost of pile,		$21 50

Cost per lineal foot of pile, 86c.

Cost of brace pile 10 ft. long @ 86c. per lineal foot,		$8 60

Reinforced concrete cross beam, Type B:

36 cu. ft. of concrete @ 20c.,	$7 20	
Forms,	4 80	
Steel reinforcement, 175 lbs., @ 2c.,	3 50	
		$15 50

Reinforced concrete cross beam, Type A, in place:

15 cu. ft. of concrete @ 20c.,	$3 00	
Forms,	3 00	
Steel reinforcement, 76 lbs. @ 2c.,	1 52	
		$7 52

Reinforced concrete cap or string piece in place, per foot:

2.67 cu. ft. concrete @ 20c.,	$0 54	
13 lbs. steel reinforcement @ 2c.,	26	
Forms	35	
Total per lineal foot,		$1 15

Cost of a 10 ft. bent of jetty, Type A:

10 reinforced concrete piles 25 ft. long @ $21.50,	$215 00	
Handling and driving piles @ $5 each,	50 00	
One cross beam,	15 50	
20 ft. of cap or string piece @ $1.15,	23 00	
25 cu. yds. of sand fill @ 25c.,	6 25	
10 cu. yds. of riprap @ $2.50,	25 00	
Net cost of 10 ft. bent,		$334 75

Net cost of jetty per foot=$33.48.

Cost of 10 ft. bent of jetty, Type B:

5 reinforced concrete piles @ $21.50,	$107 50	
One brace pile 10 ft. long @ 86c.,	8 60	
Handling and driving six piles @ $5,	30 00	
10 ft. of cap or string piece @ $1.15,	11 50	
20 cu. yds. of sand fill @ 25c.,	5 00	
10 cu. yds. of riprap @ $2.50,	25 00	
Net cost of 10 ft. bent,		$187 60

Net cost per foot of jetty, $18.76.

Cost of jetty, Type C, per foot:

Reinforced concrete pile 13 ft. long @ 86c. per lineal foot $11.18 for 2 feet of jetty=per foot,	$5 59	
One foot of cap or string piece,	1 15	
½ cu. yd. of riprap @ $2.50,	1 25	
½ cu. yd. of sand fill @ 25c.,	13	
Handling and driving piles,	2 50	
Net cost of jetty per foot,		$10 62

SUMMARY OF COST.

250 ft. of jetty Type A @ $33.48,		$8.370 00
1,400 ft. of jetty Type B @ $18.76,		26,264 00
850 ft. of jetty Type C @ $10.62,		9,027 00
Removing old piles and jetties,		2,500 00
Contractor's profit, 15%,		6,924 15
Engineering, inspection, etc., 5%,		2,654 25
Contingencies and incidentals,		2,260 60
		$58,000 00
Should it be necessary to extend the jetty 350 ft. further to sea, we must add as follows:		
350 ft. of jetty Type A @ $33.48,	$11,718 00	
Contractor's profit, 15%,	1,758 00	
		13,476 00
Making total cost,		$71,476 00

As I have previously stated, the necessity of the extension of the jetty further out to sea cannot well be determined at the present time, and since it is possible that it will prove unneccessary, I suggest that for the present $58,000 be provided, and that the extension of the jetty further seaward be deferred until experience has shown it to be necessary or otherwise, but that the possibility of its proving necessary should be borne in mind and in the event that it does prove necessary, provision should be made for adding the 350 feet.

The balance of the appropriation of $1,000 already made for engineering work will prove inadequate to carry this work to a point which will enable me to prepare the specifications and final plans intelligently. For the purpose of making the necessary borings and completing the surveys, plans and specifications, $1,250 over and above the present appropriation should be provided. I assume that the cost of inspection and engineering supervision will be provided for out of the appropriation for the work, as I have added it to the estimate. This work is of a nature which requires intelligent supervision until it is finally constructed, for no matter how complete may be the surveys and borings, emergencies are almost sure to arise during the progress of the work which requires intelligent modification of the plans to meet unexpected conditions. The proper completion of the surveys, borings and plans, however, should he provided for separately.

Respectfully submitted,

C. C. VERMEULE.

PUBLICATIONS.

The appended list makes brief mention of all the publications of the present Survey since its inception in 1864, with a statement of the editions now out of print. The reports of the Survey are distributed without further expense than that of transportation. Single reports can usually be sent more cheaply by *mail* than otherwise, and requests should be accompanied by the proper postage as indicated in the list. Otherwise they are sent *express collect. When the stock on hand of any report is reduced to 200 copies, the remaining volumes are withdrawn from free distribution and are sold at cost price.*

The maps are distributed only by sale, at a price, 25 cents per sheet, to cover cost of paper, printing and transportation. In order to secure prompt attention, requests for both reports and maps should be addressed simply "State Geologist." Trenton. N. J.

CATALOGUE OF PUBLICATIONS.

GEOLOGY OF NEW JERSEY. Newark, 1868, 8vo., xxiv+899 pp. Out of print.

PORTFOLIO OF MAPS accompanying the same, as follows:

1. Azoic and paleozoic formations, including the iron-ore and limestone districts; colored. Scale, 2 miles to an inch.
2. Triassic formation, including the red sandstone and trap-rocks of Central New Jersey; colored. Scale, 2 miles to an inch.
3. Cretaceous formation, including the greensand-marl beds; colored. Scale, 2 miles to an inch.
4. Tertiary and recent formations of Southern New Jersey; colored. Scale, 2 miles to an inch.
5. Map of a group of iron mines in Morris County; printed in two colors. Scale, 3 inches to 1 mile.
6. Map of the Ringwood iron mines; printed in two colors. Scale, 8 inches to 1 mile.
7. Map of Oxford Furnace iron-ore veins; colored. Scale, 8 inches to 1 mile.
8. Map of the zinc mines, Sussex County ; colored. Scale, 8 inches to 1 mile.

A few copies can be distributed at $2.00 per set.

REPORT ON THE CLAY DEPOSITS of Woodbridge, South Amboy and other places in New Jersey, together with their uses for firebrick, pottery, &c. Trenton, 1878, 8vo., viii+381 pp., with map. Out of print.

A PRELIMINARY CATALOGUE of the Flora of New Jersey, compiled by N. L. Britton, Ph.D. New Brunswick, 1881, 8vo., xi+233 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. I. Topography. Magnetism. Climate. Trenton, 1888, 8vo., xi+439 pp. Out of print.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8vo., x+642 pp. Unbound copies, postage, 25 cents. Bound copies, $1.50.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, I890, 8vo., x+824 pp. (Postage, 30 cents.)

REPORT ON WATER-SUPPLY. Vol. III. of the Final Reports of the State Geologist. Trenton, 1894, 8vo., xvi+352 and 96 pp. (Postage, 21 cents.)

REPORT ON THE PHYSICAL GEOGRAPHY of New Jersey. Vol. IV. of the Final Reports of the State Geologist. Trenton, 1898, 8vo., xvi+170+200 pp. Unbound copies, $1.00; cloth bound, $1.35, with photo-relief map of State, $2.85. Map separate, $1.50.

REPORT ON THE GLACIAL GEOLOGY of New Jersey. Vol. V. of the Final Reports of the State Geologist. Trenton, 1902, 8vo., xxvii+802 pp. (Sent by express, 35 cents if prepaid, or charges collect.)

REPORT ON CLAYS AND CLAY INDUSTRY of New Jersey. Vol. VI. of the Final Reports of the State Geologist. Trenton, 1904, 8vo., xxviii+548 pp. (Sent by express, 30 cents if prepaid, or charges collect.)

REPORT ON IRON MINES AND MINING in New Jersey. Vol. VII. of the Final Report of the State Geologist. Trenton, 1910, 8vo., xv+512 pp., with two maps in a separate envelope. (Postage, 25 cents.)

BRACHIOPODA AND LAMELLIBANCHIATA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1886, quarto, pp. 338, plates XXXV. and Map. (Paleontology, Vol. I.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.50, charges prepaid.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, Plates L. (Paleontology, Vol. II.) (To residents of New Jersey, by express, charges collect; to non-residents, $1.40, charges prepaid.)

PALEOZOIC PALEONTOLOGY. Trenton, 1903, 8vo., xii+462 pp., Plates LIII. (Paleontology, Vol. III.) (Price, $1.00.)

CRETACEOUS PALEONTOLOGY. Trenton, 1907, 8vo., ix+1106 pp., Plates CXI. (Paleontology, Vol. IV.) (Price, $2.70.)

ATLAS OF NEW JERSEY. The complete work is made up of twenty sheets, each about 27 by 37 inches, including margin. Seventeen sheets are on a scale of 1 inch per mile and three on a scale of 5 miles per inch. Sheets numbered 21 to 37 replace old sheets numbered 1-17, which cannot longer be furnished. These sheets each cover the same territory as eight of the large maps, on a scale of 2,000 feet per inch.

No. 19. New Jersey Relief Map. Scale, 5 miles to the inch. Hypsometric.

No. 20. New Jersey Geological Map. Scale, 5 miles to the inch. (Out of print.)

No. 21. Northern Warren and Western Sussex counties. Replaces Sheet 1.

No. 22. Eastern Sussex and Western Passaic counties. Replaces Sheet 4.

No. 23. Northern Bergen and Eastern Passaic counties, to West Point, New York, Replaces northern part of Sheet 7.

No. 24. Southern Warren, Northern Hunterdon and Western Morris counties. Replaces Sheet 2. (Out of print.)

No. 25. Morris and Somerset counties, from Lake Hopatcong to Somerville and New Brunswick. Replaces Sheet 6.

No. 26. Vicinity of Newark and Jersey City-Paterson to Perth Amboy. Replaces in part Sheet 7.

No. 27. Vicinity of Trenton-Raven Rock to Palmyra, with inset, Trenton to Princeton. Replaces Sheet 5.

No. 28. Trenton and Eastward-Trenton to Sayreville. Replaces Sheet 8. (Out of print.)

No. 29. Monmouth Shore, with the interior from Ernston to Lakehurst. Replaces Sheet 9.

No. 30. Parts of Gloucester and Salem counties, from Paulsboro on the north, to Quinton and Deerfield on the south, with adjacent portions of Pennsylvania and Delaware.

No. 31. Vicinity of Camden, to Mount Holly, Hammonton and Elmer. Replaces Sheet 11.

No. 32. Part of Burlington and Ocean counties, from Pemberton and Whitings to Egg Harbor City and Tuckerton. Replaces Sheet 12.

No. 33. Southern Ocean County-Tuckerton to Tom's River and Chadwicks. Replaces Sheet 13.

No. 34. Western Cumberland county, including Bridgeton, with Delaware bay and adjacent portion of Delaware.

No. 35. Vicinity of Millville, from Newfield to Port Norris and Cape May Court House.

No. 36. Parts of Atlantic and Cape May counties-Egg Harbor City to Townsend's Inlet, with inset of New Inlet and Great Bay.

No. 37. Cape May-Cape May City to Ocean City and Mauricetown.

No. 38. *New Jersey State Map.* Scale, 5 miles to the inch. Shows all municipalities. (Out of print.)

All the maps are sold at the uniform price of twenty-five cents per sheet, either singly or in lots. Since the Survey cannot open small accounts, and the charge is merely nominal, remittance should be made with the order. Order by *number* of the State Geologist, Trenton, N. J.

TOPOGRAPHIC MAPS, NEW SERIES.

These maps are the result of revision of the earlier surveys, and contain practically all of the features of the one-inch scale maps, with much new material. They are published on a scale of 2,000 feet to an inch, and the sheets measure 26 by 34 inches. The Hackensack, Paterson, Boonton, Dover, Jersey City, Newark, Morristown, Chester, New York Bay, Elizabeth, Plainfield, Pluckemin, Amboy, New Brunswick, Somerville, Navesink, Long Branch, Shark River, Trenton, Camden, Mt. Holly, Woodbury, Taunton and Atlantic City sheets have been published and are now on sale. The price is twenty-five cents per sheet, *payable in advance.* Order by *name* any of the sheets above indicated as ready, of the State Geologist, Trenton, New Jersey.

GEOLOGIC ATLAS OF NEW JERSEY.

The State Geological Survey, in co-operation with the U. S. Geological Survey, is engaged in the publication of a Geologic Atlas of New Jersey. It will be issued in several parts, each part containing a complete discussion of the geography and geology for the region covered. Each volume will comprise (1) pages of descriptive text, (2) a topographic map, (3) geologic maps showing the distribution and structure of the various rock formations, the occurrence of all mineral deposits of economic importance, and (4) in some cases pages of half-tone illustrations. The following folios are now ready:

THE PASSAIC FOLIO, which covers the region from Morristown to Jersey City, and from Perth Amboy and New Brunswick to Pompton and Westwood, comprising 945 square miles; scale, 2 miles to an inch. It includes 27 pages of text, a topographic map, 3 geologic maps and a page of illustrations. Price, 25 cents; postage, 15 cents; if sent by express, charges collect.

THE FRANKLIN FOLIO covers the territory from Branchville and Newton, on the west, to Stockholm on the east, and from Andover and Petersburg, on the south, to Libertyville on the north, or 235 square miles; scale, 1 inch to a mile. In addition to the regular text and maps it includes a special study and description of the famous zinc deposits at Franklin Furnace, and of the white crystalline limestones. Price, 25 cents; postage, 15 cents extra; if sent by express, charges collect.

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THE TRENTON FOLIO describes the region around Trenton as far as Stockton, Millstone, Hightstown, New Egypt, Mount Holly, Delanco and Newtown, Pa., an area of 911 square miles. It contains descriptive text and three maps (scale, 2 miles per inch), It is published in two forms, the folio size (21 3/4 by 18 1/2 inches) and a pocket or octavo size (9 1/4 by 6 inches). In the latter the maps are on thin paper, are folded and in a pocket. This size is more convenient for field use than the folio size. Price, folio edition, 25 cents, postage is 15 cents extra; pocket edition, 50 cents, postage 10 cents extra. If sent by express, charges collect.

Other folios will be prepared and issued from time to time until the entire State is covered.

Orders for these folios should be addressed to the State Geologist, Trenton, N. J., and *remittance must accompany the order.*

ANNUAL REPORTS.

REPORT OF PROFESSOR GEORGE H. COOK upon the Geological Survey of New Jersey and its progress during the year 1863. Trenton, 1864, 8vo., 13 pp. Out of print.

THE ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1864. Trenton, 1865, 8vo., 24 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, to his Excellency Joel Parker, President of the Board of Managers of the Geological Survey of New Jersey, for the year 1865. Trenton, 1866, 8vo., 12 pp. Out of print.

ANNUAL REPORT of Prof. Geo. H. Cook, State Geologist, on the Geological Survey of New Jersey, for the year 1866. Trenton, 1867, 8vo., 28 pp. Out of print.

REPORT OF THE STATE GEOLOGIST, Prof. Geo. H. Cook, for the year of 1867. Trenton, 1868, 8vo., 28 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1869. Trenton 1870, 8vo., 57 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1870. New Brunswick, 1871, 8vo., 75 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1871. New Brunswick, 1872, 8vo., 46 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1872. Trenton, 1872, 8vo., 44 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1873. Trenton, 1874, 8vo., 128 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1874. Trenton, 1874, 8vo., 115 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1875. Trenton, 1875, 8vo., 41 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1876. Trenton, 1876, 8vo., 56 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1877. Trenton, 1877, 8vo., 55 pp. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1878. Trenton, 1878, 8vo., 131 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1879. Trenton, 1879, 8vo., 199 pp., with maps. Out of print

ANNUAL REPORT of the State Geologist of New Jersey for 1880. Trenton, 1880, 8 vo., 220 pp., with map. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1881. Trenton, 1881, 8vo., 87+107+xiv. pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1882. Camden, 1882, 8vo., 191 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1883. Camden, 1883, 8vo., 188 pp. (Price, 50 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1884. Trenton, 1884, 8vo., 168 pp., with maps. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1885. Trenton. 1885, 8vo., 228 pp., with maps. (Postage, 9 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1886. Trenton 1887, 8 vo., 254 pp., with maps. (Postage, 9 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1887. Trenton, 1887, 8vo., 45 pp., with maps. (Postage, 5 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1888. Camden, 1889, 8vo., 87 pp., with map. (Postage, 5 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1889. Camden. 1889, 8vo., 112 pp. (Postage, 6 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1890. Trenton, 1891, 8vo., 305 pp., with maps. (Postage, 10 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1891. Trenton, 1892, 8vo., xii+270 pp., with maps. Out of print.

ANNUAL REPORT of the State Geologist of New Jersey for 1892. Trenton, 1893, 8vo., x+368 pp., with maps. (Price, $1.55.)

ANNUAL REPORT of the State Geologist of New Jersey for 1893. Trenton, 1894, 8vo., x+452 pp., with maps. (Postage, 18 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1894. Trenton, 1895, 8vo., x+304 pp., with geological map. (Postage, 11 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1895. Trenton, 1896, 8vo., xl+198 pp., with geological map. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist of New Jersey for 1896. Trenton, 1897, 8vo., xxviii+377 pp., with map of Hackensack meadows. (Postage, 15 cents.)

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ANNUAL REPORT of the State Geologist for 1898. Trenton, 1899, 8vo., xxxii+244 pp., with Appendix, 102 pp. (Postage, 14 cents.)

ANNUAL REPORT of the State Geologist for 1899 and REPORT ON FORESTS. Trenton, 1900, 2 vols., 8vo., Annual Report, xliii+192 pp. FORESTS, xvi+327 pp., with seven maps in a roll. (Postage, 8 and 22 cents,)

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ANNUAL REPORT of the State Geologist for 1901. Trenton, 1902, 8vo., xxviii+178 pp., with one map in pocket. (Postage, 10 cents.)

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ANNUAL REPORT of the State Geologist for 1904. Trenton, 1905, 8vo., x+317 pp. (Postage, 12 cents.)

ANNUAL REPORT of the State Geologist for 1905. Trenton, 1906, 8vo-, x+338 pp., with three maps in a pocket (Price, 55 cents.)

ANNUAL REPORT of the State Geologist for 1906. Trenton, 1907, 8vo., vii+192 pp. (Postage, 10 cents.)

ANNUAL REPORT of the State Geologist for 1907. Trenton, 1908, 8vo., ix+192 pp. (Postage, 12 cents.)

ANNUAL REPORT of the State Geologist for I908. Trenton, 1909, 8vo., xi+159 pp. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist for 1909. Trenton, 1910, 8vo., vii+123 pp. (Postage, 6 cents.)

BULLETINS.

In 1910 the series of Annual Reports was replaced by a series of Bulletins, each being a separate report upon some subject. Up to date five Bulletins have been issued.

BULLETIN 1.—Administrative Report of the State Geologist of New Jersey for 1910. Trenton, 1911, 43 pp. (Out of print.)

BULLETIN 2.—A Report on the Approximate Cost of a Canal between Bay Head and the Shrewsbury River, by H. B. Kümmel. Trenton, 1911, 20 pp., 1 map.

BULLETIN 3.—The Flora of the Raritan Formation, by Edward W. Berry. Trenton, 1911, v+233 pp. and xxix plates.

BULLETIN 4.—A Description of Fossil Fish Remains of the Cretaceous, Eocene and Miocene Formations of New Jersey, by Henry W. Fowler. Trenton, 1911, 192 pp.

BULLETIN 5.—The Mineral Industry of New Jersey for 1910, by H. B. Kümmel and S. Percy Jones. Trenton, 1911, 24 pp.

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