GEOLOGICAL SURVEY OF NEW JERSEY

# ANNUAL REPORT

OF THE

# STATE GEOLOGIST

For the Year 1903

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

1904.

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| | | Terms expire. |
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| Frederick W. Stevens, ...................... | Morristown, .............. | 1904 |
| Emmor Roberts, ............................ | Moorestown, ............ | 1905 |
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| I. | Frederick R. Brace, ................ | Blackwood, .............. | 1906 |
| II. | Edward C. Stokes, .................. | Millville, ............... | 1907 |
| III. | M. D. Valentine, ................... | Woodbridge, ............ | 1904 |
| IV. | Washington A. Roebling, ............ | Trenton, ................ | 1908 |
| V. | Frederick A. Canfield, ............. | Dover, .................. | 1905 |
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| X. | Aaron S. Baldwin, .................. | Hoboken, ................ | 1905 |

*State Geologist.*

Henry B. Kümmel.

*To His Excellency Franklin Murphy, Governor of the State of New Jersey and ex-officio President of the Board of Managers of the Geological Survey:*

SIR—I have the honor to submit my Annual Report upon the work of the Geological Survey for the year 1903.

Yours respectfully,

HENRY B. KÜMMEL,

*State Geologist.*

TRENTON, N. J., December 22, 1903.

# ADMINISTRATIVE REPORT.

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# Administrative Report.

BY HENRY B. KÜMMEL, STATE GEOLOGIST.

A summary of the work of the Geological Survey for the year ending October 31st, 1903, is herewith presented in the Administrative Report, while the accompanying papers give in fuller detail some of the scientific results.

The administrative work of the Survey demands a considerable portion of my time. This work includes answering letters of inquiry regarding the resources of the State, supervision of all expenditures, editorial work upon reports, supervision of the distribution of reports, of the proper care and classification of the Survey collections, as well as the direction of the scientific investigations. In much of this work most efficient aid has been rendered by Miss Laura Lee, whose familiarity with the office routine has relieved me of many details.

A long and severe illness during the latter part of the year compelled me to relinquish entirely all work. In this emergency the Board of Managers requested former State Geologist Dr. John C. Smock to assume control, which he kindly consented to do. Dr. Smock not only gave attention to the routine work, but also very kindly undertook the major part of the preparation of the Annual Report, so that when I was able to resume my duties late in December I found only a few paragraphs of the Administrative Report needing to be written. My thanks are also due to other members of the Survey staff, particularly to Mr. G. N. Knapp and to Miss Lee, for their efficient services in the office work during my absence.

During the year the mailing list has been revised and partly rewritten, and the photographic negatives and prints have been classified both geographically and geologically.

My scientific work during the year has been partly in the field and partly in the office. Several weeks were spent in the field in collecting additional data regarding the clay deposits and in completing the detailed clay map in the vicinity of South Amboy and Matawan, as well as in visiting numerous localities in the northern part of the State. A few days were also spent with Mr. Knapp and with Dr. Weller in their work upon the formations in the southern part of the State.

In the office the scientific work has been as follows. The Annual Report for 1902 was compiled and proofs read. The Report on Paleozoic Paleontology, Vol. III, by Dr. Weller, was read in manuscript and afterwards in proof. That portion of the Report on Clays which relates to the stratigraphy of the clay-bearing formations was written and Dr. Ries' portion of the manuscript was also read. Maps to accompany this report were prepared. Some time was also spent in preparing maps and manuscript for two geological folios to be published in cooperation with the United States Geological Survey.

### TOPOGRAPHIC WORK.

The topographic work has been, as heretofore, directed by Mr. C. C. Vermeule, who has been assisted at various times by Messrs. P. D. Staats, W. A. Coriell, J. F. Scrimshaw, G. A. Johnson and Robert Allen.

At the beginning of the year many of the sheets of the Atlas of New Jersey—scale, one inch per mile—were out of print, so that new editions were necessary. This fact has given opportunity for extensive revisions, particularly in the vicinity of the important cities, thus bringing the maps down to date. It also raised the question whether the old system of overlapping sheets was the best which could be adopted. Correspondence with a number of the largest purchasers of these maps showed an almost unanimous opinion that a system of non-overlapping sheets, matching edge to edge, and arranged in tiers across the State, would be better than the present system. It was determined, therefore, to replace the old sheets as rapidly as the editions on hand became exhausted by new sheets, practically the same size and on the same scale, but somewhat differently arranged. The new sheets will be numbered from 21 to 37 inclusive, and when the entire substitution has been made they will take the place of the old sheets 1 to 17. At the present time Nos. 2, 4, 5, 7, 11 and 12 of the old series are out of print and can no longer be supplied. Nos. 22, 24, 26 and 27 of the revised sheets have already been issued, and sheets 31 and 32 will be published shortly. In large part these revised new sheets cover the same territory as those which are out of print.

The necessary field revision, the preparation of copy for the engraver and the reading of proofs of these sheets has engaged the attention of the topographic force. In addition the proofs of the Shark River sheet and the New York Bay sheet of the large scale maps were examined and corrected.

Mr. Vermeule's office force has also spent considerable time in preparing drawings to illustrate the Annual Report for 1902, as well as the Clay Report.

During the coming year it is proposed to continue the revision of the older maps, particularly of sheet 8 and 17, editions of which will probably be exhausted at the end of the year. Sheet 8 will be replaced by No. 28, covering nearly the same ground, and sheet 17 in part by 37.

### SURFACE GEOLOGY.

Prof. R. D. Salisbury has continued in charge of the Surface or Pleistocene work. He was in the field for a short time in June.

Mr. G. N. Knapp, working as Mr. Salisbury's assistant, began field work in April and, with the exception of a few weeks in September, was engaged in these investigations until late in October. His work was chiefly in Burlington, Mercer, Middlesex and Monmouth counties, and the detailed revision of the mapping of the surface formations commenced the year previous was completed. Incidental to the work upon the surface sands and gravels the mapping of the underlying formations—chiefly the sands, clays and marls of Cretaceous age—was revised so that the Survey now has data on hand for a correct map of the Cretaceous formations on a scale of one mile to an inch. After the field season, Mr. Knapp compiled his field data and wrote up his results.

The preparation of a monograph upon the Surface geology of South Jersey, comparable in scope to the Report upon the Glacial Geology, needs now to be undertaken. Great interest has been aroused by the "Glacial Geology," and frequent requests for it are received from all classes of citizens and from all parts of New Jersey, as well as from citizens of other States. This interest warrants the preparation of a companion volume upon the southern counties. Probably no previous report of the Survey has ever been so widely read, over 3,300 copies being distributed, chiefly in answer to requests, and its publication has undoubtedly done more to bring the work of the Survey to the notice of the public than any other work, except perhaps the publication of the topographic maps.

Mr. Salisbury will begin the preparation of the new report during the coming year.

## PALEONTOLOGY.

The paleontological work of the Survey in the division of invertebrate fossil forms has been in charge of Dr. Stuart Weller. During the early part of the year he supervised the publication of his report upon the Paleontology of the Paleozoic formations, Vol. III of the Paleontology series. Later in the year he commenced the study of the fossils found in the sands, clays and marls of the southern portion of the State. He was in the field from July 16th to September 9th and examined the Cretaceous formations in Monmouth, Burlington, Camden, Gloucester and Salem counties. The work was in the study of the stratigraphy and the collection of fossils from the various strata. A large collection of fossils was made, which will throw much light upon the range and distribution of the species when they have been thoroughly elaborated and studied. At the time of publication of Volumes I and II of the Paleontology of New Jersey by Prof. Whitfield the data furnished with the specimens was insufficient to make them of much use in a close stratigraphic study of the Cretaceous beds. It is the purpose of his work to furnish this data and to work out the stratigraphic relations of the various species and assemblages of species or faunas.

Since the close of the field season Dr. Weller has devoted his entire time to the preparation and identification of the collections, but has not yet progressed far enough to make any final statement of results. He reports, however, that there are definitely recognizable faunal zones in the Cretaceous which can be readily traced entirely across the State, and which will constitute an efficient aid in the correlation and mapping of the strata.

It will probably be necessary to spend some time in the field during the next season in order to complete the data for the investigation.

Dr. Eastman's continued absence from this country has heretofore prevented the completion of his studies upon the Triassic fossil fish. He has now returned, however, and arrangements have been made to complete this work at once. In addition to the material collected by the Survey, he will examine and report upon material in several private collections, as well as similar forms in the larger museums of the country.

## CLAYS AND THE CLAY INDUSTRY.

During the winter and spring Dr. Heinrich Ries was engaged in completing the laboratory tests and analyses for the Clay Report, and preparing his manuscript and drawings for the printer. The first draft of the report was submitted the latter part of June. Inasmuch as the complete report will be the work of several authors, considerable revision of the several parts was necessary to prevent contradictions and guard against omissions, so that there has been some delay in its completion. It was expected that the manuscript could go to the printer some time in October, but my illness further retarded its publication. This delay has not, however, been entirely a misfortune, since there has thus been opportunity to make additional fire-tests of many clays and so increase the value of the report. Unless there are unforeseen delays the work will be issued some time during the winter.

### GLASS, MOLDING AND FURNACE SANDS.

The glass sands of the State were discussed in some detail in the "Geology of New Jersey, 1868," by Dr. Cook. At that time the most extensive diggings were about three miles below Millville, on the west bank of the Maurice river. About 10,000 tons were dug annually and sold on the dock at two dollars a ton, being shipped to New York, Philadelphia and other points. It was estimated that nearly 20,000 tons were also produced at other points. In the same report a list of forty-three glasshouses was given, of which fourteen made window glass and the remainder hollow ware. Since the above report was written many changes have taken place in the glass industry. Some towns which were glass manufacturing centers twenty-five years ago have ceased to be producers, whereas other localities still continue in the front rank. At numerous places through the pine belt one may see the ruins of old glasshouses that have been so long abandoned that almost all trace of them has disappeared, only the glass refuse which marks the site of the old blast furnaces indicating their former existence. The old Lebanon Glass Works, three miles north of Woodmansie, and the old glasshouse near Manumuskin, Cumberland County, are instances of this.

Since in the early days of glass manufacture sand was dug in most instances in the vicinity of glasshouses, the distribution of these old ruins shows approximately the points at which glass sand was obtained. In these early days the sand was dug at more points than at present, but nowhere was it dug so extensively.

In not a few instances in the early days very superficial deposits of sand were used. Sometimes these were the banks or bars of sand bordering the streams, but at present no glass sand is derived from these sources. With the advent of railroad facilities for transportation and distribution the sand industry has become localized and the largest deposits of sand which can be most cheaply worked have displaced the numerous small workings.

Inasmuch as the sand industry has been so little studied by the Survey, and since it has for many years maintained an important position among the industries of the State, a somewhat extended investigation of the character and distribution of the sands and their uses is contemplated by the Survey. As a preliminary step in this work, Mr. G. N. Knapp has collected some statistics showing the amount of sand dug in the State. Owing to the limited time available for this work, these statistics are not complete, but they give some idea of the extent of this industry, and they are therefore published.

*Glass sands.*—Of the eighteen glasshouses making window and bottle glass in the State, eleven establishments kindly replied to the circular letters sent out by Mr. Knapp and report an aggregate of 40,236 tons of glass sand used by them annually, of which 8,907 tons are imported and 31,429 tons are obtained in New Jersey. These figures represent probably more than half the total amount of glass sand annually consumed.

*Furnace sands.*—Furnace sands, variously called silica sands, fire sands and cupola sands, are used to line the steel and iron furnaces to protect their walls from the intense heat to which a continuous blast for months subjects them. These sands, therefore, are valuable or worthless as they can or can not stand up to a temperature of 2,200 to 3,000 degrees Fahrenheit and obtain a standard coherency. Statistics obtained from six of the more important sand producers show that during the past year 92,493 tons of furnace sand was dug by these firms, about 72,000 tons being sold out of the State.

*Core sands.*—The same six firms report the production of 59,051 tons of core sand, of which 42,500 tons were shipped to other States. This is probably only a small fraction of all the core sand annually produced in New Jersey.

*Molding sand.*—The annual production of molding sand as reported by six firms is 92,000 tons, of which 83,500 tons were shipped to other States.

*Molding loam.*—About 20,000 tons of molding loam are annually dug by these firms, 14,000 tons being sold out of the State.

Information was also sought from founders and furnaces in the State to learn amount and grades of sand used. The statistics in the following table were obtained from eighteen firms.

| | | Price | | |
|---|---|---|---|---|
| | Tons. | Average. | Range. | Obtained Outside State. |
| Molding loam, | 10,087 | $1.50 | $0.50-$2.10 | .... |
| Molding sand, | 18,752 | 1.50 | .70- 2.30 | 5,549 |
| Core sand, | 9,613 | 1.25 | .50- 1.75 | 983 |
| Silica sand, | 9,048 | 1.85 | 1.75- 2.50 | 50 |
| Furnace sand, | 3,125 | 2.50 | | |
| Shore or beach sand, | 70 | 1.25 | | |
| Other grades, | 1,210 | 1.00 | | |
| | 51,905 | | | 6,582 |

The wide range in the price of the molding sands and loam is in part due to the fact that in some cases founders are able to obtain certain grades near the foundry, but must import others. For instance, one founder can obtain his loam in the adjacent fields; he gets it with his own help and his teams; it costs him fifty to seventy cents per ton, but he must ship in his core sand at $1.50 to $2.30 per ton. Another founder may be able, by virtue of his location, to obtain his core sand at fifty cents per ton and be compelled to import his molding loam for $1.50 per ton.

It is proposed during the coming season to continue these investigations and to prepare a report which shall consider not only the geographical distribution of the various grades of sand in the State, but also the chemical and physical composition, which renders one sand available for certain classes of work and another sand of similar appearance utterly useless. Such studies will include not only chemical analyses, but also physical and microscopic examinations, and to be of real value must be thorough and exhaustive.

## PASSAIC VALLEY DRAINAGE.*

The great flood of October in the valley of the Passaic river, the large aggregate damages to property in the cities of Paterson and Passaic, and the studies of Mr. Vermeule on the height of the water and the extent of land overflowed and the most practicable methods of controlling these floods suggests renewed attention to the drainage plan, which was prepared by the Geological Survey and placed in charge of the Passaic Drainage Commission, but stopped by lack of the necessary funds for its completion. The several Annual Reports of the Geological Survey refer to the work done by the Commission and also to the prospective advantage of the drainage work and the desirability for its completion.

In the light of the most recent scientific investigations on the cause of malarial diseases and the agency of the mosquito in spreading them, we learn that stagnant pools of water, such as abound in the warmer months of the year on these flat lands and in the sluggish streams of this Upper Passaic valley, favor the breeding of the pestiferous insect as well as the innocuous mosquito, and, as a result, we are conversant with the prevalence of malarial disorders in the valley. The execution of the drainage plan would tend to the more rapid discharge of the lesser floods, which occur every summer, and would promote the flow of the streams and the movement of the draining-ditch waters, so that there would be much less of stagnant surface-waters and consequently little or no cause for malarial troubles. Their removal would be a great gain to the residents of the valley, and also to hillsides immediately adjoining the wet meadows in it, if not to localities further away from them. The prevalence of malaria in this valley is a most serious drawback to its improvement and

*The paragraphs in reference to this and the following topic have been prepared by Dr. J. C. Smock, whose long connection with the Geological Survey, for nearly forty years as Assistant Geologist, State Geologist and later Member of the Board of Managers, has made him thoroughly conversant with these problems and the studies undertaken by the Survey to obtain the preliminary information necessary to their amelioration.

a menace to the surrounding country, which is removable by an effective drainage system. Tillage of the soil and pasturage, which the thorough drainage would make possible in these wet lands, would not only add so much of productive wealth to the farmer, but would also make his abode healthful and attractive. The coming of the plough and the sickle mean the going of the mosquito. Of the advantages to the valley and to the State in the increase of arable land and consequent ratables it is not necessary to do more than refer to what has been said in previous reports of the Geological Survey.

The æsthetic element in the improvement by drainage deserves much greater consideration than has been given to it. All who have seen the rich polders of Holland realize what effective drainage and careful husbandry can do for the setting of the landscape. These unkempt and flood-devastated farm lands and swamps are an eyesore to the lover of rural beauty, suggesting loss of crops, waste of energy and the ills that wait on such conditions. The setting of this Passaic valley in a hill country of exceptional beauty is one of the most striking features in the topography of the northern part of the State. With so beautiful an environment it seems to be fitting that for æsthetic considerations only the drainage plan should be consummated. Man ought to complete the unfinished work of nature in draining this valley, or else restore old Lake Passaic. Not only is the valley, in its present condition, an offense to the landscape; it is productive of carelessness on the part of the farmer and consequent indifference and neglect, and this influence is felt beyond its immediate limits. Were it all in a natural condition of woodland this influence would not be of consequence or importance, but in the struggle for a pittance, or at best a livelihood, the farmer by his clearings develops conditions which are undesirable and bad examples to his fellows who live on the adjacent hillsides. The poorly-tilled farm is always a sort of nuisance among thrifty farmsteads, and this valley is not an exception. The effect of proper drainage, fully carried out in all the valley, would be on the side of order and thrift and attendant success. The moral argument for drainage is of itself worthy of consideration, if not sufficient to justify the cost of the undertaking.

The drainage plan is not inconsistent with the best protective measures which are now demanded for the protection of the cities of Paterson and Passaic. Mr. Vermeule, in his report on Floods in the Passaic in the last Annual Report of the Survey, says the results of his investigations of the floods show that "the improvements proposed by the Commissioners of Passaic Drainage would not increase, but, on the contrary, would tend to diminish the height of floods," and that there need not be any apprehension of danger from this improvement. The profiles of the river in the great floods of both 1902 and 1903 show that Beattie's dam does not exercise any controlling influence upon the height of the water during these periods. Owing to the torrential character of the streams of the upper part of the Passaic catchment basin and the flatness of the lower part, floods are inevitable and these great floods must cover these flat stretches of the valley. But it is not these extraordinarily high floods against which it is necessary to make provision by drainage, but the lower and recurring floods of every season, which run off slowly—these are to be gotten rid of by the provision of a lower dam at the Beattie Mill site and an excavated channel above the dam and the removal of the obstructions at Two Bridges. The improvements contemplated would tend to make the discharge of the floods more uniformly rapid and shorten the length of time in which the meadows would be under water during the days and weeks after the main flood has passed. As is stated by Mr. Vermeule, "the real benefits of the proposed drainage improvement do not depend on entirely preventing the overflow of the flat lands in time of great freshets. For weeks and months these lands are now saturated, not by extreme floods, but when the stream is slightly swollen, or during the tardy discharge of the waters at the end of a freshet, and it is this condition which causes sourness, prevents the raising of useful crops, and produces malarial or miasmatic diseases." The great floods probably do good in the rich sediments which the flood waters deposit in these alluvial lands, and a single flood covering them may not be altogether a disadvantage. On the contrary, the lesser floods, which recur frequently, and often during the growing season, interfere seriously with all crops and the great losses discourage the farmer.

The urgent need of some public action in controlling such floods as that of last October and that of 1902—which last year's report discussed—is recognized by all who are interested in the growth and prosperity of our cities, but the paramount interests of the cities need not be exclusive and prohibitory of improvements in the Passaic's channel at Little Falls and at Two Bridges and above in the meadows, whereby the floods shall be of shorter duration and the great and yearly losses of the farmers shall be prevented, or at least reduced greatly in amount. The city and the country can be both protected, and any plan of control which shall be equitable in its working must include in its provisions the guarding of the fields against flood, as well as the city. The last great flood appears to emphasize the need of some action by the authority of the State, and it is opportune to call attention at this time to what the State has already done through the Geological Survey and the Passaic Drainage Commission and what was proposed to be done by this plan of drainage, and further to refer again to the importance and great benefits which would result from the drainage not only to the valley of the Passaic, but to all this part of the State.

## DRAINAGE OF THE HACKENSACK AND NEWARK TIDE MARSHES.

The drainage law of 1871 authorizes the Geological Survey to make surveys and plans for the drainage and improvement of tracts "subject to overflow from freshets, or which are in a low, marshy, boggy or wet condition," upon application from the owners of such tracts. An amendment to this law makes the provisions of said law applicable to tide marshes. No work in the reclamation of tide marshes has been done, nor has there been any application for the examination and survey of tide marsh lands with a view to their improvement, but on account of the great importance of the subject the Geological Survey had a survey made of the Hackensack and Newark marshes in 1896 and 1897, and the results of the survey, made by Mr. Vermeule, were published in the Annual Reports for those years. Public attention to the value of these lands had been directed so long ago as 1869 and 1870, when the successful reclamation of low-lying lands in the Netherlands was referred to by the late State Geologist, Dr. Cook, and the methods of procedure there were described in the Annual Reports of those years. It is so important a subject that it is again included among the topics of this administrative report and the reader is referred to these previous reports for full information in regard to the location, extent, natural divisions, drainage streams and rivers, depth of mud and of water in the waterways, sites for embankments, estimated cost of reclamation and the benefits of the improvements to the lands affected and to the adjacent upland territory.

In the report for 1896 the map of the meadows shows many of these facts. The new atlas sheet and topographic map No. 26, which has been published recently by the Geological Survey, shows nearly as well the location of these wet tidal lands, and to better advantage their unique setting, in a thickly-populated district, between the peninsular city, Jersey City, and Bayonne on the east, and the larger metropolis on the Passaic, including Paterson, Passaic, Newark, and the adjacent towns and cities. These meadows, about eighteen miles long and four miles wide, are intersected by the Hackensack and the Passaic rivers, and adjoin Newark bay at the south, and contain approximately 27,000 acres of land. The improvement of the meadows by the canalization of these rivers and some of the tributary creeks would afford at least 25 miles of navigable waterways, offering to commercial enterprise nearly twice as great a length of business water front. The depth of water to be had in the Hackensack and the Overpeck creek would be 12 to 15 feet, allowing access for vessels of considerable tonnage.

The agricultural value of these rich, alluvial lands would eventually be large enough to pay for their reclamation, although the gain in this valuation could not be realized until a great part of the soil had been sweetened by cultivation and amended by proper dressing with fertilizers. The costs of embanking and pumping would probably be greater than the land would bear solely for its use in agriculture or in market gardening. The nearness to markets and the railway lines and waterways makes it valuable for crops of garden vegetables and for some of the more intensive lines of farming.

The recent discussions of the prevalence of malarial diseases in the country and cities on each side of these meadows, and the most practicable means of abating the nuisance of the mosquito, now recognized as the bearer of these malarial troubles, suggests forcibly the reclamation of these meadows and their permanent improvement as the sole effectual method whereby the mosquito plague and the consequent malaria can be gotten rid of to the great relief of the nearby cities, and this whole territory be made comfortable and healthy residential ground. It is well known that in many parts of England drainage has had the result of making the country much more healthy, and, particularly, has done away with malarial affections. In the Netherlands the polders are considered nearly as safe against malarial diseases as are the higher lands of the country. The mosquito pest is unknown there, at least in the degree of intolerable endurance which persons working in the tidal-marshes here are called upon to exercise. No other solution of the mosquito problem which has been proposed is likely to prove permanently effective, unless it be accompanied by the thorough drainage of their breeding places on these meadows and their cultivation in farms and market gardens, or by infilling and occupation by manufacturing industries or by commercial establishments. For the abatement of this nuisance of the mosquito alone it seems as if the reclamation of these meadows should be made. As a purely sanitary measure the subject is worthy of the attention of the residents of Newark and Jersey City and the other towns and cities in this valley.

Reference has been made to the best measures for accomplishing the improvement by drainage in the report of Mr. Vermeule, referred to above, and also to the relation of the Geological Survey to drainage schemes and the methods of procedure under the law of 1871 and its amendments. Whatever plan may be adopted it seems a fitting occasion to direct again attention to the subject and suggest further discussion in order to the best solution of the drainage problem as applicable to the Hackensack and Newark meadows.

## FORESTRY WORK.

Mr. F. R. Meier has acted as Consulting Forester to the Survey. Application was made by the Newark Water Department for advice and assistance in the improved handling of the watershed forest, an area comprising 7,000 acres and consisting of sprout and seedling growth of broad-leaved trees.

Plans have been prepared by Mr. Meier for the entire tract, the purpose being to improve the forest by judicious cuttings, according to forestry principles, to re-stock waste places and worn-out farms and pastures by treeplanting.

The field work consisted in the collection of data for these plans and in dividing the forest into compartments of different sizes, according to the character of the growth and the natural boundaries. For each compartment recommendations were made as to the treatment. In devising a plan it was kept in view that a constant forest cover is desired for the protection of the watershed. The plan recommended the following operations:

1. Protection against forest fires, with an estimate of the cost of a fire system.

2. Improvement cuttings in the immature woods; what trees to cut and what to leave; at what age the improvement cuttings are to begin in sprout growth, and at what age in seedling growth; how often to repeat them; cost and returns of the improvement cuttings; effect of the same.

3. A series of thinnings—reproduction cuttings—in the mature woods; what trees to remove at these cuttings; over how long a period these thinnings should stretch; how to foster a young growth of new seedlings in a sprout forest (seedlings being the result of the reproduction cutting); cost and returns of these cuttings.

4. Planting of waste places with trees; what kinds to plant; methods and cost of planting.

A somewhat similar application was received from the Lambertville Water Company. Their land comprises at the present 291 acres, of which one-half is woodland and the other half farming land. It was the desire of the water company to have the land examined and to have a plan prepared recommending what parts of the land now used for farming purposes would be more suitable for tree growth than for farming, and to recommend improved methods in handling the wood lots. A careful forest survey was made and the land more suitable for tree growth than for agriculture selected, the kind of trees and planting methods for different soils and locations were recommended and an estimate given as to the cost of the same.

The recommendations as to the cuttings were similar to those made for the Newark watershed forest.

Mr. Meier has also commenced an investigation of the cedar swamps of the State with a view of determining the amount of white cedar standing, rate of growth, age and quality, and of devising a plan whereby a valuable reproduction of young white cedar may be secured and the quantity and quality of the future stand improved. Many of the so-called white cedar swamps have been found to contain but very small amounts of this tree, the original growth having been cut off or killed by fires and a new growth of less valuable trees having taken its place. During the coming season this line of investigation will be continued.

Mr. Meier has also investigated the forest fires which occurred during the past year. Owing to the severe drought which prevailed in April and May there were numerous and extensive fires in various parts of the State. He personally inspected every burned tract and made careful estimates of the damage, based upon examination of the bark and wood of the trees in various parts of the tracts. His estimates can be accepted as reliable and conservative. His examinations show that 79 forest fires occurred during the year, distributed by counties as follows:

| | Fires. | Acres Burned. | Damage. |
|---|---|---|---|
| Atlantic, | 11 | 24,700 | $75,205.00 |
| Burlington, | 7 | 21,925 | 107,394.00 |
| Cumberland, | 9 | 8,265 | 17,342.00 |
| Cape May, | 4 | 2,720 | 13,985.00 |
| Camden, | 1 | 7 | 420.00 |
| Gloucester, | 6 | 1,055 | 4,104.00 |
| Monmouth, | 2 | 558 | 3,854.00 |
| Morris, | 10 | 4,525 | 23,921.00 |
| Ocean, | 10 | 9,123 | 18,251.00 |

| | Fires. | Acres Burned. | Damage. |
|---|---|---|---|
| Passaic, | 5 | 1,105 | 3,432.00 |
| Salem, | 4 | 2,040 | 7,430.00 |
| Somerset, | 1 | 120 | 180.00 |
| Sussex, | 8 | 8,900 | 30,225.00 |
| Union, | 1 | 3 | 1.50 |
| | 79 | 85,046 | $305,744.50 |

Comparing these figures with those for 1902, given in last year's report, it will be seen that there were 14 more fires, although the burned tracts measured 13,804 acres less. The damage, however, was much greater—$305,744.50, as against $168,-323, an increase of $137,321.50, or about 82 per cent. This great increase in the loss is due in part to the fierceness of the fires and also to the better class of timber burned. The greatest loss per acre was caused by the fire in Camden county, where a fine growth of white and red oak 50 years old was killed. The minimum loss per acre was $0.50 and the average loss was about $3.60. In making these estimates only the damage to the timber has been considered, no account being taken of buildings which were sometimes burned or of the indirect loss due to impoverishment of the soil by the destruction of the humus.

When we examine the causes of these fires we find that locomotives started 26, persons burning brush or grass, clearing land, etc., 21; smokers, 7; children, 6; incendiary, 3, and that the balance originated from a variety of causes. The fires caused by burning brush, etc., swept over 49,197 acres and did damage to the extent of $169,494, the loss from one fire alone in Burlington county being $105,000. Those set by locomotives caused a loss of $79,658, and covered 19,521 acres. These figures are interesting inasmuch as, in the popular mind at least, the railroad is supposed to be the chief, if not almost the only cause of our forest fires. While it is true that many fires have been started by sparks from the locomotives, yet during the past season only one-third the fires originated in this way and these caused only about one-fourth of the loss. Negligence in burning brush and grass, particularly on windy days, started one-fourth the fires, burned nearly 60 per cent. of the total acreage and did more than 50 per cent. of the damage. In view of these facts it is evident that there is need for a more rigid enforcement of the law in reference to forest fires, particularly of those provisions which forbid the burning of brush, grass, etc., without maintaining a sufficient watch to prevent it spreading.

*Methods of Prevention.*—In about 50 per cent. of the fires some effort was made to extinguish them. Many of those started by locomotives were fought by railroad section gangs, and the measure of their success may be seen from the fact that the average number of acres burned by the locomotive fires was 750 acres per fire, as against 2,342 acres per fire for those caused by farmers, and 1,076 acres the average for all classes. In some cases the section gangs were slow in arriving at the fire and so were handicapped in their work, for with forest fires, as with other fires, prompt action is indispensable for successful fighting.

Several fires in Cumberland county were successfully fought by fire marshals who had been appointed by the townships, in accordance with the provisions of the law passed in 1902. Other fires were opposed by the organized force of men employed by Mr. Joseph Wharton on his large forest tract near Atco and Atsion.

In many cases back fires were started and these sometimes proved successful, but in other cases they did more harm than good through injudicious management. While it is absolutely necessary in many cases to start back fires to check a great conflagration, yet it should never be done except under proper authority, and indiscriminate back firing by private individuals should be made punishable by law.

Chapter 139, Laws of 1902, made provision for fighting fires. Cities, townships and other municipalities have been given the power to appropriate money for preventing and fighting forest fires and to appoint fire marshals. The State has obligated itself to pay annually (up to $200 and not exceeding $10,000 in all) to every city, township, or other municipality, double the amount of money appropriated by the township for fighting fires, so that townships, by an appropriation of $100 themselves, can receive $200 from the State for this purpose.

Sections 7 to 13 of the law are as follows:

"7. No person shall burn, or cause to be burned, any pit of charcoal, or shall willfully or negligently set fire to or burn, or cause to be set fire to or burned, any brush, grass, leaves or other material whereby the property of any other person is endangered or destroyed, unless he shall keep and maintain a careful and competent watchman in charge of said burning pit, brush, grass, leaves or other material, from the beginning of said fire until it is extinguished.

"8. Any person offending against any of the provisions of any of the last section of this act shall be guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine not exceeding one thousand dollars, or by imprisonment not exceeding three years, or both.

"9. Upon the application of not less than ten freeholders of any city, township or other municipality in which any forest fire has occurred, to the fire marshal, or, in case there shall be no fire marshal, then to any constable, representing that they believe an investigation of the origin and other matters pertaining to said fire should be had, it shall be the duty of said fire marshal, or constable, to apply to some justice of the peace to investigate the same, and it shall be the duty of said justice to make such investigation; for the purpose of such investigation said justice shall have power to issue subpœnas for and swear witnesses, and shall have like powers and duties as in the examination and hearing of persons brought before him charged with crime, and said investigation shall be conducted, as far as can be, in like manner thereto; the said fire marshal, or any constable, shall have power to serve all subpœnas, warrants or other papers required to be served in the course of said investigation, or of any proceedings for the arrest and commitment of any person as the result of said investigation.

"10. At the conclusion of said investigation the said justice shall make, in writing, a certificate thereof, in which he shall find and certify how and in what manner such fire happened or was attempted, and all the circumstances attending the same; if he shall find that there is evidence that the said fire probably originated from, or was fostered by, the act of any person or persons in violation of any law of this state in force at the time of said fire, he shall so certify, and who was or were guilty thereof, either as principal or accessory, and in what manner; if he shall be unable to ascertain the origin or circumstances of such fire, he shall find and certify accordingly.

"11. If the said justice shall find that there is evidence that the said fire probably originated from, or was fostered by, the act of any person or persons in violation of any law of this state, as above specified, he shall issue process for the arrest of the person or persons who have so violated such law, and may, after due examination, in his discretion, commit him or hold him to bail, to await the action thereon of the next grand jury of the county; and said justice shall also have power, when in his judgment necessary so to do, to bind over the witnesses to appear and testify at the next court of quarter sessions of the peace of said county.

"The testimony of all witnesses examined before the said justices in said investigation shall be reduced to writing by the said justice or under his direction, and shall be returned by him, together with his certificate of his said investigation, and all recognizances and examinations taken under his hand and seal to the next court of quarter sessions of the peace of said county."

In view of these provisions of the law and the fact that 21 fires were caused by persons burning brush, grass, etc., 7 by smokers, and 3 by incendiaries, it would seem that ***not more law, but more enforcement of the present law is needed.*** A few convictions and fines according to the above provisions would do much to prevent a large proportion of the forest fires in the State. The remedy is in the hands of the local communities. Ten freeholders of any township can compel an investigation into the origin of any fire and, where the law has been violated, can start the legal machinery for the punishment of those guilty. Even if conviction fails in some cases, as it very likely may, through local apathy, sympathy for the defendant "who did not mean to start the fire," or the indifference of the proper officials, the trouble and expense of defending a suit would prove a salutary lesson not only to the defendant himself, but to the community.

Printed notices referring to the forest laws and the penalties for their violation have in some townships been posted on trees, and serve as a reminder to the unthinking and careless that fires cannot be started with impunity.

During the past year three townships—Weymouth, in Atlantic county, and Landis and Deerfield, in Cumberland—have each appointed fire marshals, appropriated money and received State aid for this work. More of the townships should accept the provisions of this law, which, if it be strenuously enforced, will largely put an end to this annual destruction of our forests. Probably, however, many of the townships are ignorant of this law and unfortunately public sentiment in some of the townships which most need it is such that there is very little chance of its provisions being adopted, at least for many years. Although the law has not yet been fully tried and its efficacy is still in doubt, it is an open question whether an organized State force along the lines suggested in the report for 1902, and reiterated this year by Mr. Meier, will not ultimately be necessary if New Jersey is to save her forests.

The figures and statements presented by Mr. Meier relative to the forests of Europe and the subject of forest fire insurance are interesting and instructive in this connection. Under present conditions in New Jersey there is practically no incentive to the forest land-owner in the pines belt to do anything towards improving his holdings, since there is almost a certainty that, even if he himself takes all due precautions, fires started by his careless neighbor or in the adjoining township, which has no fire marshal, will destroy his timber before it is ready for market. When the forest fire risk has been reduced to that of European countries, then there will be some inducement for the holders of large forest tracts to spend money in replanting and otherwise improving their holdings. Before the forests of the State can be of great value, *forest fires must be prevented.*

## COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

As was noted a year ago, the United States Geological Survey is publishing a geological map of the entire country. The folios relating to New Jersey will be prepared in cooperation with the State Survey. During the past year data for mapping the distribution of the Cambrian and Ordovician rocks of the Franklin Furnace folio were prepared. The map and text of the glacial geology, also for this folio, was furnished by Mr. Salisbury of the State Survey.

Preparation of the Passaic folio was likewise commenced. The geology of the Triassic rocks—the red sandstones and traps—has been prepared conjointly by the State Geologist and Mr. N. H. Darton, of the U. S. G. S. The map of the glacial formations will be taken from data furnished by the State Survey, and this portion of the descriptive text will be written by Mr. Salisbury. The crystalline formations have been studied and described by the geologists of the National Survey, which bears all the cost of engraving the maps.

Field studies on the crystallines of Warren and Morris counties were carried on during the past season by Dr. W. S. Bayley and his assistant, working under the auspices of the U. S. Survey. As soon as these studies are completed it will be possible, with the material already collected by the State Survey on the sedimentary rocks and glacial deposits to prepare the Raritan folio, which lies next west of the Passaic.

UNITED STATES DEPARTMENT OF AGRICULTURE.

The Division of Soils of the U. S. Department of Agriculture is making a soil map of the United States. In 1901 the area covered by Sheet 10 of the Atlas of New Jersey was so surveyed and in 1902 the region east of Trenton, Sheet 8, was so mapped. This work was carried out entirely by U. S. parties in the Division of Soils. However, the atlas sheets of the New Jersey Geological Survey were used in their field work, and both maps as published were printed from transfers furnished by the State Survey from its engraved stones.

THE ST. LOUIS EXPOSITION.

Late in the summer the St. Louis Exposition Commissioners appropriated $5,000 for the preparation of a geological exhibit of New Jersey's natural resources, and requested the State Geologist to prepare it. Mr. S. H. Hamilton, who had had considerable experience in museum work, was engaged to take active charge of this work and commenced his labors September 1st. Eight months is none too long a time to prepare, pack, ship and install a creditable exhibit, and Mr. Hamilton has had much to do. A plaster-of-paris reproduction of the Hadrosaurous skeleton found years ago at Haddonfield, the bones of which are now in the Museum of the Philadelphia Academy of Sciences, will be a central feature of the exhibit.

Suites of specimens showing the geological series of rocks as represented in New Jersey, the minerals, the metals and ores, the clays, marls, sands and other economic resources will be another marked feature. Illustrations, photographs, transparencies and maps will make known the attractiveness of New Jersey scenery, the distribution of her resources and the importance of her industries. After the close of the Exposition the material will be available for exhibit in the State Museum. The work has been greatly facilitated by the hearty cooperation of several citizens of the commonwealth and by the courtesies extended by officials of the larger museums in the East.

## LIBRARY.

During the year the Survey library received by exchange and purchase 48 bound volumes, 156 unbound volumes, 113 pamphlets and 337 maps.

## PUBLICATIONS.

The Report on Glacial Geology, Volume V, of the Final Report series, pp. xxvii + 802, plates 56, figures 102, was issued early in the year. It aroused a deep interest in this phase of geology and the demand for it was for several weeks much greater than the mailing department of the Survey could supply. During the year 3,394 copies were distributed.

The Annual Report for 1902, pp. viii + 155 and 8 plates, was published in March and distribution was at once begun, 3,368 copies being sent out during the year.

In April Dr. Weller's report, Paleozoic Paleontology, Vol. III, was issued. Owing to the highly technical character of this report it was sent only to those who requested copies, and 675 were distributed.

Requests for previous reports are constantly being received, both from libraries and individuals, and, so far as possible, these are granted. It is impossible, however, to furnish all the reports, since many are out of print, and of some others the supply is so low that discrimination is necessary to insure the few remaining copies going to persons who will make the best use of them. The appearance of Vol. V caused a brisk demand for the previous volumes, of which II, III and IV could be supplied. So, too, Paleontology III brought many inquiries for Vols. I and II of the Paleontological series. Of the earlier reports—annuals and finals—there were distributed during the year about 3,000 copies, making a total of about 10,400 volumes distributed. The stock of several of these reports, notably Vols. I and IV and Annuals 1891, 1892, 1893, is so far depleted that it is not possible to grant indiscriminate requests for them.

Of the large scale maps, 2,000 feet to an inch, the Shark River sheet was issued in April and the New York bay sheet in June and put on sale.

Of the new one-inch-per-mile maps, Sheet 4 has been displaced by Sheet 22, Sheet 2 by No. 24, and Sheet 5 by No. 27. All these sheets were revised in the vicinity of the important towns before publishing the new editions. So many changes had occurred in the vicinity of Newark and Jersey City that it was found necessary to engrave entirely new stones, rather than to attempt to alter the old ones. This work was nearly completed at the close of the year, and Sheet 26, which replaces No. 7, was issued early in December of the new year.

During the year 808 copies of the one-inch-per-mile sheets and 1,381 copies of the large scale maps were sold, a total of 2,189 sheets.

# PART I.

## Report on a Proposed Tide Waterway Between Bay Head and Manasquan Inlet.

By C. C. VERMEULE.

# INTRODUCTION.

The One Hundred and Twenty-seventh Legislature at its session in 1903 passed the following act, in accordance with which the accompanying report is submitted:

CHAPTER 129, LAWS OF 1903.

An Act making an appropriation for surveying a waterway to connect Barnegat bay with Manasquan inlet, for the reclamation of oyster and clam lands in upper waters of said bay.

WHEREAS, It is represented to the Legislature that all the upper part of said bay formerly bearing oysters and clams is now barren through the closing of Cranberry inlet;

WHEREAS, Thousands of acres would resume producing oysters and clams if salt water were re-introduced therein;

WHEREAS, The said lands now contain shells in abundance, making them immediately available without the expense of shell planting;

WHEREAS, It is deemed feasible to connect said Manasquan inlet with Bay Head by a tide waterway; therefore,

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 for a tide waterway between Bay Head and the Manasquan inlet, said sum to be used for the purpose of defraying the expenses of the engineer in making the survey and 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 in 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 waterway, in the annual report of said board to the governor of the state of New Jersey.

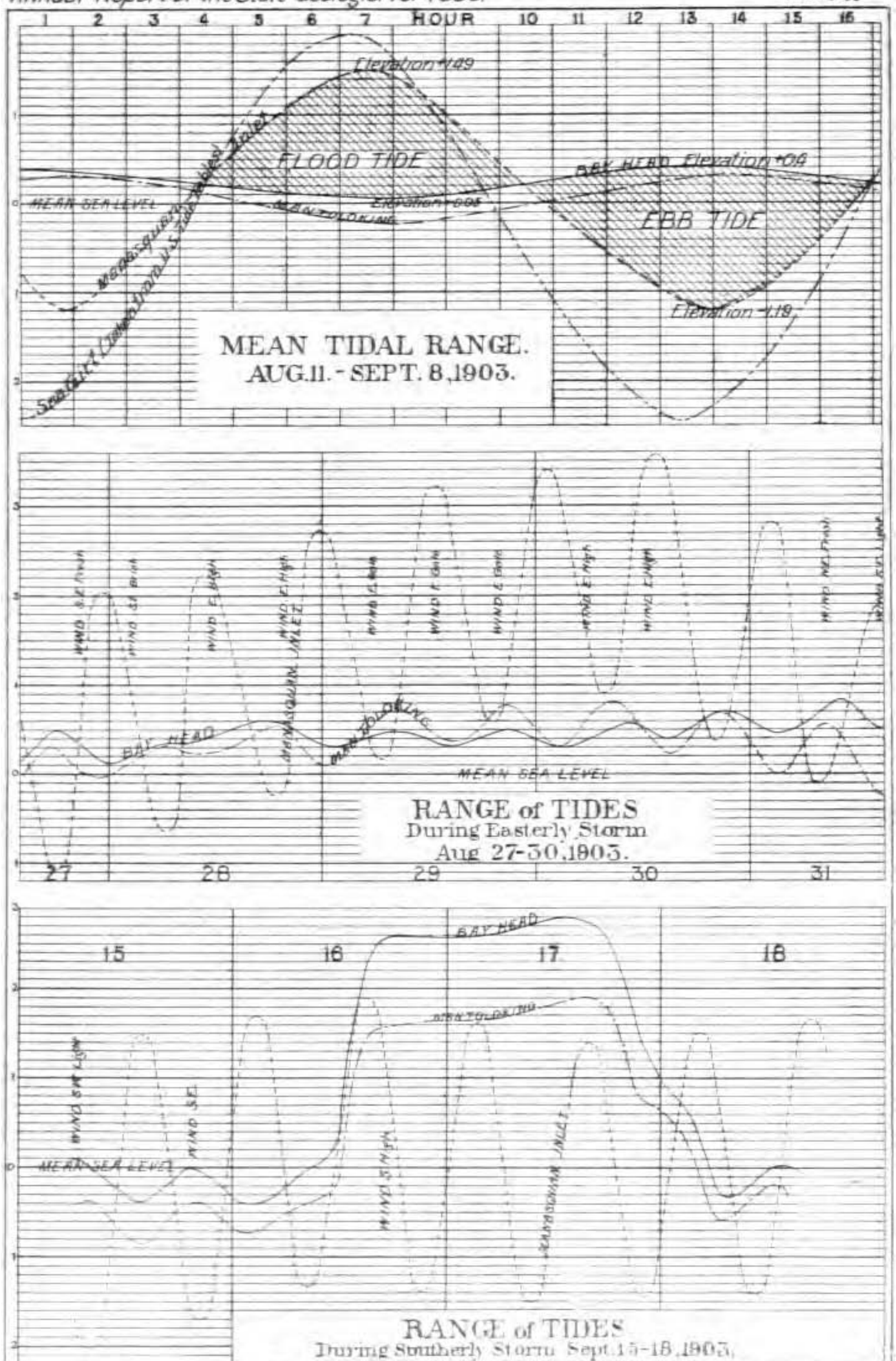
2. This act shall take effect immediately.

Approved April 7, 1903.

The Board of Managers of the Survey, at a meeting held April 28th, 1903, authorized the State Geologist to engage as engineer Mr. C. C. Vermeule, of East Orange, to make the necessary surveys, and directed that the work be done under the direction of the State Geologist and Executive Committee of the Board. On July 31st, the Committee of the Board, Mr. Vermeule and the State Geologist visited Point Pleasant and in company with a local committee examined the site of the proposed waterway. Detailed surveys and tidal observations were carried on under Mr. Vermeule's direction during the following weeks, after which the accompanying report was prepared by him and submitted to the Board of Managers of the Geological Survey at their Annual Meeting, December 22d.

In accordance with the above statute, it has been transmitted to the Governor, and is herewith submitted to the Legislature.

HENRY B. KÜMMEL,
*State Geologist.*


HOUR
Elevation +1.49
Elevation +0.6
Elevation +0.05
Elevation -1.19
FLOOD TIDE
EBB TIDE
MEAN SEA LEVEL
BAY HEAD
MANTOLOKING
MANASQUAN INLET
MEAN TIDAL RANGE.
AUG. 11. - SEPT. 8, 1903.
RANGE of TIDES
During Easterly Storm
Aug 27-30, 1903.
27
28
29
30
31
RANGE of TIDES
During Southerly Storm Sept. 15-18, 1903.
15
16
17
18

# Report on a Proposed Tide Waterway Between Bay Head and Manasquan Inlet.

In accordance with instructions, and by authority of the Act of the Legislature approved April 7th, 1903, I have made a survey and estimates of the proposed tide waterway connecting Manasquan Inlet with Barnegat Bay, at Bay Head. An examination of the proposed route was made in company with a committee of the Board of Managers and the State Geologist, on the 31st day of July last. A few days previous surveys had been begun, and the entire route of the canal was surveyed from Manasquan Inlet to Bay Head. Tidal observations were also made at Manasquan Inlet, Bay Head and Mantoloking. The results of the surveys and examinations are shown, together with the proposed route of the canal, on the general plan accompanying this report.

The first matter which required careful consideration was the relative height of tides in Barnegat Bay and in Manasquan Inlet. Something was already known as to this from the results of the topographic survey, but more definite information was obtained by means of the tide gauges established this summer. The results of the gaugings are shown in Plate I.

The first diagram, entitled "Mean Tidal Range," gives average conditions during a single tide at the several points, and also at Sea Girt, the curve for which place represents the tides in the ocean during the period under consideration. The period taken, from August 11th to September 8th, fairly represents average conditions, and the tides shown in the diagram may be considered to be typical. It should be observed that high tide just within Manasquan Inlet is a little later than in the ocean, and is 0.4 of a foot lower; while low tide is about 40 minutes later within the inlet, and 1.25 feet higher than low tide in the ocean, the range within the inlet being, therefore, 1.65 feet less than in the ocean, during the same period.

The observations at Bay Head and Mantoloking indicate the conditions at the head of Barnegat Bay during the same period. It will be seen that at both of these places low tide is nearly coincident with high tide in the ocean outside. It will also be noted that the range of tide is quite small in the bay, being less than 0.4 of a foot at Bay Head, and about 0.55 feet at Mantoloking. The diagram shows that at high tide in Manasquan Inlet the water at the head of Barnegat Bay is 1.44 feet lower than at Manasquan Inlet, and that at the time of low tide at Manasquan Inlet the water in the bay is 1.59 feet higher. Supposing a canal to be cut connecting the two, the shaded portion, lettered "Flood Tide," in the diagram represents the time during which the water would flow from the Inlet into Barnegat Bay, and the shaded portion, marked "Ebb Tide," shows the time during which the water would flow from the bay toward Manasquan Inlet, the two shaded portions representing one complete cycle of tides, and illustrating, as we have said before, average conditions.

The second diagram in the plate, entitled "Range of Tides during Easterly Storm, August 27–30, 1903," shows the relative height of the tides at Manasquan Inlet, Mantoloking, and Bay Head. It will be observed that the water during this storm was generally much higher at the Inlet than it was in Barnegat Bay. On August 30th, the ocean was about 1.7 feet higher on the average than the bay, and high water at Manasquan Inlet was 3.1 feet higher than the water at Bay Head in the bay. This is due to the fact that since the general direction from the head of the bay to Barnegat Inlet is southwesterly, the effect of an easterly storm is to drive the water out of the bay toward the inlet, causing low water at the head of the bay; whereas in the ocean the tendency is to pile up the tides higher than usual.

The third diagram, entitled "Range of Tides during Southerly Storm," shows contrary conditions to the previous one. The effect of a southerly storm is to pile up the water at the head of Barnegat Bay to an unusual height. It will be observed that during low water at Manasquan Inlet, on the 17th of September, the water at Bay Head was 4.3 feet higher than it was at Manasquan Inlet, and that even during high tide at Manasquan Inlet the water at no time reached so high a point as the level of the bay at Bay Head or Mantoloking.

These three diagrams show about the range of conditions which we would have to contend with when the proposed canal is constructed. That is, for ordinary working conditions we should have a fall, during high water at Manasquan Inlet, of 1.44 feet toward Barnegat Bay, and during the time of low water in Manasquan Inlet we should have a fall of 1.59 feet from the bay toward the inlet, and the variation of fall in either direction is shown by the first diagram in the plate. But during an easterly storm, such as that shown in the second diagram, the water would flow from the inlet into Barnegat Bay almost without cessation, during a period of two days or more; while during a southerly storm the water would flow continuously from Barnegat Bay toward Manasquan Inlet, during a period covered by two or three tides; and the canal must be so designed that the maximum fall during such a period of storm will not cause so high a velocity of water as to wash away the banks of the canal.

Considering further conditions in Barnegat Bay, which it is sought to remedy by the construction of the proposed tide waterway, we find that, while the average range of tide in the ocean, or the difference between average low tide and average high tide, amounts to 4.7 feet, the range just inside of the inlet, in Barnegat Bay, is only 2.04 feet, and at Seaside Park it is reduced to 0.88 feet, at Kettle Creek to 0.47 feet, and, as shown by our diagram, at Mantoloking to 0.55 feet, and at Bay Head to 0.35 feet. The distance from Barnegat Inlet to Bay Head is about twenty-one miles. Although there is a great rush of water into and out of Barnegat Inlet at each tide, there is not time during a single high tide to fill up the bay inside, nor is there time for the water in the bay to run out at low tide. There was formerly an inlet known as Cranberry Inlet, between Seaside Park and Ortley. This inlet is shown as closed in a map dated 1850. It is also stated that there was another inlet opposite the mouth of the Metedeconk River, which inlet closed some time about 1755. There are evidences that at a still earlier date the Metedeconk River found its way out northward to Manasquan Inlet, along a line now proposed for the tide waterway.

The effect of the closing up of the old inlets has been to constantly decrease the saltness of the water at the head of Barnegat Bay, and to greatly limit the area adapted for oyster culture. In order to determine the difference in salinity of the water at points where the oyster now thrives, and at points near the head of the bay where there are at present no oysters, four samples of water were taken and submitted to Dr. Thomas B. Stillman, of Stevens Institute, for analysis. The results of the analyses are given herewith:

STEVENS INSTITUTE OF TECHNOLOGY,
HOBOKEN, N. J., August 22d, 1903.

*Cornelius C. Vermeule, C. E., 203 Broadway, New York City:*

DEAR SIR—The four samples of water, received from you August 16th, have been subjected to a partial chemical analysis, with the following results (figures represent grains per U. S. gallon):

| | *Total Solids.* | *Organic and Volatile Matter.* | *Sodium Chloride.* |
|---|---|---|---|
| No. 1, marked Seaside Park, Barnegat Bay,.. | 522.21 | 108.56 | 403.71 |
| No, 2, Bay Head, Barnegat Bay, ............ | 16.79 | 4.19 | 12.80 |
| No. 3, Manasquan Inlet, .................... | 1851.52 | 181.86 | 1533.61 |
| No. 4, Mantoloking, Barnegat Bay, .......... | 3.96 | 2.30 | 1.90 |

Respectfully yours,
(Signed) THOS. B. STILLMAN.

Sample No. 3 of the above was taken at Manasquan Inlet, and represents practically pure sea water. Sample No. 1 was taken about one mile below the railroad bridge, at Seaside Park, and at a point where oysters are raised successfully. No. 2, at Bay Head, and No. 4, at Mantoloking, represent conditions at the head of the bay and are practically equivalent to fresh water. It will be observed that the sodium chloride in sample No. 1 is only a little more than one-fourth as much as in sample No. 3, and yet, as we have said, this water appears to be well adapted to raising oysters; so that it would appear that 30 per cent. of its volume in sea water would be sufficient to add to the water at the head of Barnegat Bay, in order to make it suitable for oyster raising.

The fresh water inflow to the head of Barnegat Bay, including all the streams entering above Toms River, I estimate amounts to an average of 134,000,000 gallons daily, so that if we could add to the bay 30 per cent. of this amount, or 40,000,000 gallons each day of pure sea water, we should have the proper proportions for oyster culture. It would be easy to add this proportion of sea water if the flow of the canal were always in one direction; but inasmuch as the flow is half of the time from the bay toward the ocean, as shown by the diagrams of the tides, the average capacity of the canal during the incoming tide would have to be at least double the above amount, or 40,000,000 gallons in twelve hours.

### ROUTE OF THE CANAL.

Consideration was given to two possible routes for the proposed tide waterway. One of these is about 1½ miles west of the New York and Long Branch Railroad, starting from a point 2½ miles up the Manasquan River, from the inlet, and running in a direct line to Metedeconk River. This route was examined, but it involves heavy cutting, and the first cost will be greater than on the route chosen because of the large amount of earth to be handled. Furthermore, the effectiveness of a canal at this point is doubtful, because it starts so far up the Manasquan River that the water would be much less salt than if taken near the inlet. Finally, considering its merits as a navigable waterway, it would be very much inferior to the route selected because of the shallowness of the Manasquan River between the proposed route of the canal and the inlet.

The route finally selected is shown in detail on the accompanying map, Plate II. It passes through a chain of small ponds and a line of marshes, the ground along the route being very low, the highest ground met with being 4.7 feet above mean tide, while much of the way it is actually below mean sea level. The proposed route begins a little north of the present railroad bridge over the outlet of Twilight Lake at Bay Head, and follows up said outlet and through Twilight Lake. Thence crossing Osborn avenue and Sea avenue, it skirts the easterly edge of Maxon's

Pond, after which it follows the line of Baltimore avenue through Point Pleasant.

In order to get proper room for the canal and for a roadway each side, it will be necessary to acquire a row of lots 50 feet wide at the easterly side of Baltimore avenue. This will give room not only for the canal with a width of 60 feet, but for a roadway on each bank 17 feet wide, and an 8-foot sidewalk, as shown in section on the plan. This necessitates the removal of one house, this being the only structure interfered with along the entire route. After reaching Central avenue, the canal curves eastward through Cook's Pond, and follows the outlet of Cook's Pond to Manasquan Inlet. It will be observed that this route is quite direct, while at the same time it follows existing water courses and cuts through the several seaside resorts in such a manner as to do the least possible injury to property. The section adopted for the canal, in order to meet all requirements, viz., to pass a sufficient amount of salt water into Barnegat Bay to adapt the head of the bay to the culture of oysters, and also to render the canal as valuable as possible for a navigable waterway, has a width of 60 feet at mean tide level, with side slopes of one perpendicular to two base, and a depth of 10 feet, giving a bottom width of 20 feet. Through Baltimore avenue, both banks of the canal would be bulkheaded with low bulkheads, as shown in the section.

The several ponds met with, viz., Cook's Pond, Little Silver Lake, Maxon's Pond and Twilight Lake, or some of them, if allowed to constantly empty and refill with each tide, would absorb a large part of the capacity of the canal and diminish the amount of water which would reach through the canal into Barnegat Bay; consequently some of these are cut off by side embankments, as shown in the section, through Twilight Lake, these embankments being formed of material dredged from the canal. Cook's Pond is allowed to ebb and flow at each tide, the canal from that point to the inlet being increased in width to 80 feet, in order to admit of this. Little Silver Lake has an ordinary water elevation of 1.2 feet above mean tide, while the elevation of the bottom is shown by the figures on the plan to be generally slightly below mean tide, and the deepest is but two feet below. If the tide were allowed to ebb and flow in this lake its bottom would be largely bare at low water, consequently it is embanked off from the canal; and waste-weirs should be provided at about high-tide level over which any excess of water in the lake may flow into the canal.

The ordinary elevation of Maxon's Pond is 3.1 feet above mean tide, which is about 2 feet higher than high tide in the canal, as shown by the profile. This pond could be either banked off like the others, or could be almost entirely drained off through the canal by means of tide sluices, which would allow the water to flow out at low tide, but would not allow any water to flow from the canal into the pond. Twilight Lake has a considerable depth and quite a large area, and I have planned to embank this off in the manner shown in the section providing a waste-weir over which the surplus waters can flow into the canal when the lake fills to mean high tide. The portion of this lake lying between the canal and Lake avenue is about 150 feet wide, and could perhaps be very advantageously filled in the future and used for building purposes.

Eight highway bridges would be required across the canal, and one railroad bridge. If the canal should be used as a navigable waterway, for which purpose it would probably be largely in demand, these bridges should be draw-bridges. They could properly be bascule bridges, of about 30 feet clear span, and I have estimated upon bridges of this character.

If constructed of these dimensions and on these general lines, the cost of the proposed tidal waterway would be as follows:

| | |
|---|---|
| Excavation, 727,411 cubic yards, at 15 cents, | $109,111 00 |
| Bulkhead, 3,860 feet, at $1.80, | 6,948 00 |
| Eight highway bridges, | 19,200 00 |
| One railway bridge, | 5,250 00 |
| Total, | $140,509 00 |
| Incidentals, engineering, contingencies, | 14,051 00 |
| | $154,560 00 |

The exact effect of such a tide waterway as above designed can be best ascertained by following the sequence of events through a single tide. We are able to compute accurately the amount of water passing from the data furnished by the surveys. At the beginning, the inflow during an average flood tide lasting 6 hours will be 88,500,000 gallons, while the average outflow during an ebb tide lasting 6½ hours will be 93,500,000 gallons. Of course, the excess of outflow cannot be kept up without slightly affecting the level of the bay, but we find by computation that when the bay has fallen 0.1 foot the inflow and outflow will be equalized, and will amount to 91,000,000 of inflow and the same amount of outflow during each tide. It is impossible for the canal to affect the level of Barnegat Bay more than 0.1 foot therefore, which is practically inappreciable.

When the flow has been equalized we must bear in mind that the outflow from the bay will fill the entire prism of the canal with water of the same character as the bay water, which will be mixed with sea water as soon as the canal begins to operate. Consequently, while the inflow into the canal from Manasquan Inlet will be 91,000,000 gallons for each tide, all of this will not reach the bay, but the quantity contained in the prism of the canal, amounting to 48,000,000 gallons, will have to be first pushed back into Barnegat Bay. This will leave 43,000,000 gallons net inflow of sea water into the bay, at Bay Head, during each flood tide, and to this must be added the proportion of sea water which is contained in the canal prism, which will be the same proportion, practically, as in Barnegat Bay.

At the beginning, therefore, when very little salt water has been introduced into the bay, there will be 43,000,000 gallons net inflow of sea water, while there will be practically no outflow of salt water, and consequently each tide will deposit upwards of 40,000,000 gallons of salt water in the bay. This will rapidly increase the saltness of Barnegat Bay at first, and the saltness later on will increase more and more slowly during the operation of the canal. We have already seen that the proportion should be at least 30 per cent. of sea water to make possible the cultivation of oysters. Let us estimate, therefore, the conditions of inflow and outflow when the bay water has become 30 per cent. salt.

During the flood tide, the inflow into the bay will be, from the canal prism, 48,000,000 gallons, which contains 30 per cent. of sea water, making 14,400,000 gallons of sea water from the canal:

and to this must be added 43,000,000 gallons additional of pure sea water, making the total amount of sea water added, 57,400,000 gallons. For the same conditions, the outflow on the ebb tide will be 91,000,000 gallons of bay water, which contains 30 per cent. of sea water, amounting to 27,300,000 gallons. There will, therefore, be left in the bay, during each tide, the difference between 57,400,000 gallons and 27,300,000 gallons, or 30,100,000 gallons of salt water. As there are not quite two full tides in 24 hours, the net addition of salt water to the bay during 24 hours will be 58,000,000 gallons. We have previously seen, however, that the inflow of fresh water from the upland streams into the bay averages 134,000,000 gallons in 24 hours, and that in order to maintain the bay at 30 per cent. sea water we need to add only 40,000,000 gallons of sea water each 24 hours. This is considerably less than what is actually added according to the above estimate; consequently the saltness of the bay will go on increasing beyond the estimated 30 per cent.

A similar computation shows that when the bay has had added to it 40 per cent. of sea water, the canal will still be adding slightly to the saltness, so that by this system of computation Barnegat Bay will be maintained in a condition averaging a little more than 40 per cent. of sea water, the saltness increasing somewhat beyond this when the upland streams are low, and decreasing somewhat below it during wet weather.

A canal of the size which we have planned, therefore, will maintain the water of Barnegat Bay in a sufficiently salt condition to make possible the cultivation of oysters, and will do this leaving a margin of safety of over 30 per cent. in our estimates.

The section of the canal could be diminished to a top width of 40 feet, and the total cost could be thereby reduced to $105,000; but the efficiency would thereby be very considerably diminished, and the capacity of the canal would not be sufficient to make all of the head of the bay available for oyster culture, although it would render a considerable part of it sufficiently salt for this purpose.

The area of that portion of Barnegat Bay north of Toms River, which would, through the operation of this canal, be made available for culture of oysters, covers 9,000 acres in all.

A further important advantage of such a waterway will be as an aid to navigation through our inland waters, particularly in connection with the development of our sea-coast summer resorts. These summer resorts have assumed an importance to this State which makes them equally worthy of consideration with the oyster industry. Many of the New England States recognize the advanages of catering to the increasing number of persons who seek an outing by the seaside and elsewhere during the summer; and there is no reason why the State of New Jersey should not do likewise. Either yachts, oyster boats, or other craft desiring to reach the head of Barnegat Bay from the north, must now pass south to Barnegat Inlet, and thence northward to the head of the bay. The distance from Manasquan Inlet to Bay Head, by this route, is 46 miles, whereas by the proposed canal it would be reduced to 3 miles. What is true as to craft desiring to reach Bay Head, is true to only a slightly less degree of those wishing to reach other points on Barnegat Bay, such as Mantoloking, Silverton, Seaside Park, Island Heights, Toms River, etc.

The importance of the canal as a navigable waterway would be still further enhanced if the Federal Government should continue its policy of improving Manasquan Inlet. Jetties were built there some years ago, but the design adopted has proven to be not well adapted to the locality, and the southern jetty has been undermined and almost disappeared. The northern one, however, stands in good condition but needs to be extended, and if extended, there appears to be no good reason why a depth of 10 feet should not be maintained through the inlet. It is doubtful if the southerly jetty is needed at all. It seems probable that this improvement will be continued, and in that case the canal will admit of vessels of 9 feet draft passing through into Manasquan Inlet, and thence to Bay Head.

The canal would be a further advantage as a means of draining the low-lying section through which it passes, and its advantages in this respect would probably be sufficient to induce the property owners along the line to grant a free right of way, consequently I have added nothing to my estimate for the cost of right of way.

The surveys and examinations made are sufficient to enable me to report definitely that such a tide waterway is practicable, and will be effective as a benefit to the oyster industry as well as in other directions which I have pointed out.

Respectfully submitted,

C. C. VERMEULE,

*Consulting Engineer.*

## PART II.

# The Floods of October, 1903.—Passaic Floods and Their Control.

By C. C. VERMEULE.

# Passaic Floods and Their Control.

BY C. C. VERMEULE.

This Survey has kept a record of all the important floods on the Passaic river during the last twenty-seven years, and has obtained data of earlier floods so far as possible. Although the Passaic is by no means a violent stream during floods, when measured by its maximum discharge per square mile of watershed, nevertheless it has long been apparent that the steady increase of the valuable property upon the lower reaches of the stream, and the gradual encroachment upon its channel, would be likely to call for some regulation of the flood-flows. Inasmuch as any regulation of the flow would call for a thorough understanding of the movement of floods in the valley above Little Falls, special attention has been given to this phase of the subject in previous reports of the Survey. In the Report on Water-Supply of 1894 we gave a list of all the floods of seventeen years previous to that date, and a full analysis of the flood of 1882, which at that time was the highest flood of which we had complete records. Again, in the Annual Report for 1896 we gave full data and an analysis of the flood of that year, which, although it was comparatively a harmless flood on the lower part of the stream, was rather violent on some of the branches, and had features which rendered it peculiarly instructive. In the report for 1902 we gave a full analysis of the great flood of that spring and the effect of the proposed drainage works above Little Falls upon the flood-flows. In that report we also called attention to the possibilities of controlling floods by means of a large storage reservoir. Furthermore, the report of 1902 gave the more important data included in a special report upon the drainage works above Little Falls, which had been made to a Committee of the Board of Managers of this Survey in 1893-4.

It has long been apparent to us that any effectual control of the floods of the river must be exercised at or above Little Falls. The present report, dealing with the flood of last October, is in continuation of the previous studies of these floods, and contains more explicit information as to proposed methods of control.

## FLOOD OF OCTOBER, 1903.

For the second time since the writing of the Report on Water-Supply in 1894, we are called upon to record a flood on the Passaic exceeding the great flood of September, 1882. In October, 1903, floods occurred on the Passaic which exceeded in height and volume any previous floods of which we have record. In last year's report it was stated that the flood of March, 1902, exceeded all since 1810. The flood of October, 1903, exceeded the flood of 1810. The rainfall was particularly heavy in the extreme northern part of the State, but much lighter on the more southerly streams, so that previous flood records were not broken on any other streams than the Passaic and the Delaware.

*Cause.*—There is a growing impression in the public mind that the increased violence of floods is due to some artificial changes in the streams or on their watersheds; but if we direct our attention to the meteorological conditions and compare them with previous conditions, we find that they are ample to account for the particular violence of the floods of last October. The average precipitation at eleven stations, distributed over the Passaic catchment in such a manner as to indicate accurately the average precipitation on the catchment, shows the rainfall to have been as follows:

On the 8th of October, including a light rain which fell on the 7th, the rainfall was 2.21 inches; on the 9th it was 7.83 inches; on the 10th, 1.55 inch, and on the 11th, 0.39 inch, making a total for four days of 11.98 inches on the Passaic watershed. The rainfall at the several stations varied from 9.74 inches, at Hanover, to 15.61 inches, at Paterson. It was 13.39 inches at

Little Falls, and 13.50 inches at Pompton Lakes, the heaviest precipitation having occurred on the Pompton river and its tributaries, the Ramapo, Wanaque and Pequannock.

*Comparison with previous rainfall.*—It becomes interesting to compare the daily rainfall during the four high floods of the present century, in order to show the importance of the relative concentration of the rainfall, which is one of the important factors causing extreme floods. The following table furnishes the data of daily rainfall for these floods. In it I have taken the rainfall for 1882 from the best records obtainable to exhibit the average rainfall on the Passaic catchment, although the record for that year is not as satisfactory as for the more recent floods. A comparison with the several stations of which data are available leads me to believe that the figures here given are, however, reasonably accurate for 1882.

TABLE I.

DAILY RAINFALL—INCHES.

| *Flood of 1882.* | | *Flood of 1903.* | |
|---|---|---|---|
| Sept. 20, | 0.73 | Oct. 8, | 2.21 |
| 21, | 0.73 | 9, | 7.83 |
| 22, | 4.70 | 10, | 1.55 |
| 23, | 7.40 | 11, | 0.39 |
| Total, | 13.56 | Total, | 11.98 |

| *Flood of 1896.* | | *Flood of 1902.* | |
|---|---|---|---|
| Feb. 6 and 7, | 4.37 | Melting snow, | 2.65 |
| Includes rain and melting snow. | | Feb. 28, | 1.61 |
| | | Mar. 2, | 0.91 |
| | | 5, | 1.05 |
| Total, | 4.37 | Total, | 6.22 |

The floods of 1882 and 1903, both being autumn floods, may be properly compared, while those of 1896 and 1902, being winter floods, are also comparable. It will be observed that, although the flood of 1903 was much greater than that of 1882, the total rainfall was less, and it was less concentrated. We must, therefore, look to some other cause than the volume of rainfall and its concentration for this difference. The primary cause of the great flood of last October will be found to be that the heavy rainfall occurred at a time when the streams were already full and the ground was filled with water. Our previous reports have called attention to the fact that in 1882 the ground was very dry, and a large part of the rainfall was absorbed by percolation. The difference in the rainfall conditions preceding the two floods is well exhibited in the following table of precipitation:

TABLE II.

RAINFALL CONDITIONS PRECEDING AND DURING THE FLOODS OF SEPTEMBER 25, 1882, AND OCTOBER 10, 1903.

*Inches of Rainfall.*

| | 1882 | | | 1903 | | |
|---|---|---|---|---|---|---|
| | *July.* | *Aug.* | *Sept.* | *Aug.* | *Sept.* | *Oct.* |
| Paterson, | 7.02 | 2.37 | 25.98 | 10.98 | 2.88 | 16.19 |
| Newark, | 3.52 | 1.31 | 17.66 | 14.54 | 4.56 | 13.26 |
| South Orange, | 3.61 | 1.35 | 14.45 | 13.57 | 3.80 | 11.46 |
| Elizabeth, | 4.32 | 2.49 | 18.58 | 7.15 | 3.88 | 10.25 |
| New Brunswick, | 3.04 | 3.20 | 15.52 | 6.52 | 3.23 | 7.76 |
| Average, | 4.30 | 2.14 | 18.44 | 10.55 | 3.67 | 11.78 |

It will be observed that in 1882 there had been a light rainfall in July and August. Indeed, there had been a protracted deficiency of rainfall during several months, and this continued down to the 19th of September, when the heavy rain began, whereas in 1903 the summer had been wet.

The different conditions existing during the several floods brought about results which are well exhibited in the following table, the figures therein given for 1882 being re-computed for this report from data which probably fairly represent actual conditions on the Passaic catchment:

TABLE III.

| | *Rainfall, inches.* | *Run-off, inches.* | *Per cent. of Rain.* | *Computed Evaporation, inches.* | *Percolation or Loss, inches.* |
|---|---|---|---|---|---|
| September, 1882, | 13.56 | 3.71 | 27.4 | 3.14 | 6.71 |
| February, 1896, | 4.37 | 3.18 | 73.0 | 0.53 | 0.66 |
| March, 1902, | 6.47 | 5.35 | 82.7 | 0.77 | 0.35 |
| October, 1903, | 11.98 | 7.12 | 59.3 | 1.73 | 3.13 |

In this table the rainfall is that to which the flood is immediately due in each case, and the run-off gives the volume of water discharged by the Passaic during the flood, which lasted eight days for the first three floods given, and eleven days during October of the present year. The run-off is given in inches on the catchment, and also as the percentage of rainfall. The percentage of rain flowing off will be seen to vary through wide limits, being greatest in March, 1902, and least in September, 1882. The next column, showing "Computed Evaporation," gives the amount of water evaporated during the eight to eleven days of flood, this quantity being computed by the monthly formulæ given on page 80 of the Report on Water-Supply. Adding together the computed evaporation and the run-off, and subtracting the sum from the rainfall, we have left the percolation, or water otherwise unaccounted for, as shown in the last column. This will be seen to vary considerably according to the condition of the ground at the beginning of the rain. The above computation of percolation for 1882 agrees very well with an entirely independent method of computation given on page 215 of the Report on Water-Supply.

Table III, as I have said, exhibits clearly what occurred during each of the floods on the Passaic, and explains why a larger amount of rain in September, 1882, produced a smaller flood than a less amount of rain in October, 1903, the cause being simply the greater ability of the ground to absorb water at the end of the protracted drought of 1882. The table also inevitably presents to the mind the question of what might occur if such a rain as that of September, 1882, or that of October, 1903, should come with the ground as fully saturated as it was in March, 1902, when it absorbed almost no water. Under those conditions, instead of the 7.12 inches of run-off from the catchment, which we had during October last, we should have had from 11.63 to 13.21 inches of run-off. It cannot be said that such a coincidence is impossible, any more than we could say after the flood of 1882 that such heavy rainfall could not come on ground nearly saturated, which actually happened last October.

The flood which resulted from the rainfall of last October is shown graphically in the diagram, Plate III, being compared with similar diagrams for the other three great floods. The diagram makes the great violence of this flood apparent to the eye. The suddenness of the rise is marked, as compared with the flood of 1902, and in this respect the flood of the present year agrees generally with the other two floods shown in the diagram. The relative volume, as well as the relative maximum discharge, is also shown by the diagram, and is further exhibited in the following table:

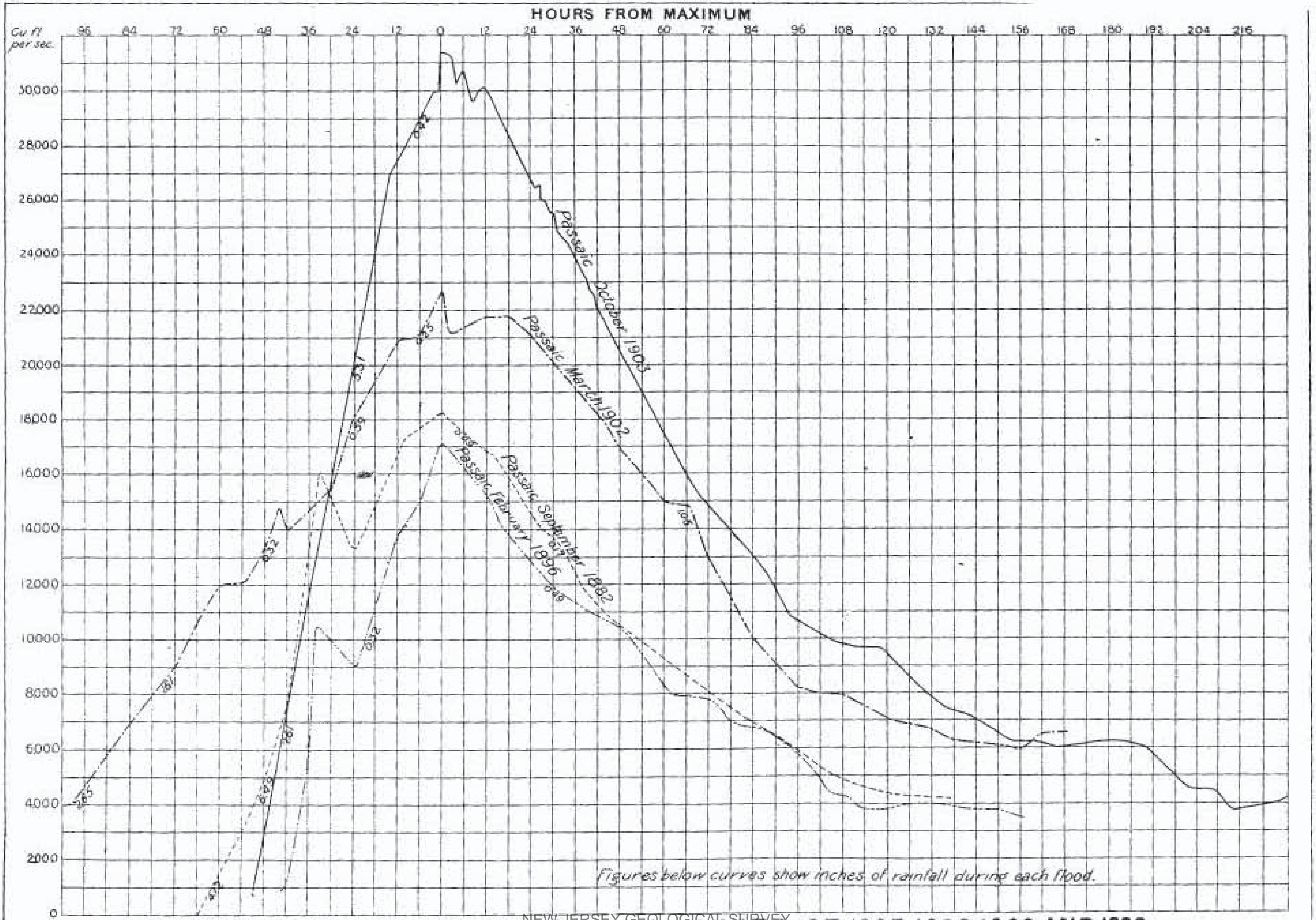
TABLE IV.

GREAT FLOODS ON THE PASSAIC AT DUNDEE SINCE 1876. AREA OF WATERSHED, 822.7 SQUARE MILES.

| *Date of Maximum Discharge.* | *Greatest Discharge, Cubic Feet, per Second.* | *Time from Beginning of Rise to— Maximum Hours.* | *End, Days.* | *Total Discharge— In Million Cubic Feet.* | *Inches on Watershed.* |
|---|---|---|---|---|---|
| October 10, 1903,.... | 31,410 | 50 | 11 | 13,619 | 7.12 |
| March 2, 1902,....... | 22,677 | 91 | 8 | 10,219 | 5.35 |
| September 25, 1882,.. | 18,265 | 66 | 8 | 7,101 | 3.71 |
| February 8, 1896,.... | 17,217 | 44 | 8 | 6,083 | 3.18 |
| December 12, 1878,.. | 16,592 | 60 | 8 | 6,878 | 3.47 |
| February 14, 1886,... | 12,452 | 60 | 8 | 5,729 | 3.00 |

The only other extreme floods of which we have any record are those of 1810 and 1865. From flood marks up the valley above Little Falls I estimate that the flood of 1810 had a maximum discharge of 25,500 cubic feet per second, while that of 1865 was nearly as high as the flood of 1902. Table IV makes plain the fact that the flood of October 10th of the present year was a very unusual one, both in its maximum discharge and in the total volume of run-off. The time from the beginning of the rise to the maximum, being only fifty hours, is also very short for so great a flood.

*History of the October flood.*—Ae we have already pointed out, Plate III shows the comparative rapidity of rise and volume of the four great floods of which we have a reliable record. The history of the flood of last October is exhibited in Plate IV. The beginning of the sudden rise was almost simultaneous on all branches, being at about 6 P. M. on Thursday, October 8th. The






COMPARATIVE DIAGRAM FOR PASSAIC FLOODS OF 1903, 1902, 1896, AND 1882.

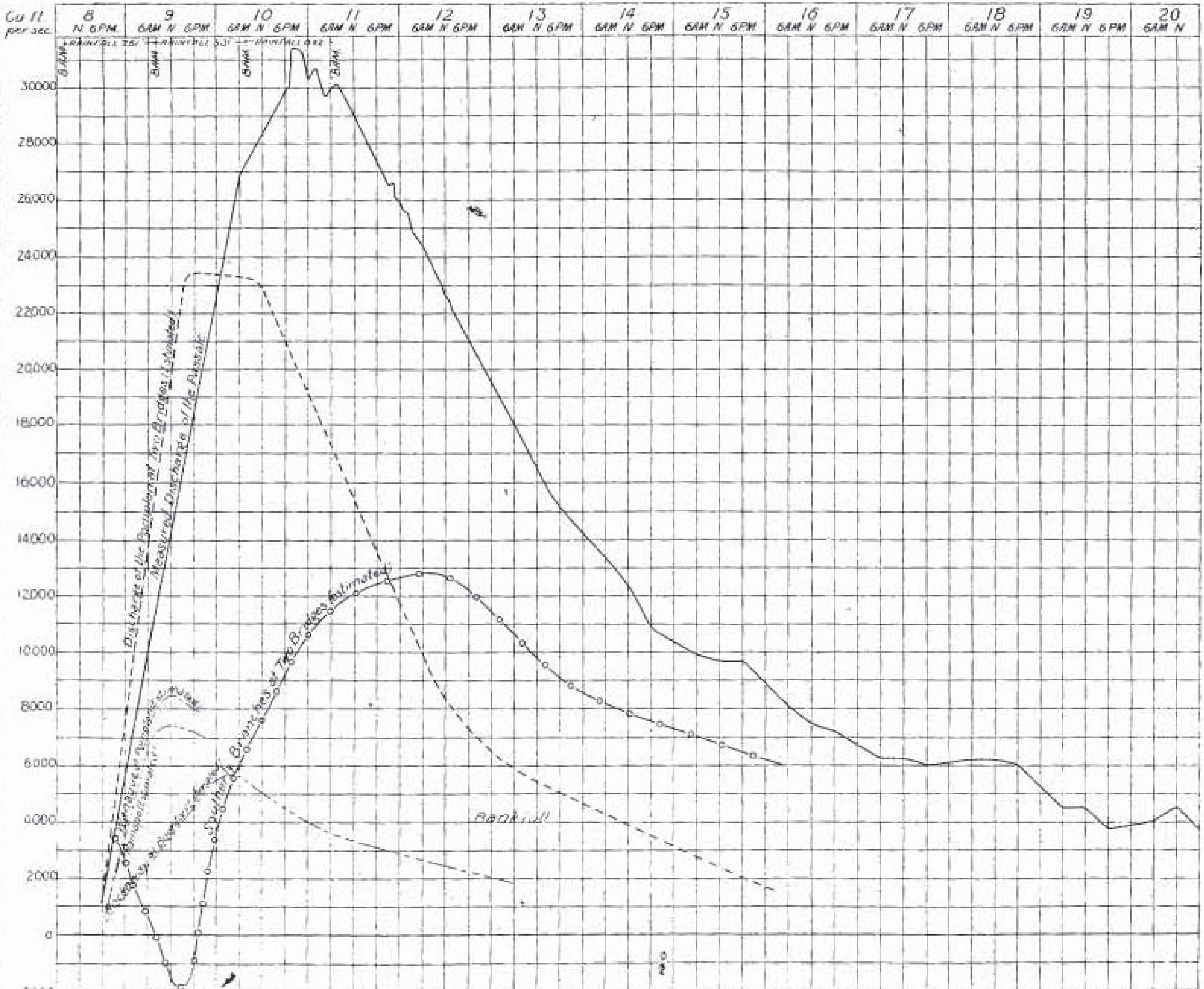



DIAGRAM SHOWING MEASURED FLOW OF PASSAIC RIVER OCT. 8 TO OCT. 20, 1903
AND THE ESTIMATED FLOW OF ITS TWO TRIBUTARIES AT TWO BRIDGES.

main stream reached its maximum at Little Falls at 2 P. M. of the 10th, and at Dundee at about 8 P. M., the difference being, as usual, six hours.

The maximum at Two Bridges was between Saturday noon and 2 P. M. The Pompton, however, reached a maximum at 4:30 P. M. of the 9th (Friday), at which time a fairly close estimate of the discharge past the Morris Canal aqueduct at Mountain View gives 23,407 cubic feet per second. At the same hour the flow over the dam at Dundee amounted to only 17,000 cubic feet per second, and the recorded heights at Little Falls show that it was still less there. This phenomenon is explained by the fact that part of the waters of the Pompton were at that time flowing past Two Bridges up-stream into Great Piece meadow. This is represented graphically in Plate IV by a negative discharge of the southerly branches at Two Bridges. This is a peculiar phenomenon to which we have frequently called attention heretofore, especially in the report of 1902.

The Pompton has a catchment of only 380 square miles, while the main Passaic at Little Falls has a catchment of 773 square miles; yet at a certain time during the rising flood the Pompton branch shows a materially greater discharge than the main stream. This is due to the more precipitous topography of the Pompton catchment, and to the fact that the southerly branches spread their waters over the large area of flat lands comprised in Great Piece meadow, Hatfield swamp and the Troy and Black meadows.

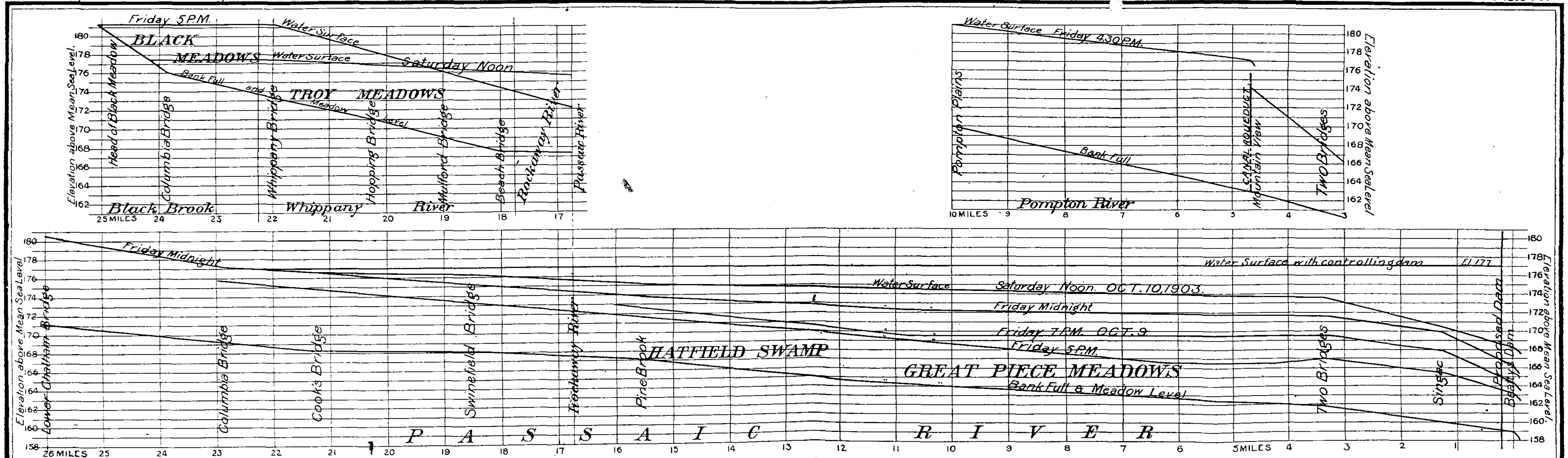
The main channel below Two Bridges, to Little Falls, is somewhat restricted, as is shown by the several cross-sections in the report of 1902. Before this channel can discharge a quantity as great as the Pompton maximum, Great Piece meadow above Two Bridges must be filled up to the necessary height.

After 4:30 P. M. of the 9th the Pompton continued a high rate of discharge until noon of the 10th, after which it steadily fell off. Plate IV shows graphically the time of the maximum on the Wanaque, Ramapo and Rockaway. The Whippany reached a maximum at 5 P. M. of the 9th, and the upper Passaic at Chatham was at its highest about midnight of the 9th. From the beginning of the rise, therefore, the Wanaque, Ramapo, Pequannock and Whippany reached a maximum in from 18 to 23 hours, and the average may be taken at 20 hours. The Rockaway and upper Passaic required from 30 to 33 hours, while the Pompton at Mountain View reached a maximum in about 22 hours, the Passaic at Little Falls in 44 hours, and the Passaic at Dundee in 50 hours.

Plate V (in pocket) is a map showing the area of the submerged lands during the October flood. The area tinted blue represents the land covered at the maximum height of the flood, although this maximum did not occur at all points at the same time.

Plate VI shows in profile the movement of the flood on the Passaic and its branches above Little Falls. Beginning with the bank-full stage, which was reached on the evening of the 8th instant, the water rose steadily until at 5 P. M. on the 9th, or Friday, it had reached a maximum on the Pompton at Mountain View, and also on the Whippany at Whippany. The profile shows the stage of the water along the river at this time. It will be seen that the slope was rapid down through the Troy meadows and the other branches into the Great Piece meadows, but that it was higher at Two Bridges than in the meadows, as at this time the water was flowing backward from the Pompton and filling up the Great Piece. At 7 P. M. the Great Piece had been filled up, and at this time the discharge of the Pompton and of the main Passaic at Little Falls were about equal.

From this time the water began to flow downward from Great Piece meadow, past Two Bridges, although it continued to rise at all points from Little Falls to Cook's bridge on the main stream until Saturday noon. It was, however, at the same time falling on the Black meadows and the upper part of the Troy meadows, and also on the Pompton. At the maximum on Saturday noon the river was nearly 12 feet above bank-full stage at Two Bridges, and 8 feet above at Pine Brook, Swinefield bridge and Cook's bridge. I estimate the volume of water on these flats to have been very close to 6,000,000,000 cubic feet at the time of the maximum accumulation, at noon of October 10th. After this time it steadily subsided. Up to 2 P. M. of the 10th the discharge past Little Falls had aggregated about 2,500,000,000 cubic feet. Adding the 6,000,000,000 cubic feet accumulated on




PROFILE SHOWING SUCCESSIVE STAGES OF RISING FLOOD OF OCTOBER 9TH. AND 10TH. 1903 ON PASSAIC AND BRANCHES ABOVE LITTLE FALLS.

the flats, we have 8,500,000,000 cubic feet discharged by the several branches into the flats during these 44 hours. Following this time to the end of the flood, the branches discharged about 5,000,000,000 cubic feet additional.

The Ramapo at about 5:40 A. M. of October 9th, when the Pompton Steel Works dam broke, had reached a discharge of 7,123 cubic feet per second. The Wanaque about noon of Friday reached a discharge at Pompton Lakes of 8,445 cubic feet per second, and the Rockaway at the head of Boonton falls reached a discharge of 5,764 cubic feet per second Saturday at 4 A. M. Table V shows the maximum rates of discharge and the relative suddenness of the rise for the four great floods under consideration.

TABLE V.

MAXIMUM RATES OF DISCHARGE ON THE PASSAIC AND ITS BRANCHES.

| | Catchment, square miles. | September 22, 1882. | | February 6, 1896. | | March 2, 1902. | | October 10, 1903. | |
|---|---|---|---|---|---|---|---|---|---|
| | | Hours, beginning to maximum. | Greatest discharge, cubic feet per second. | Hours, beginning to maximum. | Greatest discharge, cubic feet per second. | Hours, beginning to maximum. | Greatest discharge, cubic feet per second. | Hours, beginning to maximum. | Greatest discharge, cubic feet per second. |
| Passaic at Dundee,......... | 822 | 65 | 18,265 | 44 | 17,217 | 91 | 22,677 | 50 | 31,410 |
| Passaic at Little Falls,...... | 773 | 66 | 19,000 | 44 | 16,745 | 81 | 21,207 | 44 | ...... |
| Pompton at Two Bridges,a. | 380 | 30 | 16,000 | 13 | 18,500 | 54 | 17,900 | 22 | 23,407 |
| Ramapo at Pompton,....... | 160 | 24 | 10,540 | 24 | 8,731 | 54 | 7,049 | 12 | 7,123 b |
| Wanaque at Pompton,...... | 101 | 24 | 6,666 | 11 | 7,203 | 54 | 6,187 | 18 | 8,445 |
| Pequannock at Pompton,... | 85 | 20 | 4,460 | 7 | 5,500 | 50 | 4,600 | ... | ...... |
| Rockaway at Boonton,...... | 118 | 36 | 4,800 | 16 | 5,445 | 51 | 4,540 | 32 | 5,764 |
| Whippany at Whippany,.... | 38 | ... | ...... | 10 | 3,200 | 47 | 2,600 | ... | ...... |

*Note.*—*a.* Pompton river discharge is approximate only.
*b.* Dam went out—actual maximum probably near 9,000.

Referring to Plate VII, which shows the profile of the river from Two Bridges to Beattie's dam, it will be noted that the flood of 1903 was proportionately higher at Beattie's dam than at other points up stream. It, therefore, seems doubtful if any detailed computation of the discharge over Beattie's dam for the present flood is reliable, and I have not attempted to make such computation. Table V shows that not only the Passaic, but its several branches, reached a higher point than ever before during the flood of last October. The Ramapo river has been gauged heretofore at Pompton dam, but this structure went out when the discharge had reached a little over 7,000 cubic feet per second. Undoubtedly the maximum discharge was much in excess of this.

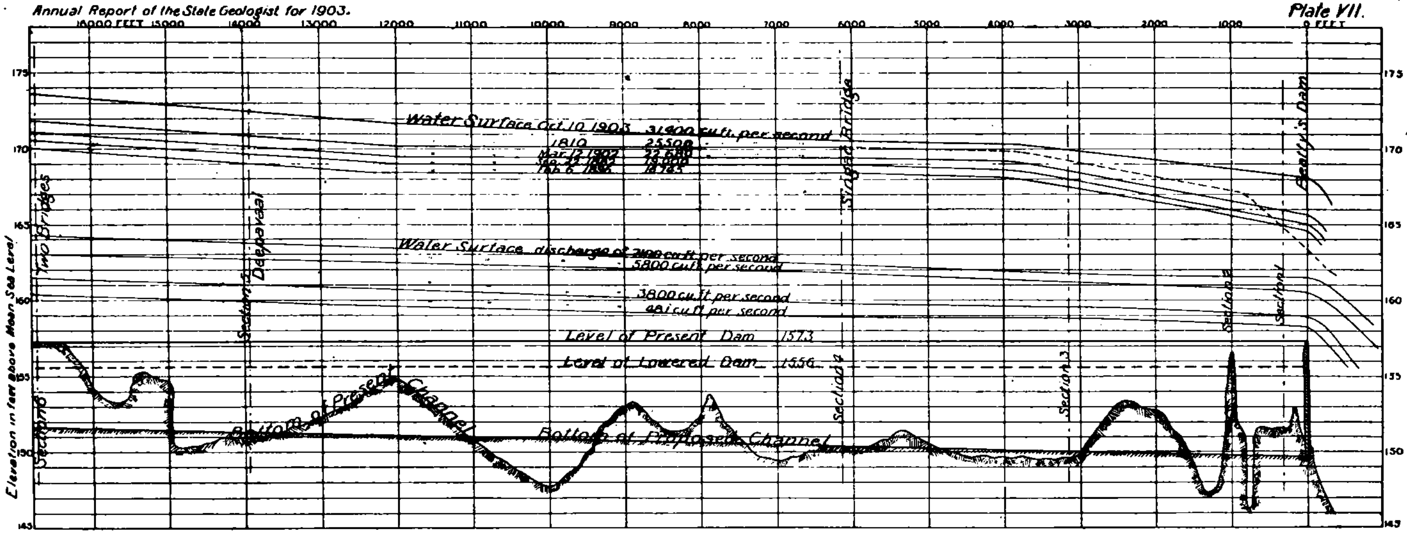
Plate VII, showing the height of the several floods from Beattie's dam to Two Bridges, brings out the fact that the difference between this and the flood of 1902 was greater at Deepavaal and Two Bridges than at points near Singac, and thereby indicates what we have previously pointed out; *i. e.*, that this part of the river channel from Two Bridges to Beattie's dam, rather than the dam itself, really controls the discharge of floods.

Referring again to Plate V, we have shown the lands submerged immediately above Little Falls. The area of lands submerged, shown on the map by a blue tint, amounts to 22,323 acres. There were, of course, other lands, such as the Great swamp above Millington, and the flats between Millington and Chatham, also submerged, but these other areas have no direct relation to the problem in hand, and have not been considered by us. Their only effect is to make the upper Passaic discharging past Chatham a more tardy and less violent stream than the other branches. The discharge of the Passaic below Little Falls, however, is affected only (1) by the channel from Two Bridges to Little Falls, which limits the discharge, and (2) by the area of flat lands shown on Plate V upon which the floodwaters accumulate during the early part of a flood.

Referring to Plate IV, it will be observed that the Pompton reached its maximum and was falling some 26 hours before the Passaic reached a maximum at Dundee. The Pompton represents about half of the total watershed above Little Falls.

### EFFECT OF THE PROPOSED DRAINAGE WORKS ABOVE LITTLE FALLS ON THE HEIGHT OF FLOODS.

The effect of the works begun about 12 years ago for the drainage of the flats above Little Falls in increasing or otherwise affect-




PROFILE OF PASSAIC RIVER, TWO BRIDGES TO LITTLE FALLS, SHOWING PRESENT CHANNEL, SLOPE OF WATER AT VARIOUS STAGES, AND PROPOSED IMPROVEMENT.

ing the height of great floods on the Passaic was treated at length in the report of 1902. The subject is one which must be considered in connection with any proposed method of controlling the Passaic floods; consequently, I repeat in this connection the considerations which have led me to the conclusion that such drainage works, as they are planned, can have no important effect on the flood-flow, excepting to slightly diminish the height of such floods.

In the agreement made by the Commissioners with the Beattie Manufacturing Co., the following points are fixed as to the extent of the proposed improvements at Beattie's dam and in the channel up to Two Bridges. The dam is to be lowered 20 inches, the channel of the river above the dam to be excavated to a depth of not less than 5 feet below the lowered dam, and to a width of not less than 200 feet. The bar at Two Bridges is to be excavated to a depth of not less than 4 feet below the crest of the lowered dam, and to a width of not less than 200 feet below and 100 feet above the mouth of the Pequannock or Pompton river. It is also agreed to remove such obstructions in the Passaic, between said dam and the reef at Two Bridges, as shall insure a clear waterway of a width of not less than 200 feet, and a depth conformable to a grade line which at said dam shall not be less than 5 feet, and at Two Bridges not less than 4 feet below the level of the crest of the lowered dam. Floodgates are also to be inserted at the dam.

It will be noted that this agreement merely fixes a minimum improvement. The extent of the improvement, however, cannot very much exceed this, owing to the cost. My report of 1894, to the Committee on Drainage of the Board of Managers of the Geological Survey, pointed out that the most that could be done, keeping within the limits of a practicable cost, would be to increase the channel width to 250 feet and make its depth, at Two Bridges, 4 feet below the crest of the dam, and 6 feet below the crest just above the dam, thereby giving a grade or slope to the channel of .12 in 1,000, which we found to be desirable. The side slopes of this rectified channel we made one perpendicular to one and one-half base. There is little doubt that even this scale of improvement very materially exceeds in cost the funds which will ever be available for the work, but for the purpose of this discussion we assume that the work may be completed to this extent in order to show the maximum possible effect on the height of floods. The proposed improvements of the channel are shown in profile on Plate VII.

The result of such improvements would be a slightly increased cross-section of the river, and what is more important, a lower value of the co-efficient of roughness, giving a higher velocity for a given slope. Our surveys and investigations show that the present obstructed channel has a coefficient of roughness, "n" in the Kutter formula, of .032, and it may be safely assumed that the improved channel would reduce this to .025. A lower value than this could not reasonably be expected during flood discharge, owing to the crooked course of the river. A computation based on the data furnished by our surveys shows that the effect of the improvements above indicated would be to reduce the height of the water at Two Bridges, for given stages of the river, to the extent shown in the following table:

TABLE VI.

| *Stream Discharge, in Cubic Feet, per Second.* | *Elevation of Surface of Water at Two Bridges.* | |
|---|---|---|
| | *Present Channel.* | *Improved Channel.* |
| 4,000 | 161.50 | 158.75 |
| 8,000 | 164.80 | 161.50 |
| 12,000 | 167.80 | 164.90 |
| 16,000 | 169.75 | 166.75 |
| 20,000 | 170.70 | 168.70 |
| 22,000 | 171.10 | 169.50 |

The present bank-full stage at Two Bridges is 4,000 cubic feet per second, and the table shows that for this discharge the elevation of the water will be reduced by the improvement of the channel from its present height of 161.50 to 158.75, or nearly 3 feet. With the improved channel, when the water reaches elevation 161.50 it will be discharging 8,000 cubic feet per second, or just double what it now discharges at that height. For all stages of the river up to 16,000 cubic feet per second, the height at Two Bridges would be reduced by the improvement about 3 feet, whereas at the maximum flood discharge the reduction would be only the difference between 171.10 and 169.50, or 1.6 feet.

It may be well to urge in this connection that the real benefits of the proposed drainage improvement do not depend on entirely preventing the overflow of the flat lands in time of great freshets. Such prevention would be not only financially impracticable and dangerous to Paterson, but it may be doubted if it would be entirely desirable for the lands. They are considerably enriched by the sediment deposited at such times. A lowering of the water surface at Two Bridges 3 feet during stages between 3,000 and 8,000 cubic feet per second would be of very much greater benefit than the prevention of overflow by occasional high freshets. Data recorded in the Report on Water-Supply show that the stream is between these stages, on the average, over six weeks of each year, while it exceeds 8,000 cubic feet per second less than four and one-half days each year. For weeks and months these lands are now saturated, not by extreme floods, but when the stream is slightly swollen, or during the tardy discharge of the waters at the end of a freshet, and it is this condition which causes sourness, prevents the raising of useful crops, and produces malarial or miasmatic diseases. The lowering of the river 3 feet during such times would almost entirely remove these serious blights from the Central Passaic Valley.

The profile of the river, Plate VII, shows plainly that at the higher flood stages Beattie's dam is not a controlling point. It will be noted that the steep flood slope extends a distance of 4,000 feet above the dam, and the observed height, together with a computation at the cross-sections, made by means of the Kutter formula, show that this control rests with the entire channel, from the dam up to Two Bridges, but is especially affected by the reefs and constricted channel between Singac and the dam. Indeed, for the higher flood stages, Beattie's dam could be entirely removed without causing any appreciable difference in the height of the floods or the maximum discharge of the river.

It was intended by the Drainage Commissioners to put floodgates in the dam, and one of the questions investigated by the Committee on Drainage of the Geological Survey was the proper size of these gates and their effect. The result of careful computation showed that a capacity of flood-gates in excess of 4,000 cubic feet per second would be useless, and that even with the improved channel the height of floods at Two Bridges would not be affected to any practicable extent by the existence of such gates. At the higher flood stages the discharge would be controlled entirely, even after improvement, by the capacity of the channel from Two Bridges to Little Falls. The effect of such gates, however, would be very beneficial at lower stages of the river, keeping the water level at Two Bridges lower at times when the meadows are now soured by deficient drainage, although not actually submerged by floods.

Since the rate of discharge of the main stream depends entirely upon the height at Two Bridges, whether the channel be improved or not, the question whether the proposed improvement will increase the flood discharge will be determined by ascertaining if, after improvement, the waters at Two Bridges will rise high enough to produce a discharge greater than the present maximum. By referring to Plate VIII, which shows the movement of the flood of 1902, the reader will be enabled to follow the reasoning on which we base our conclusions that no such increased flood discharge can occur. We have seen in our analyses of the several floods that the maximum discharge of the Pompton, at Two Bridges, is reached usually about 33 hours earlier than the maximum of the main stream below Two Bridges, and that the channel below Two Bridges is at present insufficient to carry off the Pompton waters as fast as they come down to Two Bridges, so that these waters are held back and driven up stream into Great Piece meadow to augment the flood-waters coming down from the southerly branches. The improved channel, because of its greater capacity, will carry off a larger volume of these Pompton waters during the early hours of the flood, and thereby decrease the accumulation of water on Great Piece meadow, making it impossible for the water to rise as high at Two Bridges after improvement as it now does.

Taking the diagram of the flood of 1902, Plate VIII, we estimate that the rise of the stream after improvement will not differ materially from that observed for the present channel, as shown

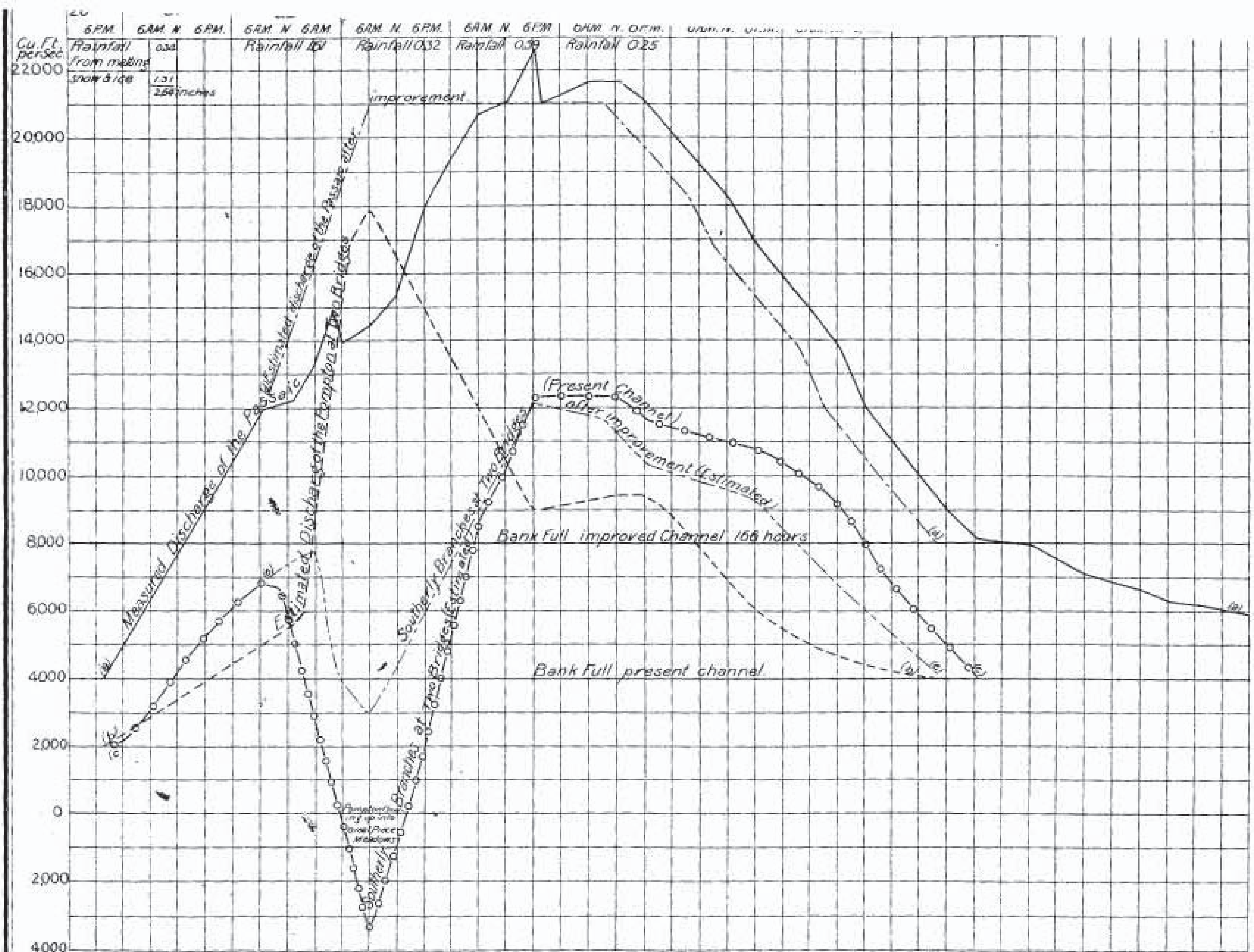



DIAGRAM SHOWING MEASURED FLOW OF PASSAIC RIVER FEB. 27 TO MAR. 9, 1902 AND THE ESTIMATED FLOW OF ITS TWO TRIBUTARIES AT TWO BRIDGES. ALSO ESTIMATED FLOW OF THE PASSAIC AFTER COMPLETION OF PROPOSED DRAINAGE WORKS ABOVE LITTLE FALLS.

by line "a," until the discharge has reached 12,000 cubic feet per second, because during that period the rise of the Passaic was uniform and controlled by the steady swelling of the several branches, which had not yet begun to rise in a violent manner; but from that time forward the discharge by the new channel, shown by line "d," would have been accelerated more rapidly than with the old channel, because of the rapid rise of the Pompton, and, by 6 A. M. of March 1st, we estimate that it would have reached 21,000 cubic feet per second. Continuing at this rate until noon of the 2d of March, it would have disposed of 569,160,000 cubic feet of the waters accumulated on the flats, or about one-third of the whole; consequently, it would have been impossible for the stream to rise at Two Bridges as high as it did before improvement. We estimate that it would not have increased above 21,000 cubic feet per second, but with adequate improvement of the upper channel it would have been maintained at about this rate until 10 A. M. of the 3d, after which it would steadily decline. It will be noted that during this flood, after improvement, the flow of the Pompton is taken care of as fast as it comes down, and that the waters from the southerly branches, or the Upper Passaic, the discharge of which is shown by line "e," will consequently come down more rapidly at the start, but are estimated to reach a maximum discharge almost as great and at about the same time that it actually occurred with the existing channel, as shown by line "c," after which there will be a steady decline as the waters are discharged from the flats.

It may be thought that the fact that the water at Two Bridges would be maintained at a lower level after improvement, should cause a greater slope of the water surface through Great Piece meadow, and consequently an accelerated discharge of the waters of the Upper Passaic; but it will be found that the reduction of depth over the flat, and consequent reduction of the hydraulic mean radius, will effectually prevent any such acceleration, and that consequently a very considerable improvement of the upper channels will be absolutely essential to maintain the flow at even as high a stage as we have estimated.

The result of our earlier studies, confirmed by the history of the floods of 1896 and 1902, indicate clearly, therefore, that any drainage of the wet lands which is financially practicable, or which is necessary and desirable, can be carried out without increasing, but actually decreasing the rate of discharge of floods on the lower river. In order to emphasize the impracticability of any scale of improvement which would imperil the lower river, it may be well to point out that the cost of an improvement on a scale which we have assumed in the above studies would be, for the work below Two Bridges alone, $192,500, while in order to make this improvement effective above Two Bridges it would be necessary to spend at least enough more to bring the total up to $250,000, a sum which is far more than the Drainage Commission has ever contemplated. While an improvement to this extent would be entirely safe and desirable, a more moderate scale of works could nevertheless be made effective and useful.

### METHODS OF CONTROL.

Two possible methods of controlling the floods on the Passaic present themselves for consideration. One of these was suggested in the report of last year, and consists in the construction of large storage reservoirs to hold back the flow of the river to such an extent as to reduce the flood discharge to a harmless maximum. A second plan consists in temporarily impounding the water to throttle down the discharge to a maximum of about 17,000 cubic feet per second, which could be discharged without damage by the lower channel through Paterson, and then allowing the accumulated waters to flow off gradually. The plan of storage reservoirs would be more costly to make it entirely effective, but would have the advantage of adding largely to the flow of the stream during dry weather. The plan of temporarily throttling down the stream would flow no lands permanently, but would increase by about 9% the area subject to occasional flooding and would also increase the length of the period of flooding.

*Control by throttling the discharge at Little Falls.*—We will consider first the practical application of a system of throttling down the floods without creating a permanent lake or storage reservoir. We find only one point which is entirely suited to the erection of a dam or barrier which would exercise a proper control, and that point is within 1,000 feet above Beattie's dam at Little Falls. At this point the valley is narrow, and the dam would be founded throughout on trap rock and could be made as enduring as the trap reef itself. At its highest it need not exceed 22 feet, the top being at an elevation of 180 feet above the sea. To make it secure beyond peradventure, it should be given a large margin of strength over that which would be considered necessary for an ordinary dam. Such a dam would hold the water back if necessary at an elevation of 180 feet above mean sea level, an elevation which would be sufficient to impound 3,840,000,000 cubic feet in addition to what accumulated on the flats last October. It should be provided with open sluices having no means of closing, consequently always in operation. They would then have acted as follows during such a flood as that of last October: The discharge through the sluices would have steadily increased up to 17,000 cubic feet per second, which would have been reached 110 hours after the beginning of the flood. The accumulation in excess of the natural maximum accumulation at this time would have been 1,600,000,000 cubic feet, raising the pond back of the controlling dam to elevation 177 or a little less. The discharging sluices would have an area of about 900 square feet, as the maximum head would be 11 feet. These openings should be placed below the ordinary summer level of the river, so as to leave the flow at ordinary stages unrestricted.

Now, the area of land flooded last October, between Little Falls, Chatham, Whippany and Pompton, amounted to 22,323 acres. With such an impounding dam as is now proposed, this area would be increased by only about 800 acres. If we acquire the right to flood 3 feet higher, or to 180, we shall need but 1,900 acres in addition to what is now flooded at times. This additional land would include a few houses and other improvements, and the land which is now flooded would be flooded a little longer time than at present, a little over three days longer during such a phenomenal flood as that of last October.

The effect upon that flood and those of 1902 and 1896 is shown graphically in Plate IX. The maximum discharge for March, 1902, would be reduced to 14,000 cubic feet per second, and for February, 1896, to 12,400 cubic feet per second; while for the flood of last October, the greatest on record, it would be but 17,000 cubic feet, a discharge which would be entirely harmless to interests below Little Falls.

The damages to land resulting from such a method of controlling the river would be this additional flooding of the lands now flooded, and occasionally, at long intervals, the flooding of 1,900 acres of land not now subject to flooding. The additional damage to land which is already flooded would be most liberally estimated at $20 per acre. As a matter of fact, this wet land has not at the present time an average value exceeding $20 per acre. The damage to the 1,900 acres of additional land which would be made subject to flooding, and its improvements, would be liberally covered at $100 per acre, which is about the full value of the property. Other damages which must be considered would be to the Delaware, Lackawanna and Western railroad, and the New York and Greenwood Lake railroad, which pass through the flooded area. Four and one-half miles of the Delaware, Lackawanna and Western railroad would have to be partially raised and partially re-located on higher ground, which could be done without impairing the alignment, and the cost of which would not exceed $90,000. The New York and Greenwood Lake railroad from Little Falls to Pequannock, a distance of five and one-half miles, would also have to be re-located and raised, unless an arrangement could be made by which this road beyond Little Falls could be abandoned and the upper end operated in connection with the New York, Susquehanna and Western railroad. If this could not be arranged, the re-grading and re-location of the road would cost about $75,000. The land flooded is almost all farm land, pasture land and wet meadow. This and the few improvements interfered with are subject to flooding under present conditions, a fact which should be considered in estimating damages.

The entire cost of executing the works necessary for throttling down and holding the river at a maximum discharge not exceed-

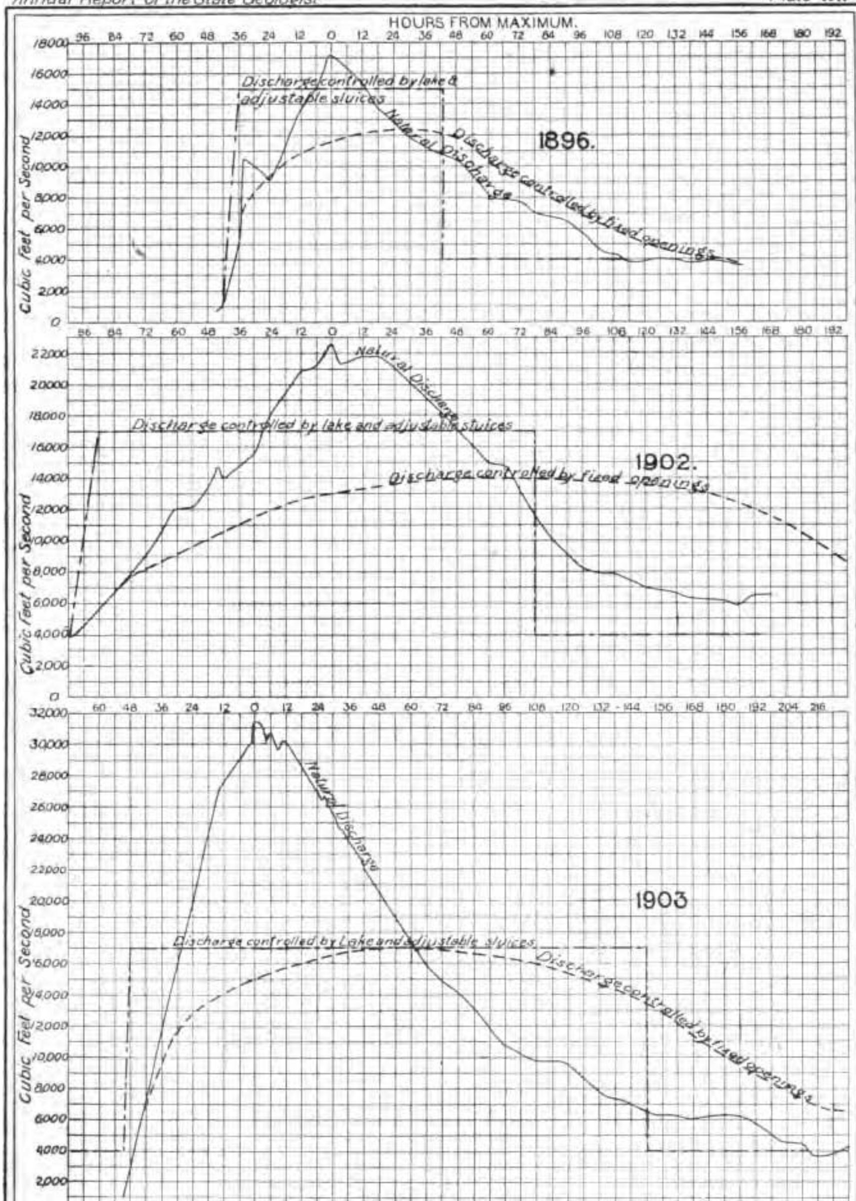



DIAGRAM OF PASSAIC FLOODS SHOWING EFFECT OF PROPOSED CONTROLLING WORKS.

ing 17,000 cubic feet per second may, therefore, be estimated approximately as follows:

| | |
|---|---|
| Land damages— | |
| 22,323 acres flooded three days longer than at present during extreme floods, at $20 per acre, | $446,460 |
| 1,900 acres of land made subject to floods, but which is not now flooded, at $100 per acre, | 190,000 |
| Re-location of railways, | 165,000 |
| Other damages, | 50,000 |
| Cost of constructing masonry dam, | 225,000 |
| Incidentals and contingencies, 20 per cent., | 215,292 |
| Total, | $1,291,752 |

When it is considered that this entire cost is much less than the total damage done during a single flood, and that we have had destructive floods now two years in succession, it is apparent that, although this scheme is somewhat bold, and at first sight radical, it is nevertheless entirely feasible and warranted by the conditions.

In practical operation, such a controlling dam would be provided with openings which would have no provision for closing, but which could not possibly, at any stage of the river, pass a greater quantity than 17,000 cubic feet per second. In addition to these permanent openings, others might be provided which would be closed by sluice-gates, in order to insure further regulation of the discharge, and especially to prevent unnecessary backing up of the water during slight floods. The sluices could be so designed that they would not in the least interfere with the ordinary flow of the river, and, indeed, the drainage works now in contemplation, to drain the wet lands, could be still carried out without hindrance.

We have frequently pointed out that such drainage works can in no case prevent or mitigate the flooding of these lands during high freshets, and that the real intent of the drainage is to promptly dry up the lands after the flood has subsided; whereas, at the present time, the flats often remain saturated with water for weeks and months together. Paradoxical as it may seem, therefore, the provision for holding back the water is not inconsistent with the completion of the drainage, and the only effect detrimental to the low lands would be, as already noted, to prolong the flooding about three days during the most severe floods.

The changes in the railroads which we have mentioned should not prove a serious barrier, as these railroads are both subject to flooding under present conditions, and were greatly damaged by the flood of last October, traffic being interrupted for several days, so that they would benefit substantially by the proposed raising of their grade above high-water mark. I have not mentioned the Morris canal. This would also be flooded for a distance of about four miles, but the most that could occur would be a temporary interruption of traffic, which is, in any case. light, while it is probable that in the near future the canal will be abandoned.

The map, Plate V, accompanying this report shows, by a blue tint, the land which was submerged by the flood of last October, and also shows, in red, the outline of the additional lands, the right to flood which would be acquired, although this is three feet higher than the water would have been raised last October, by the proposed controlling dam above Little Falls. The profile of the river, Plate VI, also shows the high-water level through the flats during the flood of last October, and the high-water level represented by elevation 177 to which the water would have risen if the proposed controlling dam had been in operation. At the height of the flood the difference of level above and below the controlling dam would have been about 11 feet, and the permanent openings, consequently, should have sufficient size to enable them to pass 17,000 cubic feet per second with a head of 11 feet. Inasmuch as the maximum height of the water back of the controlling dam last October would have been but 177 feet elevation above the sea, while the top of the dam and the right of flowage extends to elevation 180, such controlling works could control a much greater flood than the highest ever known.

I have thoroughly examined the valley above Little Falls at higher points, and find no location at which the foundations are so good, or the control would be so effective, as at this point within 1,000 feet of Beattie's dam; and a dam at this point, as I have stated, could be made safe beyond peradventure, owing to the excellence of the foundations.

*Control by permanent lakes or storage reservoirs.*—The same dam which I have proposed for the control of the floods by throttling might be converted into a permanent storage dam with sluices regulated by gates. Such a great storage lake would exercise control as follows: Taking its normal water-level at 180 elevation, the shore-line would be as represented upon Plate V by a red line. It would be drawn below that level only to maintain the flow during dry seasons, while in great floods it could rise to about 186. At the beginning of a flood the superintendent at the dam, being informed as to conditions upon the several branches, would at once throw open the sluices to a discharge of from 15,000 to 17,000 cubic feet per second, according to the probable extent of the flood. This would anticipate the flood to some extent, and draw down the lake before the height of the flood, as shown by the diagrams of Plate IX. In such a flood as that of 1903, the inflow to the lake would have been, for the first 90 hours, 10,944,000,000 cubic feet; the outflow through the sluices would have been for the same time 5,508,000,000 cubic feet. The difference of 5,436,000,000 cubic feet would have accumulated in the lake, raising it to a maximum height of 184 feet. Continuing the discharge at 17,000 cubic feet per second would have discharged the entire flood, bringing the lake down to its normal level, in 110 hours, or about 4½ days, from the beginning, as shown by the diagram, Plate IX. This great flood could have been limited to only 15,000 cubic feet per second by this method, and the lake would have risen but 6 inches higher, or to 184.5 feet elevation.

A further advantage to be derived from such a storage lake would be the maintenance of an increased flow of the river at and below Little Falls during the dry seasons, to the great advantage of the water power and the sanitary condition of the river. During the worst drought of which we have record a draught of 6 feet from this lake would have easily maintained the flow of the Passaic at 445,000,000 gallons daily, or 700 cubic feet per second. Under present conditions the river falls to less than one-fifth of this discharge. This would add fully 10,000 horsepower for 24 hours daily to the effective power at Little Falls, Paterson and Dundee. Power is now rented at these points at from $30 upward per horsepower for only 12 hours daily; and, taking $50 per horsepower as the fair rental value for 24 hours daily, we have a total of $500,000 per annum as the value of the additional power created by the storage dam, assuming the lake to be drawn down 6 feet in the greatest droughts, which will only occur at intervals of upwards of a quarter century. As a further advantage, such a reservoir might be used to create an artificial flood when it becomes necessary to flush and cleanse the river below during periods of low water.

The proposed lake would have an area of 25,500 acres at its ordinary level; when temporarily raised by such an extreme flood as that of 1903, it would for two or three days flood 2,400 acres additional, or less than ten per cent. of its area. At ordinary stages its depth, over 18,300 acres, or nearly three-fourths the total lake area, would range from 6 to 15 feet, the remainder being 6 feet deep or less. The depth could be materially improved by an auxiliary dam across the Whippany, near the highway leading from Hanover to Whippany. Such a dam should raise the waters on Black meadows to elevation 190, making a deep and attractive lake between Madison and Morristown. With this auxiliary dam the area less than 6 feet deep would be reduced to 5,000 acres, or 20 per cent. of the whole; and taking into account its great area, which would allow the winds to continually agitate it and sweep its shores with waves, this depth would be ample to preserve its waters in good condition.

Such a great storage reservoir might be supplemented by the other reservoir on Pompton Plains, created by a dam at Mountain View, to which the writer first called attention in 1884 (see Engineering News, April 12, 1884), and which was referred to in the Report on Water-Supply (page 159). A dam at Mountain View, 2,200 feet long, and 57 feet high above the river, would flood Pompton Plains to elevation 220, and the reservoir would have an area of 11,520 acres, with a depth of from 20 to 50 feet, with little shallow flowage. It would create a supply of 332,000,000 gallons daily of potable water. As the lake would be at elevation 220 feet above sea-level, all the lower parts of the populous region east of the Watchung mountains could be supplied from it by gravity, while for the higher portions the water could be pumped with a small fraction of the water-power created at Little Falls by this storage system. This Pompton Plains reservoir would greatly reduce the fluctuations in level of the previously described reservoir on the southern branches, created by the dam at Little Falls.

Such a development of the Passaic by storage would not only control its floods, but would, in a magnificent way, utilize its waters to benefit the people of the State. Taking the power now in use at Dundee, Paterson and Little Falls at about 4,800 horsepower, the present system of diverting the river to supply our cities will steadily reduce and ultimately destroy the value of this power; whereas the above plan of utilization will enable us to draw all the water now used by our cities and still leave power now in use and new power created aggregating 14,000 horsepower for 24 hours daily. Ultimately, when the entire Pompton river shall have been appropriated, yielding 304,000,000 gallons daily, for public water-supply, we shall still have 7,000 horsepower for use in our manufacturing cities.

The cost of such a storage system would, of course, be much greater than the cost of the throttling dam first described; but since the additional power created would alone pay five per cent. interest on $10,000,000, which is much more than the total cost of the reservoirs, it is almost certain that fuller study will show it to be of the two the more profitable and advantageous plan.

As compared with any plan for providing for flood discharge by deepening and enlarging the river channel through Paterson and Passaic, either of the plans here proposed is preferable, although improvement of the channel might supplement these plans in the future. It will be observed that the throttling dam first described in no wise impairs any of the valuable water-powers, while the plan of storage greatly enhances their value; whereas adequate reduction of the height of the flood through Paterson, by channel improvement, would, in our opinion, call for the destruction of the valuable Dundee water-power, involving a considerable impairment of the advantages of Passaic as a manufacturing city.

Finally, such lakes or reservoirs as are proposed would greatly enhace the beauty of the whole territory about the Passaic valley, including Summit, Chatham, Madison, Morristown, Boonton. Pompton, Little Falls, Caldwell, Essex Fells and the intervening country. In the place of existing marshes we would have great lakes surrounded by picturesque hills, abounding in beautiful village and suburban residence sites, which would overlook these extensive bodies of water aggregating some eighteen miles in length by three to four miles in width, and adding the one element of picturesqueness necessary to perfect an already attractive landscape.

In short, such a plan, properly worked out, will combine every element of utility and beauty necessary to make it worthy of the earnest attention of the State Government. We realize that there are many details to be perfected in order to make the suggested plan of storage lakes a success, but they are all well within the limits of practicability. There are many diverse interests touched by the plan, but all are benefited, and it should be possible to harmonize them and enlist them in the effort to make such a beneficent plan a reality. It has been with a view to suggesting, or, at least, furnishing the data necessary to demonstrate the practicability of some such method of controlling the destructive Passaic floods, and utilizing the great latent wealth in this stream, that this Survey has collected for years data bearing upon its flood-flows and other physical characteristics.

### OCTOBER FLOODS ON OTHER STREAMS.

On the Raritan the river reached a height of 12.25 feet on the crest of the dam below Bound Brook. In 1896 the height was 15.2 feet, and in 1882, 14.2 feet. The flood of the present year, therefore, was not phenomenal. The rainfall was much lighter on the Raritan catchment than on the Passaic. The average rainfall from the 8th to the 11th, at New Brunswick, Somerville, Flemington and Chester was but 7.18 inches, whereas we have seen that the average for the Passaic was 11.98 inches. At Theo. Ammerman's mill at South Branch the water was 18 inches lower than in February, 1896.

On the dam on the South Branch at High Bridge the water was 9 inches lower than in February, 1902.

The Pequest at Belvidere was 6 inches lower on Keener's dam than in 1902.

On the Delaware the flood of last October was very high, and the rise was unusually rapid. At Belvidere, at 6:40 P. M. Saturday, October 10th, it was 6½ inches higher than the highest flood previously known, viz., that of February, 1902. The bridge at this place was carried off at the height of the flood. The total rise was 26½ feet above low water.

At Easton, Saturday, October 10th, at 10:30 P. M., the river reached a height of 36 feet above low water. It was 4.1 feet higher than in 1841, and the highest flood of which we have any record.

At Centre Bridge, the only bridge left standing on the river between Easton and Trenton, the river was 4.33 feet higher than in 1902.

At Lambertville it was 4 feet higher than in 1902, and 3.1 feet higher than in 1841. The bridge here was destroyed.

At Trenton it was 3.8 feet higher than in 1902, and 4.2 feet higher than in December, 1901.

It will be observed that this was three to four feet higher than any previous flood on the Delaware. On the Lehigh River at Chain dam the depth on the dam was 5.5 feet, whereas in 1902 it was 11.4 feet.

# PART III.

# Forest Fires in New Jersey During 1903.

By F. R. MEIER.

# Forest Fires in New Jersey During 1903.

BY F. R. MEIER.

## HOW TO ESTIMATE FOREST FIRE LOSSES.

Without an examination of the burned areas on the ground, it is impossible to give even approximate estimates as to the extent of damage done by the fire. The extent, severity and degree of damage depends upon the kind and character of the growth, season of the year, whether burned by day or by night; whether hot, dry, windy or wet, on the direction of the wind, whether on sandy plains or mountain lands.*

It was, therefore, necessary to visit each tract burned over, and to determine the percentage of damage done by the fire by an examination of the bark of the scorched trees of a sample area. Where the fire had been severe, burning through the bark, an examination at a glance determined the degree of loss; where the outer bark had been severely scorched, slight cuts were made through the bark, at several points around the trunk, to determine whether it had been killed. If the inner bark was found to be brown, as also the surface of the sapwood, such trees were not expected to recover. Trees with a portion of the bark alive, say from one-third to one-half of the circumference, may recover,

* Pineries on plains, on account of the dry, sandy soil, are visited by more severe fires than the mountain forest. Fires burn more rapidly up-hill than down-hill.

Fires generally fall off in violence during the night and become stronger again after sunrise; this is due to the fact that the wind usually slackens at night and to the nightly dews.

The dry west and southwest winds of April and May, in which months most of the fires occur, cause the most dangerous and extensive fires.

Fires do more damage after the sap begins to move.

although their growth will be retarded to a considerable extent, and in some cases such trees may, within a year or so, succumb. Trees thus affected are called "injured" in the estimate of damages.

The actual damage to the forest by fire greatly exceeds the value of the merchantable timber which has been killed. The fact that the young, unmarketable growth is destroyed is a loss which must also be reckoned in dollars and cents. This, however, cannot be done except when two things are known. These are, 1st, the average age, size and number of immature trees which were killed, and, 2d, the length of time it would have taken them to reach merchantable size. With this data at hand the calculation of damage done is then simply one of compound interest, in which the value of immature trees is reckoned on the basis of their value at maturity, and the length of time which would have elapsed before they were mature.

When the fire has burned so severely that the burned area cannot restock itself naturally, then the cost of planting is to be added in the calculation of damages. Fortunately, the regenerative power of the New Jersey forest, especially of the pines in South Jersey, is excellent, and only in two instances was it found necessary to take this factor into consideration while estimating the extent of damages. A calculation as to the indirect damages, as that done to the soil, although in many cases heavier than the direct losses, is not included in the estimate of losses. Reference has been made as to this in the discussion of humus.*

### BEHAVIOR OF OLD AND YOUNG GROWTH AFTER FIRE.

On account of the thick, corky bark, old pitch pine withstands a great deal of fire, an ordinary light surface fire blackening the tree without doing much injury to the growth, while it has the power to recuperate rapidly. The shortleaf pine, while also being able to resist fire, does not recuperate as readily as the pitch pine. Heavy fires will kill the trees. Pitch pine sprouts from the collar after the fire has killed the tree. These sprouts grow

*No court will give any award for such indirect damages.

slowly, are crooked and knotty, and seldom have great commercial value. The more valuable shortleaf pine does not sprout.

The white cedar is very easily killed by fire, and will not sprout. Fortunately, the swamps are a great protection, and only "hot fires" with strong winds enter the interior of a swamp. Trees on the edges are frequently killed, however, from the severe heat of surrounding fires, even when themselves untouched by the flames.

The effect of fire on the oaks is varied. Only very severe fires will kill the old oaks outright; young growth is easily killed. If young and strong, they all sprout after the fire has killed their trunks, but the sprouts, like most other trees under the same conditions, do not always make large or sound trees. When the killed trees decay, a scar is usually left at the base of the tree, in which rot sooner or later will begin. White oak is not as susceptibe to the rotting as red and black oaks; yet is more easily killed or injured by fire than the Spanish, black and scrub oaks. Of all the oaks the black-jack withstands the fire best. The hickories are all sensitive to fire, but if young will sprout; the white hickory possesses the best sprouting power of the hickories after being killed by fire, and trees up to 8 inches in diameter send up sprouts freely.

Chestnuts sprout freely and vigorously after being killed by fire. Owing chiefly to fire, chestnuts from sprouts have degenerated; that is, the timber begins to rot at the heart on attaining a certain age, chiefly when 40 or 45 years old, and the growth becomes somewhat stunted in general.

The effect of even light surface fires on both seedlings and coppice is disastrous, killing outright most growth from 1 to 12 feet high. The thin-barked young stems of all species are severely scorched so that they die down soon after the fire. The greatest damage is done in the periodic destruction of from 1 to 10 years' growth of seedlings and coppice. Ordinary fires often scorch older trees severely enough to check the growth or result in unsoundness at maturity.

### FIRE DESTROYS THE MANURE OF THE FOREST—THE HUMUS.

Humus, which is an accumulation of decayed matters, such as leaves and twigs which are shed by the trees and undergrowth, is one of the most important requirements of forest growth. Humus is the manure of the forest. It enriches the ground and keeps it moist. In sandy, dry regions, like South Jersey, it is of great importance. If burned, the soil dries rapidly, and forms a hard crust, preventing germination of those seeds in the ground not killed by fire. Humus makes soil, it makes binding soil more porous, and loose soil more binding. By binding the soil it prevents the important mineral materials from being washed away. It has been proven that humus has the power of absorbing moisture and holding at least four times its own weight in water, as well as preventing rapid evaporation; it has also been established that humus loses two and one-half times less water than forest soil on which humus has been burned.

To reckon the loss of humus, caused by fire, in dollars and cents, is a somewhat difficult matter, but a few figures are given to indicate the extent of damage through its destruction. On the average, there are annually added to the soil by the fall of leaves in a dense forest, from 1,800 to 4,500 pounds per acre, containing, according to kind and condition of growth and soil, from 24 to 220 pounds of mineral matter, potash, phosphoric acid, magnesia, lime, etc., and 12 to 60 pounds of nitrogen, the whole equivalent to not less than 25 cents' worth of commercial fertilizer. If, then, the fire destroys the humus the soil is impoverished and becomes dead.

While it is well known, that both a single "hot" fire, and repeated light surface fires destroy part or all of the humus, few people realize the extent of harm to the forest floor. As long as the merchantable growth is not killed outright, people look at light surface fires—destroying the humus—with indifference and even approve of the same.

### EFFECT OF FIRE ON REPRODUCTION, SUCCESSION AND COMPOSITION.

There is still another ill effect of fire, that is, the serious injury to the reproduction, succession and composition of the forest.

Forest areas, repeatedly burned over, will finally have a growth consisting almost entirely of sprouts, and of these only the hardiest will attain tree size. Moreover, these are often of inferior kinds. By this it is not meant that no pine or hardwood seedlings whatever, will be found on such areas, but they are scattered about in clusters and are of poorer quality.

It is often due to fire that the hardier and less valuable oaks take the place of pine, also that black oak takes the place of the more valuable white oak and hickory.

### FIRE INVITES INSECTS AND ROT.

Fires scorch spots near the bases of trees and cause the death of the generative tissue. The bark over the spot then becomes loosened, or falls off, and the tree presents on its surface a layer of dead sapwood. The sapwood of most trees is then subject to the attacks of insects, borers and beetles. If the bark is merely loosened, insects will quickly enter the spot and will bore sometimes into the heart-wood. Through these openings air and water enter, and decay begins. In this way the entire interior of the base of the tree may become hollow, while the bark, remaining intact, exhibits no signs of the rottenness which is within. If the bark falls off immediately from the burned spots, the dead sapwood is then directly exposed to rot, and fungi, in the shape of punk or mushroom-like excrescences, grow upon it. The final result is that the storms blow down these trees, even such whose trunks above the rotten spot are perfectly sound.

### OTHER ILL EFFECTS OF FIRE.

Fires discourage land owners in the improved handling of their woodland; they discourage owners of barren land in tree planting. When fire has killed trees, particularly on larger tracts, people seem to regard the dead wood as public property, so that theft is encouraged. Where fire frequently occurs it tends to depopulate and impoverish those sections and destroys the game.

## FOREST FIRE LEGISLATION IN VARIOUS STATES.

Several States have enacted forest fire legislation, notably New York, Pennsylvania, Minnesota, Wisconsin, Maine, New Hampshire.

New York appoints a fire warden for each town in counties having State land. The State pays one half and the county the other half for the fire warden's service. The chief fire warden is a State officer.

Pennsylvania makes the constables fire wardens, the State paying one half and the towns the other half of their expenses.

In Minnesota the town supervisors are fire wardens. These wardens receive $2.00 per day for services, not exceeding 15 days in the year. The State pays one third and the county one third of the expenses.

The other States having forest fire laws have followed, with some modifications, the examples of New York and Minnesota.

[In New Jersey the townships have power to appoint a fire marshal and appropriate money for fighting fires. The State doubles the sum appropriated by the township, up to $100 for the township and $200 for the State, so that there is $300 available for preventing and extinguishing forest fires in such townships as have accepted the provisions of the law. The New Jersey law also provides for an investigation, by justices of the peace, of the origin of fires upon application by ten freeholders, and for punishing violations of its sections regarding burning brush, grass, etc.* At the present time, however, only three townships have accepted the provisions of the law.—H. B. K.]

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* For a fuller statement regarding the law, see the Administrative report.

FOREST FIRE STATISTICS OF FOREIGN COUNTRIES.

Prussia, with 7,000,000 acres of State forest, has had an annual average destruction by fire in the last twenty-five years of 1,400 acres, or .02%, or about one acre in 4,500. Over 50% of this total area is stocked with pine on sandy plains. The number of yearly fires vary from 15 to 250, but they are promptly extinguished, as is evident from the small extent of the burned area.

Bavaria has over 2,000,000 acres of State forest, 75% of which is coniferous. The number of yearly forest fires vary from 2 to 80, with an average yearly burned-over area of about 200 acres, or one acre in about 13,000, causing a loss of about $1,200.00. The principal causes are carelessness of excursion parties.

Compare this record with New Jersey, which has about the same extent of forest land. Here there were, last year, 79 fires, which burned 85,046 acres, with a direct loss to the timber of $305,744.00.

On 3,800,000 acres of State and Fund forest of Austria, 75% conifers, the yearly average for the last ten years is 510 fires, burning over 3,500 acres, 60% of these fires being caused by carelessness.

Saxony suffers hardly any loss from forest fires on its one half million acres of State forest, and the damage is rarely more than $300.00 per acre per year. Spruce is the prevailing tree. The causes of the fires are chiefly carelessness of pipe and cigar smokers.

On its 800,000 acres of chiefly coniferous State forest the Duchy of Baden has on an average yearly 60 forest fires, damaging not more than 100 acres, the principal causes being negligence of smokers.

The yearly average loss by forest fires in the kingdom of Würtemberg on over 400,000 State forest, stocked with 40% broad-leaved trees and 60% coniferous trees, amounts to $600.00. Smokers are the principal causes of the fires.

The average annual forest fires in Hessen-Darmstad on 165,000 acres of State forest, stocked with 60% broad-leaved and 40%

coniferous trees, do not run over more than 45 acres, the average number being 50 fires. Again the principal cause is carelessness of smokers.

Damage on the 140,000 acres of State forest of Denmark, 50% conifers, is very slight; general carelessness is the cause of the fires, with an occasional fire set by railroad locomotives.

In German forests the forest is divided into compartments; each compartment being surrounded by fire lines 8 to 40 rods wide. These fire lines are patroled and kept free from inflammable material by annual burnings or by sowing to grass, the purpose being to confine the fire within the compartment and to furnish a base from which to fight it. Private forest owners in Germany have the right to call out assistance to fight forest fires, which assistance is obligatory to every citizen.

In India measures have been taken to protect 28,000 square miles of State forest with success. Here the grass is frequently from 6 feet to 8 feet high, and in addition the leaves of many Indian trees, such as the teak and the sál, fall in the early spring, and when dry are very inflammable. It is a most dangerous forest, and yet the Indian forest department fights these fires, and succeeds in a measure. The fire lines here are often 400 feet wide.

There are fire insurance companies in Germany which insure forest properties according to age, species and local danger. The fire insurance value of young stands is calculated by a discount with a 5% interest rate on the final harvest value; for mature stands the actual present value is supposed to persist for ten years. The premiums based for each $1,000.00 insurance value are in the average:

| | |
|---|---|
| For broad-leaved forests, | $0.85 |
| For mixed conifer and broad-leaved forest, | 1.20 |
| For conifer pure, | 2.00 |

The minimum rate is 45 cents, the maximum $4.00 per $1,000.00 value.

In Belgium there are many small private forest owners, and insurance against damage to forests by fire can be effected at reasonable rates:

60 cents per $1,000.00 for broad leaved woods.
$5.50 per $1,000.00 for conifers under 20 years old.
$4.75 per $1,000.00 for conifers over 20 years old.

The above statistics are of countries which have taken practical measures toward forest protection. The statistics show that while the number of fires in some countries is great, the extent of damage is small owing to effective measures to extinguish them promptly.

## RECOMMENDATIONS.

The members of the State Geological Survey, who have studied the question of forest fires in New Jersey, have repeatedly called attention to the need of State action if the forests are to be preserved. The following recommendations do not differ essentially from those made in previous years, but are repeated to emphasize the necessity of some action.

1. The appointment of a State forester, who would also be chief fire warden, whose duty should be to control all fire wardens, instruct them, and to respond to larger fires; to give advice to owners of forest land as to the protection and best handling of their woodlands, as to tree planting, etc.; he should make forest investigations, and arouse a general interest throughout the State in all matters pertaining to forests and forestry.

2. The appointment of twenty wardens of the first class at $60.00 a year each. They should be so distributed that each should direct four second-class wardens. Their duty would be to repair at once to each fire in their district, and to take charge of the efforts to extinguish it. They should have power to call in other help in case of necessity.

3. Eighty second-class fire wardens, each warden to have fire charge of 15,000 acres; the wardens to receive $25.00 per year each. These wardens should be required to make daily observations for signs of fire and to repair at once to all fires within his limit. These limits should overlap so that several wardens would go to each fire. Power should be given the forest service to enter into agreements with townships for clearing or burning away

the brush along roads leading through woods, thus widening them to act as fire lines.

The suggestions as to fire wardens are for the pineries in South Jersey, some 1,200,000 acres. For the mountain lands in the upper part of the State it would suffice to make town constables fire wardens.

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## Description of the Fires of 1903.

The following notes are from data collected by a personal visit to each tract and careful observations on the amount of damage caused. So far as possible the cause of each fire was learned and also the efforts made to extinguish it. The fires are numbered to assist in their accurate location on the accompanying map, Plate X.

### ATLANTIC COUNTY.

1. May 1st, 1903. A man burning brush started a fire near Oakville, Weymouth township, which burned 2,400 acres of pine and oak. 1,000 acres were covered with a promising growth of pine, 500 with scattered pine and oak, while 900 acres were partly brush land with clusters of pine and oak. The average age was 18 years. All the young growth was killed, and the old trees badly injured. The fire was fought by six men with some success. Average loss, $1.50 per acre; total, $3,600.

2. April 28th, 1903. A man burning brush around a cranberry bog started by a fire one half mile southeast of Doughty Tavern, which burned to South River and to Grassy pond, being two miles long and four miles wide and covering about 5,000 acres. The timber was from 10 to 35 years old; 75 per cent. being pine and 25 per cent. oak. Seven hundred acres were barren land, but 2,000 acres of thrifty pine mostly from seed was killed. All the oak both young and old was killed, while 60 per cent. of the pine over 30 years was injured and 40 per cent. under 30 years was killed. Men from Mays Landing and Weymouth, under the direction of Pennington Taylor, an old woods-


GEOLOGICAL SURVEY OF NEW JERSEY
A MAP OF
NEW JERSEY
SHOWING
THE EXTENT OF THE
FOREST FIRES
DURING 1903.
Scale of Miles
5 10 15
PENNSYLVANIA
NEW YORK
LONG I.
ATLANTIC OCEAN
DELAWARE BAY
DELAWARE
Water Gap
Belvidere
Phillipsburg
Easton
High Bridge
Clinton
Frenchtown
Flemington
Lambertville
Pennington
Princeton
TRENTON
Bordentown
Chester
Peapack
Morristown
Orange
Newark
Summit
Elizabeth
Somerville
New Brunswick
Jamesburg
Hightstown
Freehold
Long Branch
Lakewood
Manchester
Point Pleasant
Barnegat City
Beach Haven
Atlantic City
Sea Isle City
Port Norris
Greenwich
Salem
Pennsgrove
Wilmington
Chester
Philadelphia
Camden
Medford
Shamong
Boonton
Pompton
Paterson
Englewood
Hackensack
Hoboken
New York
Caldwell
Decker Town
Ringwood
Sandy Hook
RARITAN BAY
STATEN I.
Keyport

man eighty years old, fought the fire by backfiring with some success, but no efforts were made to extinguish it until after 4,000 acres had been burned over. Average loss, $2.00 per acre; total damage, $10,000.

3. May 3d, 1903. In clearing land a fire was started one mile east of Richland, and burned 500 acres of pine and oak from 5 to 10 years old, with 25 acres of pine 25 years old. Of the young pine and oak, 80 per cent. was killed, the balance badly injured. The older pines were partly killed and partly injured. In addition a house and barn were burned, the value of which are not included in this estimate. No effort was made to check the fire except where the farm buildings were threatened. Average loss, $3.00 per acre; total, $1,500.

4. April 30th, 1903. Sparks from a locomotive started a fire at Hammonton, which burned southeast towards Weymouth covering 1,500 acres. Eighty-five per cent. of the timber was pine, 10 to 18 years' growth, the balance various kinds of oaks with some young white cedar 12 years of age. The timber was, on the whole, very promising, a great part being seedlings and not sprouts. Ninety per cent. of all the growth was killed outright. Hammonton was for a time threatened, and several buildings were burned which are not included in this estimate. The fire was fought by railroad section men after a greater portion of the area had been burned over. Average loss, $2.75 per acre; total damage, $4,125.

5. April 28th, 1903. A locomotive started a fire south of Elwood station, which burned to Mays Landing, a distance of nine miles, sweeping over 10,000 acres, 8,000 of which was covered with small pine and oak, 5 to 15 years old, chiefly sprouts. Fifteen hundred acres were more or less barren as a result of former fires, and 500 acres were good pine and oak from 25 to 50 years old. Sixty per cent. of the growth was destroyed, 20 per cent. badly injured and perhaps 20 per cent. more or less scorched. White cedars near Weymouth were killed. The fire was fought by railroad section men and farmers with but little success, since the temperature was in the neighborhood of ninety degrees, and the wind blew a gale of 20 miles an hour. Two backfires were set but with poor results, owing to lack of efficient leadership. Average loss, $4.50 per acre; total, $45,000.

6. May 10th, 1903. Another fire due to a locomotive started at Elwood station and burned easterly toward Weekstown over a section four miles long and a mile wide, 2,500 acres. Timber was mostly pine, averaging 15 years old, 90 per cent. of which was killed. The oaks were all killed. The fire was fought by railroad section men and some farmers to protect buildings. Average loss, $2.00 per acre; total, $5,000.

7. May 9th, 1903. In burning turf on a cranberry bog, a fire was started between Weekstown and Mullica pond near Greenbank, which burned 1,900 of pitch pine, white, red and black oak, with some white cedar 8 to 24 years old. 1,100 acres of this area was burned eight years ago. Sixty per cent. of the growth was killed, 30 per cent. badly injured, 10 per cent. scorched. The fire was fought by men in the employ of Joseph Wharton with shovels and sand and by backfiring. Average loss, $2.50 per acre; total, $4,750.

8. May 1st, 1903. A locomotive started a fire at Brigantine Junction which burned south toward McKee City, sweeping over 600 acres, 200 of which were pine 15 years old of poor quality, while 400 acres were more or less barren. It was fought by railroad men soon after it started, but their efforts were handicapped by a heavy wind. It was finally extinguished with shovels and sand. Average loss over 200 acres, $2.50 per acre; total, $500.

9. In April, smokers started a fire about one-half mile east of McKee City station, which burned 25 acres of good pitch pine, 20 years' growth, 50 per cent. of which was killed and the balance badly injured. The fire burned itself out, no effort being made to extinguish it. Average loss, $5.00 per acre; total, $125.

10. In April, a locomotive set fire to the timber near the head of Gravelly run and burned 150 acres, mostly pine barrens, with perhaps 20 acres of good pine and oak 8 years old, which was killed. Loss, $75.

11. May 2d, 1903. A fire, due to a locomotive, burned 125 acres of good oak and pine, 10 years of age, east of Landisville station. Ninety per cent. was killed, no effort being made to extinguish the fire. The same tract was burned eleven years ago. Loss, $4.25 per acre; total, $530.

BURLINGTON COUNTY.

12. April 27th, 1903. A farmer burning brush started a fire near Atco, which burned to Waterford and thence to Atsion, Taunton and nearly to Medford, a strip 10 miles long and 4 miles wide, including 21,000 acres. Fifty per cent. of the total area had a fine growth of pine and oak from 15 to 25 years old, in which there had been no fire for the past 25 years. Ten per cent. was barren and 40 per cent. young and scattered growth of pine and oak. It was a "hot fire," destroying all growth, including two cedar swamps and two cranberry bogs. Several houses and barns were burned and the roof of a church damaged. Although most of the burned tract is in Burlington county, the fire started in Camden. It was fought by fifteen men in the employ of Joseph Wharton, with shovel and sand. Other parties started backfires, which did more harm than good, owing to the poor judgment shown in locating them. Damage per acre ranged from $0.10 to $25.00; average, $5.00; total, $105,000.

13. April 21st, 1903. A locomotive started a fire one and one-half miles northeast of Atsion, between that place and Harris station. It burned 250 acres, 80 per cent. pine, 20 per cent. oak, ranging from 10 to 40 years old, all of which was killed, including 10 acres of short-leafed pine, 40 years old. It was fought by railroad section men with success. Average loss, $3.25 per acre; total, $812.

14. During the last week of June, a fire was accidentally started a mile east of Browns Mills and burned 100 acres of pine and oak, 65 per cent. of which was from seed, and very promising. Thirty per cent. was pine barren, the balance of the area being covered with scattered pines. The timber varied from 10 to 25 years old. The pines were killed and the oaks severely injured. It was fought with shovels and sand with success. Average loss, $2.00 per acre; total, $200.

15. April, 1903. Another fire, origin unknown, burned 75 acres, a mile northeast of Browns Mills. The timber was pine and oak, four years' growth. The tract was burned four years

aog. The fire burned itself out. Average loss, $0.50 per acre; total, $37.

16. April, 1903. Another fire, of incendiary origin, started three miles northeast of Browns Mills and destroyed 90 acres of timber, 65 per cent. of which was promising pine and oak from seed, 10 to 25 years old. The young pines were killed and the old oaks badly injured, but not killed. Thirty-five per cent. of the area was barren. No effort was made to extinguish the fire. Average loss, $3.00 per acre; total, $270.

17. May, 1903. A locomotive along the line of the Pemberton and Hightstown railroad near Cookstown started a fire which burned 10 acres. The tract had various kinds of hard wood, principally oak and chestnut from 5 to 10 years old, not very promising growth, since it had been burned two years ago. Six hundred chestnut rails were also destroyed. The fire was extinguished by section men with shovels. Value of the chestnut rails, $75.

18. May 6th, 1903. A fire was started two miles south of Chatsworth, between that point and Speedwell, in burning brush at a cranberry bog. Four hundred acres of pine and oak, 8 to 20 years old, was burned, 85 per cent. being killed. One and one-half acres of 10 year old white cedar were also killed. This tract was partly burned in 1895. Men in the employ of Joseph Wharton started backfires with good success. The fire burned three days before being extinguished. Average loss, $2.50 per acre; total, $1,000.

### CUMBERLAND COUNTY.

19. April 28th, 1903. A man burning brush started a fire in the southern part of Landis township, which burned 5,000 acres, most of which were pine, with some oak, from 10 to 18 years old. Seventy-five per cent. was killed, as well as two acres of cedar. Of the 5,000 acres, 800 were pine barren. The fire was fought by backfiring under the leadership of the township fire marshal. Average loss, $2.00 per acre; total, $10,000.

20. May 1st, 1903. A fire, started by burning brush, occurred two miles west of Mauricetown, in Commercial township, which

burned 100 acres of oak and pine, 10 to 30 years' growth. The oaks were all killed. This tract was also burned 30 years ago. Twenty-five acres of very good yellow pine, from seed, 30 years old were badly injured. The fire was fought by backfiring with good success, 1,000 cords of wood being saved by prompt action. Average loss, $6.50 per acre; total, $650.00.

21. May 7th, 1903. A fire, origin unknown, started four miles west of Millville, burning 300 acres of pine and oak, 10 to 30 years' growth, some of which was of promising growth, some barren. Some of the timber was entirely killed, some partly killed. The fire was fought by backfiring with success. Average loss, $3.00 per acre; total, $900.

22. April 12th, 1903. A little east of Gouldtown, a fire, set by burning brush, burned 500 acres of pine and oak, from 8 to 25 years old. The oaks were killed and pines badly injured. The fire was fought under the leadership of the township fire marshal. Average loss, $1.75; total, $875.00.

23. April 22d, 1903. Two and one-half miles northwest of Millville a fire was started by burning brush. It burned 150 acres of pine and oak, 10 to 30 years old, some of which was entirely killed and some partly injured. Parts of the area were promising growth; 10 acres were barren land. Fire was fought by township fire marshal. Average loss, $3.00; total, $450.00.

24. April 6th, 1903. Southwest of Vineland, on the east side of Maurice river, north of the dam, burning brush set fire to 1,000 acres of pine and oak, 6 to 30 years old. All of the oaks were killed, as were also 60 per cent. of pines over 20 years old and 90 per cent. of pines under 20 years. Part of a cedar swamp was also burned. No real efforts were made toward extinguishing the fire. Average loss per acre, $2.00; total, $2,000.

25. April 18th, 1903. School children picking wild flowers south of Rosenhayn, set fire to 1,000 acres of oak and pine, somewhat scattered, from 8 to 20 years old, which were mostly killed. Two hundred and fifty acres of the 1,000 were barren land. The fire was fought by the township fire marshal. Average loss per acre, $2.00; total, $2,000.

26. April 30th, 1903. Southwest of Rosenhayn an incendiary fire mostly killed 200 acres of scattered oak and pine from 8 to

20 years old. This fire was fought under the leadership of the township fire marshal. Average loss, $2.00 per acre; total, $400.

27. April 29th, 1903. Locomotive sparks started a fire northeast of Vineland, which burned 15 acres of pine and oak, 4 to 35 years' growth. The oak and younger pines were killed. The township fire marshal fought the fire. Average loss, $4.50 per acre; total, $67.00.

### CAPE MAY COUNTY.

28. April 10th to 20th, 1903. A fire, started by burning brush, occurred one-half mile from Woodbine, running northwest to Belle Plain and south to East creek, burning 2,000 acres, 1,200 acres of which were good pine and oak, and 800 acres partly barren, partly covered with poor pines and oaks. All the oak was killed, and some of the pines were badly injured, and some partly killed. Moreover, 500 cords of cord wood valued at $2.00 per cord were burned. The fire was fought by backfiring, but not until it had burned eight days. Loss, from $1.00 to $10.00 per acre, average, $5.00; total, $10,000. Total damage to cord wood, $1,000.

29. April, 1903. Two miles south of Woodbine, a fire, started by burning grass, burned 400 acres of good oak and pine timber, 10 to 40 years old, which were entirely killed. In addition, 300 cords of wood worth $2.75 per cord were burned. Average loss, $3.00 per acre; total, $1,200. Loss of cord wood, $825.

30. April, 1903. At Woodbine, a fire, started by a locomotive, burned 120 acres of pine and oak of good growth, 10 to 40 years old. Sixty per cent. of pines, and all oaks were killed. A part of this tract was burned 10 years ago. The fire was fought by backfiring with success. Average loss, $3.00 per acre; total, $360.

31. April, 1903. Two miles from Woodbine, between Woodbine and Tuckahoe, a locomotive set fire to 200 acres of good growth pine and oak, 10 to 40 years old. Sixty per cent. of pines, and all the oaks were killed. Part of this area was burned

10 years ago. The fire was fought by backfiring. Average loss, $3.00 per acre; total, $600.

### CAMDEN COUNTY.

32. June, 1903. On the west side of Chiselhurst, a fire, origin unknown, burned seven acres of white and red oak, 50 years old, killing a very fine growth of timber. No effort was made to extinguish the fire. Average loss, $60.00 per acre; total, $420.

The fire, No. 12, in Burlington county, originated in Camden county, near Atco.

### GLOUCESTER COUNTY.

33. April, 1903. Near Robanna, a locomotive set fire to 300 acres of very thrifty oak and pine, 10 to 20 years old, which were totally destroyed. This area had never been burned before. No efforts were made to extinguish the fire. Average loss, $3.75 per acre; total, $1,125.

34. April, 1903. Burning grass started a fire west of Broad Lane which burned 60 acres of oak and pine. Eighty per cent. of the oak, 12 to 24 years' growth, was killed, and 20 cords of wood worth $2.00 per cord, destroyed. This area was never burned before this fire. The fire was extinguished by beating it out with brush. Average loss, $4.00 per acre; total, $240. Total damage cord wood, $40.

35. April, 1903. A fire north of Cecil, caused by burning brush, burned 50 acres of oak and pine averaging 18 years old, and 10 cords of cord wood at $1.75. Seventy-five per cent. of the oak was killed. No effort was made to extinguish the fire. Average loss, $2.75 per acre; total, $137. Total damage to cord wood, $17.00.

36. April, 1903. Forty-five acres of oak and pine of 15 years' growth were badly injured, but not killed, by a fire west of Cecil, caused by burning grass. No efforts were made to extinguish this fire. Average loss, $1.00 per acre; total, $45.00.

37. May, 1903. Between Clayton and Janvier, near Scotland run, a fire, started by some unknown cause, burned and killed 400 acres of oaks and scattered pines of very thrifty growth. A part of this area was burned over one year ago (April, 1902). No efforts were made to extinguish the fire. Average loss, $3.00 per acre; total, $1,200.

38. April, 1903. A fire near Downer, of incendiary origin, burned and killed 200 acres of old oaks, 38 years old. The fire was fought by backfiring. Average loss, $6.50 per acre; total, $1,300.

### MONMOUTH COUNTY.

39. June, 1903. Four miles west of Belmar, a fire set by smokers burned 550 acres, mainly oak with some scattered pine. Forty acres of fine oak 60 years old were badly injured; 45 acres of thrifty oak 40 years old partly killed, and the young oak and pine were killed. About 80 acres were burned over four years ago. The fire was fought with success by backfiring and plowing furrows to act as a fire lane. Average loss, $7.00 per acre; total, $3,850.

40. June 4th, 1903. At South Eatontown, a fire, started by tramps, burned and killed eight acres of oak and pine, two years old. This tract was burned over two years ago. The fire was beaten out with brush. Average loss, $0.50 per acre; total, $4.00.

### MORRIS COUNTY.

41. May, 1903. One-half mile north of Mt. Freedom, southeast of Youngstown, a fire, cause unknown, burned and badly injured 1,000 acres of chestnut, oak and hickory. Two hundred acres of chestnut from 25 to 60 years of age were killed. This tract had never been burned over before. An effort was made to extinguish the fire, with but little success. Average loss, $4.00 per acre; total, $4,000.

42. October, 1903. Sparks from a locomotive started a fire near Tabor, which burned and partly injured 10 acres of chestnut

and oak, 40 years old. The fire was extinguished by railroad section men. Average loss, $1.00 per acre; total, $10.00.

43. October, 1903. Another fire near Tabor, due to a locomotive, burned 15 acres of chestnut and oak, 40 years old, which were injured but not killed. This fire was also extinguished by railroad section men. Average loss, $0.75 per acre; total $11.00.

44. June, 1903. A tramp started a fire west of Dover, which burned 350 acres, mainly oak and chestnut, 40 years old, and killed 40 per cent. No efforts were made to extinguish the fire. Average loss, $4.50 per acre; total, $1,575.

45. During the first week in July, a fire, started by smokers, occurred two and one-half miles north of Rockaway, west of Beach Glen, which burned 150 acres of 20 year old growth of oak and chestnut, 20 per cent. of the most promising growth being killed. The fire was fought by backfiring with good results. Average loss, $4.00 per acre; total, $600.00.

46. During the first week in July a fire started intentionally occurred one mile east of Hibernia, and burned 175 acres of oak and chestnut sprouts of 30 years' growth. Ten per cent. was killed and the balance more or less injured. The fire was fought by backfiring. Average, $3.75 per acre; total, $656.00.

47. May 21st, 1903. South of Denmark pond, between the pond and railroad, a fire, due to a locomotive, burned 450 acres, mainly of oak and chestnut, from 10 to 60 years' growth. The young growth was destroyed, and 70 acres of good-sized oak were partly killed. No efforts, as for as known, were made to extinguish the fire. Average loss, $6.00 per acre; total, $2,700.

48. May, 1903. East of the road from Oak Ridge to Petersburg, at the intersection of the Oak Ridge-Petersburg and Oak Ridge-Green Pond road, fire set by smokers burned and slightly injured 225 acres of good heavy chestnut. No efforts were made to extinguish the fire except to save buildings. Average loss, $0.75 per acre; total, $169.00.

49. May 18th, 1903. One and one-half miles southwest of Newfoundland, a fire, started by campers, burned 1,200 acres of oak and chestnut, 20 to 40 years old, killing 80 per cent. The fire started on the top of the mountain and burned very rapidly. One farmer fought the fire to protect his buildings, and a force

of 10 men started out from Newfoundland, but seeing that their woods were safe, returned home before reaching the fire. Average loss, $5.50 per acre; total, $6,600.

50. May 7th, 1903. One mile south of Charlottesburg, on the road from Charlottesburg to Split Rock pond, a fire, cause unknown, burned 950 acres, mainly oak and chestnut. Four hundred acres were from 2 to 20 years' growth; 200 acres from 20 to 40 years; 200 acres from 40 to 50 years; the balance being old oak of great value. Forty per cent. of the total growth were killed. The fire was fought by backfiring, but not until after it had been burning three days. Average loss, $8.00 per acre; total, $7,600.00.

OCEAN COUNTY.

51. During the last week in April, a fire, started by school children picking wild flowers, occurred one and one-half miles north of New Prospect, which burned 400 acres, mainly of pine, from 8 to 19 years old. Seventy-five per cent. of the timber were killed, no effort being made to extinguish the fire. Average loss, $1.75 per acre; total, $700.00.

52. May, 1903. Southwest of Burkville, smokers started a fire, which burned 800 acres of pine and some oak of good growth, from 10 to 25 years old. Ninety per cent. of the pine was killed, and the oak was entirely killed. The fire was fought unsuccessfully by backfiring. Average loss, $2.25 per acre; total, $1,800 dollars.

53. May, 1903. A charcoal burner started a fire northeast of Cassville, which burned 2,000 acres of pine and oak, averaging 15 years old growth. The timber was mostly all killed. No effort was made to extinguish the fire. Average loss, $2.00 per acre; total, $4,000.00.

54. April 30th, 1903. East of Whitings, near Keswick Colony, a fire, started by smokers, swept over a territory 5 by 10 miles, burning 5,500 acres of pine from 10 to 30 years old, and killing all the young pines. Pines over 25 years old were injured and the oaks were killed. Two cedar swamps with cedar 18 and 10 years were also killed. Some parts of this area had not been burned in

30 years. The fire was fought at Whitings and Lakehurst. The first day, with the wind westerly, the fire covered five miles, the second day, with the wind easterly, it covered five more miles, coming within one mile of Lakehurst. Average loss, $2.00 per acre; total, $11,000.

55. March 27th, 1903. One and one-half miles southwest of Whitings, between Whitings and Wheatland, a fire, caused by a locomotive, burned 250 acres of pine and oak from 8 to 25 years old. The oaks were killed, as were also 60 per cent. of the pines. The fire was fought by railroad section men with success. Average loss, $2.00 per acre; total, $500.00.

56. April 18th, 1903. Near Wheatland, sparks from a locomotive set fire to 75 acres of poor pine and oak, which were killed. No effort was made to extinguish the fire. Average loss, $0.75 per acre; total, $56.00.

57. April 24th, 1903. One-half mile south of Forked River, burning brush set fire to and destroyed two acres of 12 year old oaks. One house was also burned. No effort was made to fight the fire. Total loss, $10.00.

58. April 24th, 1903. At "Wells Mills," southwest of Forked River, a fire, caused by burning brush, burned and killed 50 acres of pine and oak averaging 18 years old. No efforts were made to extinguish the fire. Average loss, $2.50 per acre; total, $125.00.

59. April 29th, 1903. At the north edge of Barnegat, locomotive sparks set fire to six acres of pine, oak and maple of good growth, 30 years old. The timber was killed. The fire was fought by railroad men soon after it started. Average loss, $5.00 per acre; total, $30.00.

60. May 2d, 1903. A fire occurred at Tuckerton, west of Tuckerton mill-branch, caused by burning brush. It covered 40 acres of pine, oak and some cedar from 6 to 20 years' growth, which was killed. This tract was slightly burned in 1894. The fire was fought with shovel and sand. Total damage, $30.00.

### PASSAIC COUNTY.

61. May, 1903. Boys playing with matches started a fire three-fourths of a mile east of Charlottesburg station on the road

to Butler. Three hundred acres of very thrifty oak and chestnut, 30 years old, were badly injured. The fire was fought with brush. Average loss, $1.50 per acre; total, $450.00.

62. May, 1903. A fire, caused by a locomotive, started between Oak Ridge and Stockholm and extended toward Dunker pond. It burned and killed 70 acres of chestnut and oak of five years' growth. No efforts were made to extinguish it. Average loss, $0.75; total, $52.00.

63. May, 1903. Between Monks and Hewitt, sparks from a locomotive set fire to 15 acres of 25 year old chestnut and oak, killing 80 per cent. No effort was made to extinguish the fire. Average loss, $4.00 per acre; total, $60.00.

64. April, 1903. South of Hewitt, a locomotive started a fire which burned 20 acres of chestnut and oak, 30 years old. Sixty per cent. were killed and the balance badly injured. No effort was made to fight the fire. Average loss, $3.50 per acre; total, $70.00.

65. May 3d, 1903. Southeast of Negro pond, tramps set fire to 700 acres of chestnut and oak from 10 to 70 years old, killing 40 per cent. One hundred acres of good chestnut 55 years old were also killed. Some effort was made to extinguish the fire, but without success. Average loss, $4.00 per acre; total, $2,800.

## SOMERSET COUNTY.

66. March, 1903. Two and one-half miles northeast of Somerville, boys set fire to 120 acres of oak and chestnut, 10 years old, which were badly injured. A grove of red cedar was killed. The fire was beaten out with young cedar trees. Average loss, $1.50 per acre; total, $180.00.

## SALEM COUNTY.

67. April 23d, 1903. One-half a mile east of Elmer, a fire, started by burning brush, burned 1,600 acres. One thousand acres of young oak and chestnut of promising growth, 2 to 12 years old, were killed, and 600 acres badly injured. Two hun-

dred cords of cord wood worth $2.00 per cord were burned in the woods. The fire was fought by backfiring. Loss on cord wood, $400. Average loss per acre, on standing timber, $3.50; total, $5,600.

68. April 30th, 1903. Between Elmer and Palantine station, a fire, due to a locomotive, burned 40 acres of oak and chestnut from 8 to 38 years old. The young growth was killed, and the older trees injured. This tract was burned in 1865. No efforts were made to extinguish the fire. Average loss, $7.00 per acre; total, $280.

69. May 3d, 1903. Two miles southeast of Alloway, at "Pine Branch," a fire, started by children picking flowers, burned over 300 acres. One hundred and fifty acres of very promising oak and chestnut, 25 years old, and 150 acres of brush land were injured. No effort was made to fight the fire, it being extinguished by rain on May 4th. Average loss, $5.00 on 150 acres; total, $750.

70. May 10th, 1903. Near Alloway, 100 acres of promising oak and chestnut, 20 years old, were injured by a fire started by children picking flowers. No effort was made to extinguish the fire. Average loss, $4.00 per acre; total, $400.

## SUSSEX COUNTY.

71. April, 1903. A fire, lasting 15 days, caused by burning brush, burned over 5,000 acres in Montague, Sandyston and Wantage townships. The timber was mainly oak and chestnut, 20 to 30 years old. A quantity of fences was also destroyed. A little part was burned in 1894 and 1902. The fire was fought by a force of men who worked three days and three nights carrying water from Lake Mashipacong. They succeeded in saving buildings. Near Coleville it was fought by backfiring with success. Average loss, $2.00 per acre; total, $10,000.

72. May, 1903. Near Franklin Furnace, a fire, cause unknown, burned 100 acres of oak and chestnut of good growth, 35 years old. Fifty per cent. were killed. Average loss, $4.75 per acre; total, $475.

73. May, 1903. Sparks from a locomotive started a fire near Losee pond, south of the railroad, which burned over 800 acres. Two hundred and seventy-five acres of oak and chestnut, 15 years old, were killed; of 300 acres of oak and chestnut, 25 years old, 75 per cent. were killed; 50 acres brush land and 100 acres old oak and chestnut, 60 to 100 years old, were injured. Seventy-five acres were barren land. No efforts were made to extinguish the fire. Average loss, $6.00; total, $4,800.

74. May, 1903. Near Two Bridges, a fire, due to a locomotive, burned 700 acres, mainly oak and chestnut, 15 to 35 years' growth, 35 per cent. of which were killed. The fire was fought by railroad section men. Average loss, $2.00 per acre; total, $1,400.

75. During the first week in May, a fire, started by a locomotive, occurred north of Ford on both sides of the county line and both sides of the railroad, burning into Morris county. It burned 1,200 acres of oak and chestnut 5 to 15 years old, 95 per cent. of the growth being killed. This area was never burned over before this. No efforts were made to put the fire out. Average loss, $8.00 per acre; total, $9,600.

76. May, 1903. A fire, of unknown origin, started at White Hall, south of Andover, burning toward Waterloo. Seven hundred and fifty acres of chestnut and oak, averaging 25 years old, were burned, killing 60 per cent. Very little effort was made to extinguish the fire. Average loss, $3.00 per acre; total, $2,250.

77. May, 1903. Near Sparta Junction, a fire, due to a locomotive, occurred in the early part of May. Two hundred acres of promising oak and chestnut, with an average growth of 25 years, were burned, of which 80 per cent. were killed. No fire had ever occurred on the tract before, and no effort was made to extinguish this. Average loss, $7.00 per acre; total, $1,400.

78. May, 1903. Near Morris pond, smokers set fire to 150 acres of chestnut and oak, 15 years old. Eighty per cent. were killed, no effort being made to extinguish it. Average loss, $2.00 per acre; total, $300.

### UNION COUNTY.

79. May, 1903. During the latter part of May, tramps started a fire west of Linden, on Morses creek, which burned three acres of scrubby oak of but little value. The fire burned itself out. Average loss, $0.50 per acre; total, $1.50.

### CAUSES OF FIRES.

| | |
|---|---|
| Railroad locomotives, | 26 |
| Farmers burning brush, grass, clearing land and burning turf on cranberry bogs, | 21 |
| Unknown, | 8 |
| Smokers, | 7 |
| Children picking wild flowers and boys playing with matches, | 6 |
| Tramps, | 4 |
| Incendiary, | 3 |
| Feeble-minded person, | 1 |
| Charcoal burners, | 1 |
| Campers, | 1 |
| Accidental, | 1 |

A summary by counties is as follows:

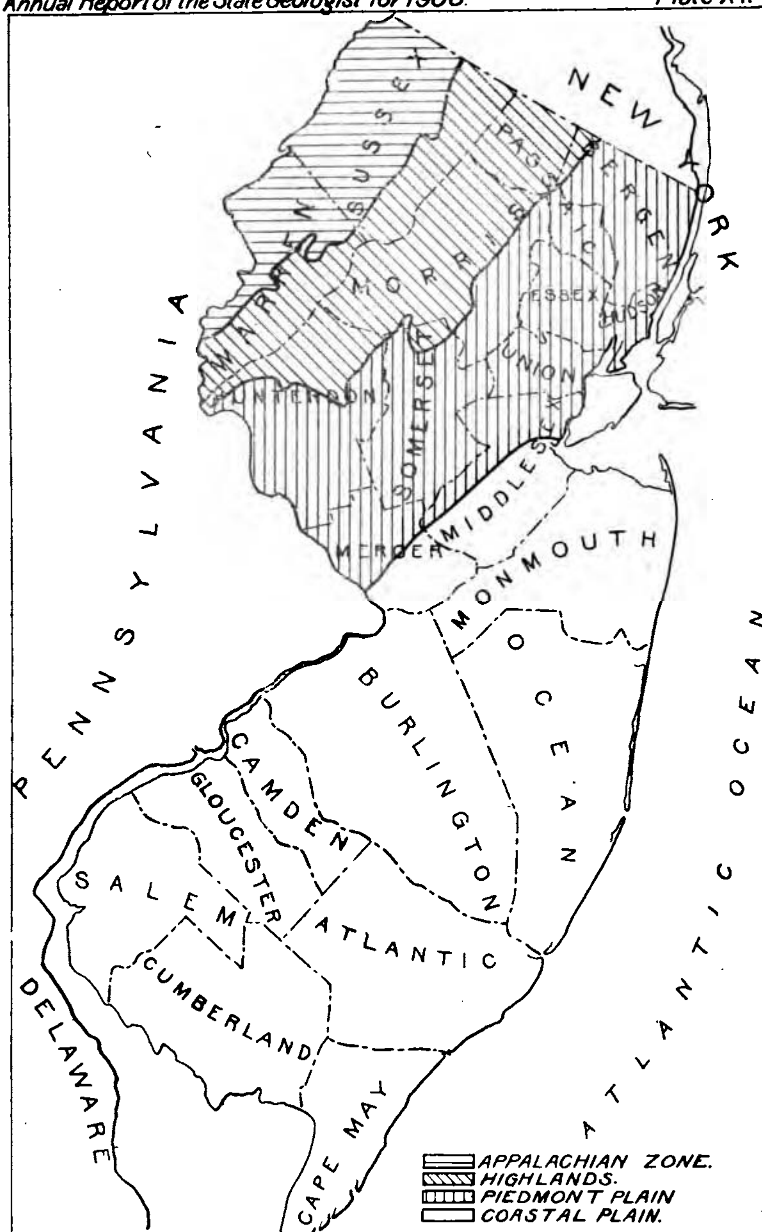
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Atlantic, | 11 | fires, | 24,700 | acres | burned | over; | damage, | $75,205 | 00 |
| Burlington, | 7 | " | 21,925 | " | " | " | " | 107,394 | 00 |
| Cumberland, | 9 | " | 8,265 | " | " | " | " | 17,342 | 00 |
| Cape May, | 4 | " | 2,720 | " | " | " | " | 13,985 | 00 |
| Camden, | 1* | " | 7 | " | " | " | " | 420 | 00 |
| Gloucester, | 6 | " | 1,055 | " | " | " | " | 4,104 | 00 |
| Monmouth, | 2 | " | 558 | " | " | " | " | 3,854 | 00 |
| Morris, | 10† | " | 4,525 | " | " | " | " | 23,921 | 00 |
| Ocean, | 10 | " | 9,123 | " | " | " | " | 18,251 | 00 |
| Passaic, | 5 | " | 1,105 | " | " | " | " | 3,432 | 00 |
| Somerset, | 1 | " | 120 | " | " | " | " | 180 | 00 |
| Salem, | 4 | " | 2,040 | " | " | " | " | 7,430 | 00 |
| Sussex, | 8 | " | 8,900 | " | " | " | " | 30,225 | 00 |
| Union, | 1 | " | 3 | " | " | " | " | 1 | 50 |
| | 79 | " | 85,046 | " | " | " | " | $305,744 | 50 |

* One of the Burlington county fires started in Camden county.
† One of the Sussex county fires burned also in Morris county.

# PART IV.

# Underground Waters of New Jersey. Wells Drilled in 1903.

By G. N. KNAPP.




MAP SHOWING THE FOUR MAJOR TOPOGRAPHICAL DIVISIONS OF NEW JERSEY.

# Underground Waters of New Jersey. Wells Drilled in 1903.

BY G. N. KNAPP.

## Artesian and Other Deeply Penetrating Waters of New Jersey.

New Jersey has been divided into four provinces or zones on the basis of its physiographic features.* These provinces are indicated on the accompanying sketch map, Plate XI, and are designated: 1°, the Appalachian; 2°, the Crystalline Highlands, 3,° the Piedmont, and 4°, the Coastal plain. The topographic features of these several provinces, by virtue of which they differ the one from the other, are in large measure simply the outward manifestation of internal characters, structural and lithological, inherent in the terranes of the different provinces, that have been given expression by subaerial and stream degradation.

As might be anticipated, the underground or deeply penetrating waters of the State sustain relations differing with the different provinces and more or less characteristic of them. Rocks so different in structure and lithological character as to give rise to topographic features so pronounced and characteristic as are those of the several provinces, might be expected to profoundly affect the disposition of underground water. This is, in fact, found to be true, and we accept this subdivision of the State as the one best adapted to a general discussion of the deep waters.

* N. J. Geol. Survey, Final Report, Vol. IV, Physical Geog., 1895.

THE APPALACHIAN PROVINCE.*

The Appalachian province, or zone, is the northern extension of the great Appalachian mountain sytem as it occurs in New Jersey. It is essentially coincident with the great Kittatinny valley and Kittatinny mountain.

It consists of limestone, slates, conglomerates, sandstones and quartzites, strongly infolded in anticlines and synclines whose axes run northeast and southwest. These primary folds have, subsequent to their development, been more or less faulted and cut by dikes and late intrusions. The whole has been profoundly eroded; plains of degradation have developed, truncating the old folds, and later broad deep valleys developed parallel to the main axes of the folds. In these broad valleys we now have the softer beds, such as limestones and shales, standing at various angles between vertical and horizontal, and dipping in discordant directions. The ridges, or mountains, inclosing these valleys consist of the harder beds, viz., conglomerates, quartzites, slates and sandstones, rising more or less abruptly 500 or 700 feet above the valleys. The beds themselves stand at various angles, commonly approaching verticality.

The various beds of the Appalachian zone have in large measure lost through induration what porosity they may once have had. The sandstones have become quartzites more or less dense; the conglomerates have suffered a like modification, reducing the porosity to a minimum, and the other rocks have suffered similar modification tending to increase the density. The rocks have, however, been fractured at various times, so that joints occur more or less abundantly through the beds, admitting water to unknown depths; solution also has developed cavities and more or less definite underground courses through the limestones.

The rocks of the Appalachian province are therefore relatively impervious, and do not carry a large volume of water. The water that does penetrate deeply does so by virtue of secondary

* Statements regarding the underground waters of the Appalachian, Crystalline Highlands, and Piedmont provinces are compiled from data in the previous reports of the Survey.

structures and other modifications that do not stand in close relation to the primary structure.

It transpires, therefore, that the structure, which is regular enough to be worked out with considerable definiteness, is not of so much service in locating successful wells as might be expected. The water seems capricious in its occurrence. The data available, however, show but few deep wells in this province, too few to be made the basis of final conclusion, so that the great Kittatinny valley has yet to be thoroughly tested for its available deep-water supply.

### THE CRYSTALLINE HIGHLANDS PROVINCE.

The Crystalline Highlands, as the name suggests, consists more largely of crystalline rocks, granites, schists and gneisses. The great structural lines of the region run northeast and southwest, like those of the Appalachian zone, but this region has been subject to more profound metamorphism; the beds have been repeatedly broken and faulted at widely separated time intervals. Intrusive rocks have been injected as dikes and bosses, at different times, and according to different systems. Secondary structures have very generally destroyed or replaced the original ones; and along with this have gone replacement and interchange in the mineral constitution until it frequently is difficult to tell whether the rock is metamorphosed sedimentary or a metamorphosed granite.

In the Crystalline Highlands, therefore, the structure is too complex and too indefinite to aid one in a practical way in predicting wells, and the formations contain no well-defined porous beds that in a true sense can be called water-bearing in contradistinction to others adjacent. The rocks, however, as a whole, are more generally permeated by water than in the Appalachian zone, so that borings made indiscriminately give a larger percentage of satisfactory wells in the former than in the latter region. We know from the numerous iron mines scattered through the Highland region that the permeation of these old crystallines by water, while very general, is by no means uniform; for some mines encounter large volumes of water greatly to their detriment, whereas others are comparatively dry. The relation, if any, that exists between the local rock structure or the depth of the mine and the volume of water encountered is not apparent.

There are in the Highland province some notable exceptions to the structure as above outlined; such, for instance, as the Green Pond mountain belt, where the structure is analogous to the infolding of the Appalachian zone. In these exceptional areas the deep waters behave much as they do in the Kittatinny region.

The numerous streams, as yet not polluted, afford an abundance of excellent water. This, together with the cost of drilling in such hard rock, i. e., five to ten dollars per foot, has heretofore limited the number of deep wells.

This province, however, is being invaded by suburban homes and country residences, and we may look forward in the near future to more deep wells than the past has afforded.

## THE PIEDMONT PROVINCE.

The Piedmont province is essentially the area of the Newark or red sandstone system. The Newark consists of three series of beds, which, from base upwards, are: The Stockton, the Lockatong and the Brunswick.

The Stockton consists of light-colored sandstones and conglomerates, more or less arkose, interbedded with a few red shales. It is the most permeable series of the Newark system.

The Lockatong consists chiefly of flagstones and argillites, and is relatively impervious.

The Brunswick series consists chiefly of shales, but includes also many beds of sandstones. It is less permeable than the Stockton.

The Newark system is traversed by a number of irregular faults, whose throw in two cases is nearly sufficient to repeat the entire system. The prevailing dip of the beds is west and northwest but accompanying the faulting was more or less local warping and tilting that gave the beds many local variations in dip and strike. The structure is further complicated by a system of volcanic intrusive sheets and trap dikes that cut across the bedding at various angles.

While our knowledge of the Newark beds is not sufficiently detailed to enable us to forecast the chances of obtaining artesian water at any given point, or even to assure us that well-defined water-bearing horizons exist, yet experience shows that a moderate supply of water can usually be obtained anywhere in these beds at depths of a few hundred feet at most. The fact that the rocks of the Newark system are thoroughly cut up by several systems of deeply penetrating joints, whose planes approach the vertical and intersect at various angles, and the further fact that in many wells the amount of water increases gradually with depth of the boring, apparently indicates that the water is present more largely in these joints and fissures than in any well-defined porous water-bearing beds. This inference is supported by observations made in several long tunnels in the red shale, where frequent streams of water were found following vertical fissures, while the bedding planes were nearly dry and no porous layers were observed.

Although the record of deep borings in the Newark rocks does not indicate the presence of copious supplies of water, yet in a few localities in the Piedmont belt conditions are such, owing to the glacial deposits of sand, gravel and bowlder clay, that flowing wells of great volume have been found. These conditions seem most commonly present in the basin of the glacial Lake Passaic, particularly where beds of open gravel beneath impervious layers of clay afford the requisite conditions for the accumulation of large supplies of water under considerable pressure. From the irregular distribution of the glacial drift, and the extremely local character of these deposits, no adequate forecasts can be made as to the occurrence of these copious water-supplies, but they may be looked for wherever the topography is such as to suggest the recurrence of a basin-shaped depression in the rock surface and a considerable accumulation of glacial drift.

Of the three provinces thus far considered the last, or Piedmont, carries vastly more deep water than either of the others. Moreover, it is found in rocks that are drilled with comparative ease. Furthermore, the Piedmont is by virtue of its geographical position the most important of the three, since it includes what is and what always will be, the most densely populated part of the State, in which the water supply, accordingly, always will be a paramount question.

### THE COASTAL PLAIN PROVINCE.

The Coastal plain differs from the three northern provinces in nearly every essential feature.

First, it includes an area greater than the combined area of the other three provinces.

Second, there are no mountains; the maximum relief is less than 400 feet. As compared with the other provinces, it is flat.

Third, the structure is of the simplest sort, consisting of a succession of beds, lying one upon the other, in a simple monocline, dipping seaward; the uppermost or youngest bed lying furthest southeast, and each successively older and lower bed reaching a little farther northwest.

The structure is indicated diagrammatically in Plate XII. (In the delineation of the salient features of the general structure, Plate XII is, to the best of our knowledge, true to the facts; subject, of course, to the accompanying explanation. In the delineation of the beds by mathematically straight lines, the figure is, of course, entirely diagrammatic.)

Fourth, there have been no faults or fold of sufficient magnitude to appreciably affect the general structure.

Fifth, the beds are unconsolidated—sands, clays, marls and gravels, and lie in essentially the same position in which they were deposited.

Sixth, the terranes have not suffered any metamorphism that has appreciably affected their permeability to water.

The Coastal plain province falls into two great natural divisions or subprovinces, viz., the Cretaceous and the Tertiary.

The Cretaceous occupies a relatively narrow belt across the State, indicated diagrammatically in Plate XII by beds 0 to 10.

The Tertiary includes the remainder of the province corresponding to beds 11 and 12, Plate XII.

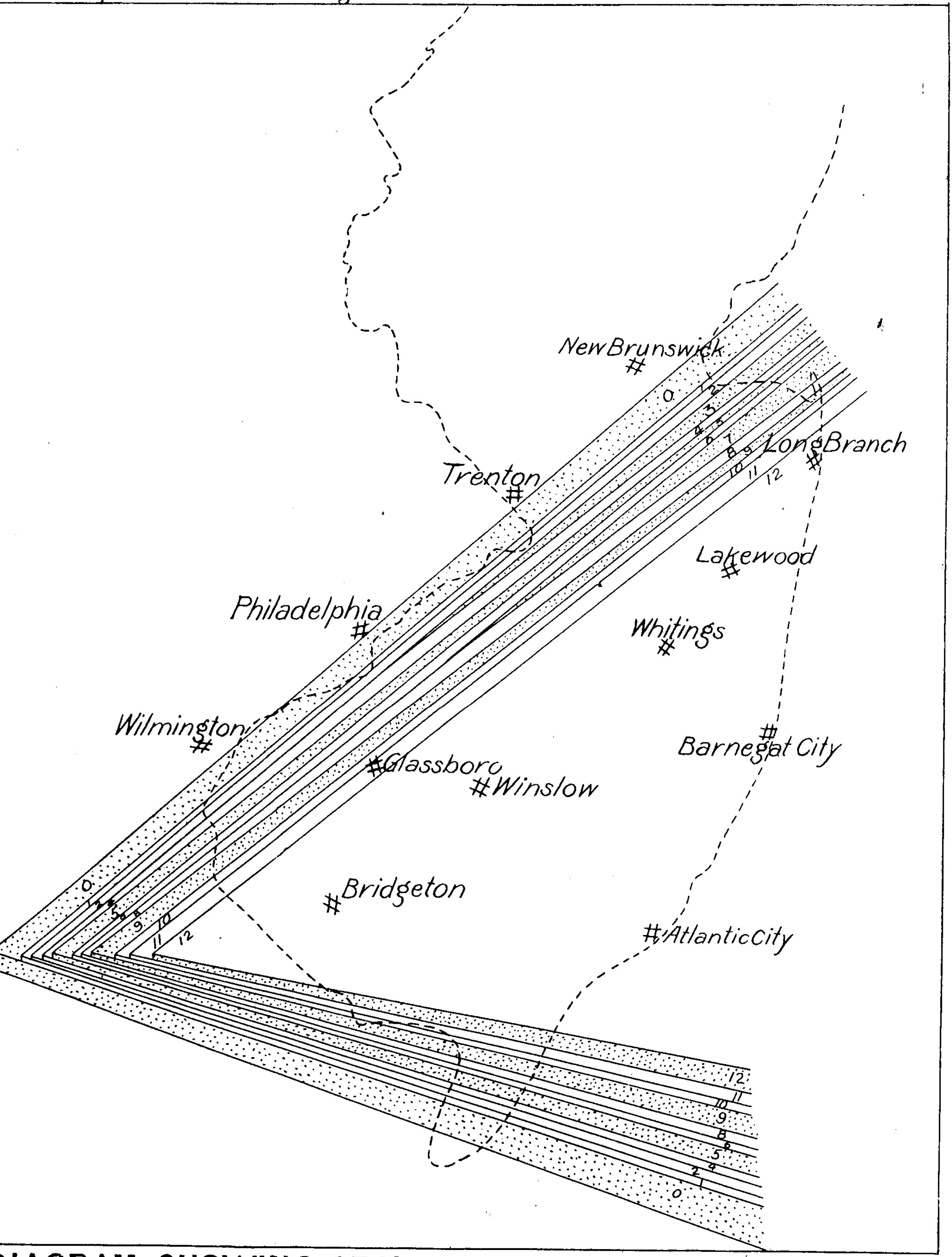



DIAGRAM SHOWING GEOLOGICAL STRUCTURE OF COASTAL PLAIN IN NEW JERSEY WITH REFERENCE TO ARTESIAN WATER HORIZONS.

The Cretaceous has three major divisions, which from base upward are the Raritan, the Clay Marl series, and the Marl series. (The Clay Marl series corresponds approximately, but not exactly, to the "Matawan" of the later nomenclature. The Marl series includes approximately, but not exactly, the "Monmouth," "Rancocas" and "Manasquan" of later nomenclature.)

The Raritan, though carrying important water beds at different stratigraphic horizons, does not admit of subdivision.

The Clay Marl series, on the other hand, is readily subdivided into five beds, corresponding to beds 1 to 5 in Plate XII.

Beds 1 and 2 are an impervious marl and clay, and serve as a cover-bed to the Raritan water-bearing sands. No. 3 is a sand-bed, which is 100 feet thick to the northeast, where it is an important water horizon; to the southwest it pinches out entirely and disappears along the strike. Bed No. 4 is an impervious marl and clay, a cover-bed to No. 3, Bed No. 5 is a sand bed 100 feet thick to the southwest, where it is an important water horizon. To the northeast it becomes less important, partly by reason of its decrease in thickness in that direction, and partly by a decrease in permeability.

The Marl series, like the Clay Marl series, is readily subdivided into five beds, corresponding to beds 6 to 10 in Plate XII.

Bed No. 6 corresponds to the Lower Marl (approximately the "Navesink"); bed No. 7 is the Red Sand (Red Bank). It is an important water horizon to the northeast, where it is a sand bed 100 feet thick, but to the southwest it pinches out like No. 3, and disappears along the strike. Bed No. 8 is the lower portion of the old Middle Marl bed, the marl proper. (It constitutes a part, but not all of the "Sewell.") Bed No. 9 is the lime and "yellow" sand; the upper part of the old Middle Marl bed (including the "Vincentown" and more). This is a very important water horizon all across the State. Bed No. 10 is the Upper Marl, a part of which is Eocene. It is the impervious cover to bed No. 10.

The second subprovince of the Coastal plain, the Tertiary, is divided into two formations, the Kirkwood (Miocene), and the Cohansey (Pliocene?) corresponding respectively to beds 11 and 12 of Plate XII.

Bed No. 11 is the Kirkwood. It carries water-bearing sands at several different stratigraphic horizons. It is an important source of water at Atlantic City and southward on the beaches. Bed No. 12 is the Cohansey formation. It carries water at several different stratigraphic horizons, and rivals the Kirkwood as a source of artesian water along the beaches.

The structure of the Coastal plain is extremely simple. The outcrop of the beds is known in great detail. The dip is known, or is readily determinable, and our topographic atlas gives us the altitude at all points. Still the predicting of artesian water at any given point is not the simple mathematical proposition that Plate XII might suggest.

The chief difficulties experienced in predicting wells are two. First, the thickening of the beds down the dip, seaward, has not been worked out in detail for individual beds. Second, the permeability of the beds is a variable factor whose exact value is yet to be worked out.

Investigations now in progress are expected to contribute much toward the solution of these difficulties.

PROVINCES.

| | *Appalachian.* | *Crystalline Highlands.* | *Piedmont.* | *Coastal Plain.* |
|---|---|---|---|---|
| Area in Sq. Miles, | 547 | 945 | 1,463 | 5,099 |
| Approximate Population, | 24,201 | 76,029 | 1,222,586 | 495,072 |
| Average No. of People per Sq. Mile, | 44.2 | 80.4 | 836.3 | 97.7 |
| Maximum Density of Pop. per Sq. Mi., per Twps., | 1,590 | 8,475 | 22,560 | 14,492 |
| Minimum Density of Pop. per Sq. Mi., per Twps., | 23 | 26 | 37 | 6 |
| Records of Wells in | 23 | 31 | 547 | 998 |
| Average No. of Sq. Miles to each well, | 24 | 30 | 26 | 5 |

The accompanying table brings into prominence many important relations and suggests many more that space forbids our discussing. A word explanatory of the table will, however, be allowable.

First. It will be noticed that of the 1,600 wells catalogued in the Survey office, 1,000 are found in the Coastal plain province;

they range in depth from 50 to 2,300 feet; probably 90 per cent. of these are of the true artesian type, that is, they draw their water from a bed whose catchment area is remote from the well, and the water in the wells rises quite to the surface, and frequently above the surface, giving flowing wells.

Of the 550 in the Piedmont plain comparatively few are of the true artesian type; they range in depth from 50 to 600 feet; some of them yield large volumes of water; a few of them flow, but, as before suggested, those in bedrock probably draw their supply more largely from the joints and the secondary structures than from the water that permeates the true bedding, and the most copious are in the glacial drift.

Of the 50 or 60 wells in the two northern provinces, with possibly a few exceptions, none are truly artesian: they are simply deep reservoir-like holes into which water is percolating from innumerable joints and fissures at all horizons from top to bottom. While the gathering ground of such waters may be remote from the wells they belong in a different class from those of the Coastal plain. It will be remembered that the wells here catalogued are the ones of which we have records, but not the actual total number of wells in these provinces. There are undoubtedly many wells doing service of which we have no record.

The Appalachian and Crystalline provinces are relatively sparsely settled; springs abound, and mountain streams, proverbially wholesome, and, as yet, unpolluted, are numerous and well distributed; so that the demand for deep wells is not a pressing one.

The Piedmont area includes two fairly distinct subprovinces. First, the northeast part of the area, in vicinity of Essex and Hudson counties, is occupied by numerous cities large and small, which are in a large measure manufacturing centers.

Second. In the northwest portion, in vicinity of Somerset county, agriculture is the dominant interest. The former of these subprovinces includes about one-fifth of the area of the Piedmont, and claims about nine-tenths of the population, while the remaining one-tenth of the population is scattered over the remaining four-fifths of the province to the southwest.

Of the 550 wells in the Piedmont more than five hundred occur in the densely populated region to the northeast; and, for the most part, subserve the interests of manufacture.

In the Coastal plain province we find the densely populated districts distributed around the periphery of the province, the interior being more sparsely settled. The distribution of the artesian wells stand in a fairly definite relation to the density of the population.

Along the beaches are many thriving towns and cities whose function is almost wholly one of ministering to those in quest of health, recreation and pleasure. These communities, while not absolutely dependent on artesian wells for their water supply, find it the most practicable source, and hence we find a large percentage of the wells along the coast.

The north and northwest border of this province, which is approximately the outcrop of the Cretaceous terranes, finds its interests divided between agriculture and manufacturing. The artesian wells, which are abundant in this region, are less deep than those along the coast, and accordingly less expensive. They are found ministering to both the manufacturing and the agricultural interests.

The distribution of the artesian wells is determined, first, by the availability of the water; second, by the density of the population; and third, by the character of the population.

---

## New Deep Wells in 1903.

On the following pages a record of the new wells bored during the year 1903 and reported to the Survey are given. This record is not so detailed as in former years, owing to the sudden death early in the year of Lewis Woolman, who had with painstaking care collected the data for previous reports. The Survey has not been able in any case to verify the records, nor to examine samples, but publishes the data substantially as reported by the welldrillers.

## WELLS DRILLED IN 1903.

| Locality. | Owner. | Diam. | Record. | | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|---|
| Allamuchy, ...... | Mrs. W. K. Vanderbilt, | 6 in., | Earth, ............<br>Gray mountain rock, hard, ........... | 16 ft.<br>139 ft. | 155 feet, ... | Stotthoff Bros., ........ | 14 gallons per minute. |
| Alpha, ........... | Alpha Portland Cement Co., .............. | 10 in., | Cement rock, .......<br>Limestone, ......... | 335 ft.<br>20 ft. | 355 feet, ... | Stotthoff Bros., ........ | Well started in bottom of quarry. 150 gallons per minute. |
| Anglesea, ........ | Arctic Ice Co., ......... | 4½ in., | ........................ | | 330 feet, ... | Uriah White Estate, .... | 30 feet of 3-inch strainer. Pumping capacity, over 200 gallons per minute. |
| Atlantic City, .... | Fairbairn & Williams, The Strand, ....... | 6 in., | ........................ | | 826 feet, ... | Uriah White Estate, .... | Finished with 50 feet of strainer. Pumping capacity, 100 gallons per minute. |
| Belmont, ......... | Botany Worsted Co., .. | 6 in., | Earth and gravel, ...<br>Red sandstone rock, . | 54 ft.<br>19 ft. | 83 feet, ... | Stotthoff Bros., ........ | 3 gallons per minute. |
| Belmont, ......... | M. Macher, .......... | 6 in., | Earth and gravel, ...<br>Red sandstone, ..... | 38 ft.<br>25 ft. | 63 feet, ... | Stotthoff Bros., ........ | 12 gallons per minute. Flowing well. |
| Bernardsville, .... | J. A. Bensel, .......... | 6 in., | Earth, .............<br>Granite rock, hard, .. | 8 ft.<br>78 ft. | 86 feet, ... | Stotthoff Bros., ........ | 100 gallons per minute at 20 feet from the surface. |
| Bordentown, ..... | French Gelatine Co., ... | 8 in., | Light brown sand, ...<br>Fine gray sand, .....<br>Yellow sand, .......<br>Gray quicksand, ....<br>Yellow quicksand, ..<br>Coarse yellow sand and water, .......<br>Blue clay, .........<br>Red clay, .......... | 11 ft.<br>5 ft.<br>5 ft.<br>8 ft.<br>6 ft.<br>22 ft.<br>6 ft.<br>10 ft. | 73 feet, ... | Stotthoff Bros., ........ | Draws water from the Raritan beds. 55 gallons per minute. |

| Locality. | Owner. | Diam. | Record. | | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|---|
| Bridgeton, ....... | Bridgeton Water Co.,.. | 8 in., | ........................ | | 990 feet, ... | Thos. B. Harper,....... | Well finally screened off at 225 ft. Water rose to within 2 feet of surface. |
| Bridgeton, ....... | Bridgeton Water Co.,.. | 8 in., | ........................ | | 88 feet, ... | Thos. B. Harper,....... | Water rose to within 2 feet of surface. |
| Bridgeton, ....... | Bridgeton Water Co.,.. | 8 in., | ........................ | | 90 feet, ... | Thos. B. Harper,....... | Water rose to within 2 feet of surface. |
| Clementon, 500 ft. south of R. R. crossing, ....... | Fred. McCann, ....... | 3 in., | Soil, ............... | 1 ft. | | | |
| | | | Light colored sand,.. | 4 ft. | | | |
| | | | Loose gravel, ...... | 2 ft. | | | |
| | | | Fine compact sand,.. | 4 ft. | | | |
| | | | Yellow quicksand, .. (Poor water.) | 12 ft. | | | |
| | | | Black mud, ........ | 28 ft. | | | |
| | | | Dark brown sandy clay, ............ | 30 ft. | | | |
| | | | Black clay, ......... | 12 ft. | | | |
| | | | Sand, some shells,... | 10 ft. | | | |
| | | | "Limestone," ....... | 2 ft. | | | |
| | | | | | 105 feet, ... | Fred. E. McCann,....... | Good water found beneath the "limestone." Rises to within 22 feet of surface. Probably from upper part of the Vincentown lime-sand. |
| Dumont, ......... | Mrs. Van Antwerp,.... | 6 in., | Earth and gravel,... | 24 ft. | | | |
| | | | Red sandstone rock,. | 126 ft. | | | |
| | | | | | 150 feet, ... | Stotthoff Bros., ........ | 20 gallons per minute. |
| East Rutherford,.. | Fuchs & Lang Mfg. Co. | 8 in., | Glacial drift, ...... | 57 ft. | | W. W. Christie,........ | Not completed. |

| Locality. | Owner. | Diam. | Record. | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|
| Easton, Pa., ...... | Easton Dairy Co.,..... | 6 in., | Sand and gravel,.... 59 ft.<br>Limestone rock, .... 87 ft. | 146 feet, ... | Stotthoff Bros., ........ | 116 gallons per minute. |
| Haledon, ......... | Theo. Leonhard, ...... | 6 in., | ......................... | 120 feet, ... | W. W. Christie,........ | Small flow. |
| Laurel Springs, Park Ave., ..... | Chas. Mund, .......... | 3 in., | Soil, ............... 1 ft.<br>Fine sand, ......... 4 ft.<br>Very fine sand,...... 2½ ft.<br>Stiff, dark sandy clay, ............. 6 ft.<br>Black mud, ......... 6 ft.<br>Black marly sand,... 10 ft.<br>Compact gray sand (some shells), .... 1 ft.<br>Lime rock, ......... 3½ ft. | 34 feet, ... | Fred. E. McCann,....... | Water found below the "lime rock" in a dark grey sand, probably in the Vincentown limesand formation. |
| Laurel Springs, Park Ave., ..... | Chas. Mund, .......... | 3 in., | Soil, ............... 1 ft.<br>Fine sand, ......... 4 ft.<br>Coarse sand, ....... 2 ft.<br>Yellow gravel, ...... 10 ft. | 17 feet, ... | Fred. E. McCann,....... | A surface water filtered through the sand and gravel. |
| Linden, .......... | Walter Luchen, ....... | 5 in., | Glacial drift, ....... 30 ft.<br>Red shale, ......... 11 ft. | 41 feet, ... | Frank T. Cladek,....... | 20 gallons per minute. |
| Linden, Wood Av. | C. H. & John Winans,. | 6 in., | No. 1 Glacial drift,.. 16 ft.<br>Red shale, .......... 184 ft. | 200 feet, ... | Frank T. Cladek,....... | These two wells each produced on three weeks' test, night and day pumping, 1,080,000 gallons per 24 hours. |
| | | 6 in., | No. 2 Glacial drift and red shale, 150 feet from No. 1,......... | 146 feet, ... | | |

| Locality. | Owner. | Diam. | Record. | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|
| Bridgeton, ....... | Bridgeton Water Co.,.. | 8 in., | ......................... | 990 feet, ... | Thos. B. Harper,....... | Well finally screened off at 225 ft. Water rose to within 2 feet of surface. |
| Bridgeton, ....... | Bridgeton Water Co.,.. | 8 in., | ......................... | 88 feet, ... | Thos. B. Harper,....... | Water rose to within 2 feet of surface. |
| Bridgeton, ....... | Bridgeton Water Co.,.. | 8 in., | ......................... | 90 feet, ... | Thos. B. Harper,....... | Water rose to within 2 feet of surface. |
| Clementon, 500 ft. south of R. R. crossing, ....... | Fred. McCann, ....... | 3 in., | Soil, ............... 1 ft.<br>Light colored sand,.. 4 ft.<br>Loose gravel, ...... 2 ft.<br>Fine compact sand,.. 4 ft.<br>Yellow quicksand, .. 12 ft.<br>(Poor water.)<br>Black mud, ........ 28 ft.<br>Dark brown sandy clay, ............. 30 ft.<br>Black clay, ......... 12 ft.<br>Sand, some shells,... 10 ft.<br>"Limestone," ....... 2 ft. | 105 feet, ... | Fred. E. McCann,....... | Good water found beneath the "limestone." Rises to within 22 feet of surface. Probably from upper part of the Vincentown lime-sand. |
| Dumont, ......... | Mrs. Van Antwerp,.... | 6 in., | Earth and gravel,... 24 ft.<br>Red sandstone rock,. 126 ft. | 150 feet, ... | Stotthoff Bros., ........ | 20 gallons per minute. |
| East Rutherford,.. | Fuchs & Lang Mfg. Co. | 8 in., | Glacial drift, ...... 57 ft. | | W. W. Christie,........ | Not completed. |

| Locality. | Owner. | Diam. | Record. | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|
| Easton, Pa., ...... | Easton Dairy Co.,..... | 6 in., | Sand and gravel,.... 59 ft.<br>Limestone rock, .... 87 ft. | 146 feet, ... | Stotthoff Bros., ........ | 116 gallons per minute. |
| Haledon, ......... | Theo. Leonhard, ...... | 6 in., | ........................ | 120 feet, ... | W. W. Christie,........ | Small flow. |
| Laurel Springs, Park Ave., ..... | Chas. Mund, .......... | 3 in., | Soil, ............... 1 ft.<br>Fine sand, ......... 4 ft.<br>Very fine sand,...... 2½ ft.<br>Stiff, dark sandy clay, ............. 6 ft.<br>Black mud, ......... 6 ft.<br>Black marly sand,... 10 ft.<br>Compact gray sand (some shells), .... 1 ft.<br>Lime rock, ......... 3½ ft. | 34 feet, ... | Fred. E. McCann,....... | Water found below the "lime rock" in a dark grey sand, probably in the Vincentown limesand formation. |
| Laurel Springs, Park Ave., ..... | Chas. Mund, .......... | 3 in., | Soil, ............... 1 ft.<br>Fine sand, ......... 4 ft.<br>Coarse sand, ....... 2 ft.<br>Yellow gravel, ...... 10 ft. | 17 feet, ... | Fred. E. McCann,....... | A surface water filtered through the sand and gravel. |
| Linden, .......... | Walter Luchen, ....... | 5 in., | Glacial drift, ....... 30 ft.<br>Red shale, ......... 11 ft. | 41 feet, ... | Frank T. Cladek,....... | 20 gallons per minute. |
| Linden, Wood Av. | C. H. & John Winans,. | 6 in., | No. 1 Glacial drift,.. 16 ft.<br>Red shale, .......... 184 ft. | 200 feet, ... | Frank T. Cladek,....... | These two wells each produced on three weeks' test, night and day pumping, 1,080,000 gallons per 24 hours. |
| | | 6 in., | No. 2 Glacial drift and red shale, 150 feet from No. 1,......... | 146 feet, ... | | |

| Locality. | Owner. | Diam. | Record. | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|
| Rahway, Milton Ave., | Edw. Savage, | 6 in., | Sand and "hardpan," 35 ft.<br>Red shale, 134 ft. | 169 feet, | Frank T. Cladek, | 20 gallons per minute at 35 feet in sand; 8 gallons per minute at 169 feet in rock. |
| Rahway, Rahway Ave., | Geo. W. Bowe, | 6 in., | Glacial drift, 14 ft.<br>Red shale, 186 ft. | 200 feet, | Frank T. Cladek, | 8 gallons per minute at 200 feet. Explosion of dynamite did not improve the flow. |
| Rahway Port, | W. H. Maze, | 5 in., | Glacial drift, 34 ft.<br>Red shale, 26 ft. | 60 feet, | Frank T. Cladek, | Elevation, 30 A. T. 20 gallons per minute. |
| Roselle, Linden St. | W. H. Weldon & Son, | 5 in., | Fine sand, 76 ft.<br>Red shale, 5 ft. | 81 feet, | Frank T. Cladek, | 20 gallons per minute at 20 feet. |
| Roselle, near Dark lane, | J. Nestor, | 6 in., | Glacial drift, 9 ft.<br>Bed rock, 23 ft. | 32 feet, | Frank T. Cladek, | 10 gallons per minute. |
| Skillman, | N. J. State Village for Epileptics, | 6 in., | Earth, 3 ft.<br>Red shale, 211 ft. | 214 feet, | Stotthoff Bros., | 14 gallons per minute. |
| Trenton, | J. A. H. Delp, | 6 in., | Earth and gravel, 18 ft.<br>Red sandstone, 18 ft. | 36 feet, | Stotthoff Bros., | 15 gallons per minute. |
| West Portal, | Farmers' Dairy Dispatch Co., | 8 in., | Earth and bowlders, 52 ft.<br>Limestone, 8 ft. | 60 feet, | Stotthoff Bros., | 28 gallons per minute. |

| Locality. | Owner. | Diam. | Record. | Total Depth. | Reported by | Remarks. |
|---|---|---|---|---|---|---|
| Wildwood, | Wildwood Water Co., | 6 in., | | 347 feet, | Uriah White Estate, | Finished with about 40 feet of strainer. Pumping capacity, about 200 gallons per minute. |
| Woodbine, | Land Improvement Co., | | | 125 feet, | Thos. B. Harper, | Water rose to within 12 ft. of surface. 40 gallons per minute when tested with 70-ft. pump. |

OAKHURST (DEAL), MONMOUTH COUNTY.

Matthew Bros. report a well for William Kinney at Oakhurst (formerly Deal), which shows some interesting features. The record as reported by the contractors is as follows:

| | | |
|---|---|---|
| 1. Grey sand, | 140 ft. | 0 to 140 ft. |
| 2. Rock with many shells, | 4 ft. | 140 to 144 ft. |
| 3. Fine white sand, | 7 ft. | 144 to 151 ft. |
| 4. Marl or blue clay marl, | 188 ft. | 151 to 339 ft. |
| 5. Grey sand, | 34 ft. | 339 to 373 ft. |
| 6. Marl, | 42 ft. | 373 to 415 ft. |
| 7. White sand, | 7 ft. | 415 to 422 ft. |
| 8. Clay, | 9 ft. | 422 to 431 ft. |
| 9. White sand (water), | 66 ft. | 431 to 497 ft. |

The well yielded 150 gallons per minute, the water rising to within 12 feet of the surface.

It is not easy to correlate this record with the geological sections of Monmouth county as we know it from surface studies, owing to the abnormal thickness of the marl, No. 4 of the section. Nevertheless, if it be admitted that there is, perhaps, a mistake in identifying all the material between 151 and 339 feet as marl, it is possible to bring this record into close accord with other records from this region. In comparing this section with the regular stratigraphic column computations based upon the dip show that the base of the Lower Marl should be found at Oakhurst about 320 feet from the surface. This corresponds fairly closely with the base of No. 4 in the well section (339 feet), and gives us a clue to the probable correlation. The Lower Marl is about 30 feet thick, and is succeeded upward by the Red Bank sand, 115 feet, which is locally a black fine earthy sand, easily mistaken in a wellboring for true marl. Above the Red Bank sand is the Green Earth, 20 feet, also easily mistaken for true marl, and then the Middle Marl, 20 feet. Above the Middle Marl, and near the base of the Vincentown limestone, the next overlying layer, is a shell bed, the Terebratula Harlani bed, which would seem to agree with No. 2 of the well section. No. 6 of the well section (Marl, 42 feet) may very well be the clayey marl bed which occurs as No. IV of the Clay Marl series. If these correlations are correct, the section would be referred as follows:

| | | | |
|---|---|---|---|
| Grey sand, | 140 ft. | Vincentown limesand and "yellow sand." | |
| Shell rock, | 4 ft. | | |
| Fine white sand, | 7 ft. | | |
| Marl or blue clay marl, | 188 ft. | Middle Marl, | 20 ft. |
| | | "Green earth," | 20 ft. |
| | | Red Bank sand, | 115 ft. |
| | | Lower Marl, | 30 ft. |
| | | | 185 ft. |
| Grey sand, | 34 ft. | No. V of Clay Marl Series. (Wenonah sand.) | |
| Marl, | 42 ft. | No. IV of Clay Marl Series. (Marshalltown marl.) | |
| White sand, | 7 ft. | No. III of Clay Marl Series. (Columbus sand.) | |
| Clay, | 9 ft. | | |
| White sand, | 66 ft. | | |

# PART V.

# The Mineral Industry. The Cement Industry.

By S. HARBERT HAMILTON.

# The Mineral and Cement Industries.

## Iron Mining in New Jersey.

A glance at the Annual Reports of the State Geologist will show a steady and apparently alarming decrease in the number of active mines from year to year. But dark as the present may appear there is really a very bright promise in the industry. Many, in fact most, of the mines in New Jersey have been known for nearly a hundred years. As early as 1682,* there was a smelting furnace and forge at Tinton Falls, in Monmouth county. In 1770 it is recorded that there were rolling mills at Old Boonton and Dover. In Revolutionary days the furnaces of New Jersey, notably Oxford, furnished cannon and shot for the patriots.

In the early days of the century not only were the magnetites and hematites of northern New Jersey used at many places, but the bog ores (limonites) of the southern Coastal plain areas supplied ore to the old Hanover Furnace, east of Mount Holly, and "Etna," at Tuckahoe. Miles and miles of scrub pine and oak were cut from the region about these works to furnish the charcoal fuel.

With the new era, inaugurated by the ingenious William Henry, at Oxford Furnace, in 1834, of using hot blast and higher pressure, the numerous open stack, trompe furnaces and Catalon forges went out of blast. Although this new order of things decreased the number of manufactories, and produced a drop in the statistical curve, yet it was in reality an advance; for, as pointed out by Mr. James M. Swank, the progress made in American iron metallurgy has been the great civilizer of this broad continent of ours.

* Historic notes compiled from Geology of N. J., 1868, and U. S. Geol. Sur. Mineral Resources, 1900.

Following the introduction at Trenton, in 1868, of the first Siemens-Martin open hearth furnace and the Bessemer process at other places, a still higher standard was demanded of iron ore. With the "chemical epoch" in ascendancy there was again a weeding out and only the fittest survived.

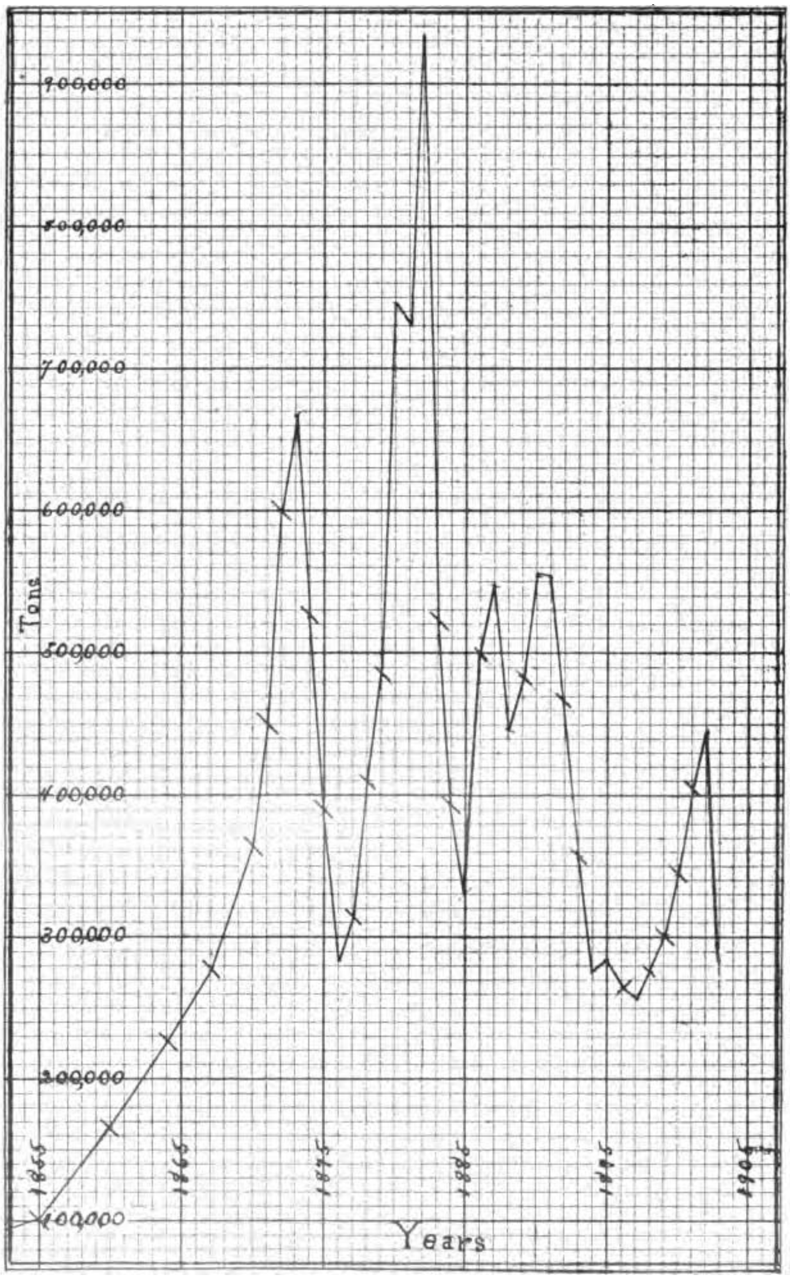
To-day the New Jersey iron-mining industry is in painful process of rejuvenation. The problem is not at the furnace (for there are no richer ores than the New Jersey magnetites), but at the mines. During the several decades that the best of New Jersey's mines have been operating, they have reached considerable depths. There is rich ore under Jersey still, but the problem is to get it out. The old shafts are crooked and narrow, mining has been carried on regardless of the future. When prices were good little of the profits were retained as permanent improvements on the properties. As a result of narrow, crooked workings and scattered boilers and machinery, a dull iron market and dear fuel closed many of the mines. Thus it is that New Jersey ores cannot compete with Lake and foreign ores—not because they are poor in iron, for they are not—but because the lower percentage ores can be mined so much more cheaply. The new era that is dawning in New Jersey is one of concentrated power plants, new straight shafts, electric separators and permanent improvements. The "ups and downs" of the iron-mining industry, since 1855, are graphically shown in Plate XIII.

The mines that are now in operation are run in direct connection with blast furnaces. The Hibernia mines ship their output to the Wharton and Andover furnaces. Oxford consumes its own ore. Richard ore goes to the Thomas furnaces, and the Ahlis ore is used in the Pequest stack. Hude ore is reduced at Stanhope.

### THE OXFORD MINES, OXFORD FURNACE.

Empire Steel and Iron Company, Catasauqua, Pa., owners and operators; S. B. Patterson, General Manager; J. R. Wynn, Superintendent.

During the past year the work at these mines has been along the line of development only. The power plant noted in last




CURVE SHOWING THE IRON ORE PRODUCTION IN NEW JERSEY FROM 1855 TO 1904.

year's report having been completed, attention was turned to developing the mines so as to insure an increased and steady output.

*At the Washington Mine* the old shaft was so small and crooked and afforded such poor ventilation that another attempt to sink a new shaft was undertaken. Several previous attempts having been abortive, extra precautions were taken. This was finally successful and has resulted in a fine three-compartment shaft. The record is as follows:

From the surface down 60 feet is through glacial debris, 30 feet of this being "quicksand"; then through 65 feet of rock, at which distance the backing of ore 11 feet thick was struck. Through this backing and the old gunnies the shaft was timbered to the bottom of the mine, a distance of 229 feet. Next it was sunk 132 feet through the ore, making a total depth of 497 feet.

The Washington ore is a massive magnetite quite thoroughly impregnated with pyrite, so that the raw ore runs about five per cent. sulphur. This is considerably reduced by roasting, as the following recent analysis shows:

| | |
|---|---|
| Silica, | 10.18 |
| Iron oxide, | 82.22 |
| Alumina, | 1.90 |
| Lime, | 2.86 |
| Magnesia, | .85 |
| Sulphur dioxide, | .75 |
| Phosphorus pentoxide, | .98 |
| Manganese Oxide, | .14 |
| Titanic oxide, | .17 |

This mine produced 30,172 tons during 1902.

*McKinley Mine* (formerly Oxford Slope 3).—The old shaft was so crooked and inadequate that in July, 1902, a new three-compartment shaft was started, which was completed by October of the same year. The first 60 feet penetrated soft, treacherous glacial debris. Here rock was encountered, which continued for 126 feet. The old workings were then struck and re-timbered for a distance of 379 feet, the shaft next being carried down through ore 50 feet, making its total length on the slope 615 feet. Stoping was done for some distance, but not much ore was taken out. The vein dips about 56 degrees to the east, and trends north and south.

The analysis of this ore is:

| | |
|---|---|
| Silica | 14.84 |
| Alumina, | 2.04 |
| Iron oxide, | 70.78 |
| Lime, | 7.54 |
| Magnesia, | 2.98 |
| Manganese, | .22 |
| Phosphorus, | .28 |
| Titanium, | .36 |
| Sulphur, | .15 |

A portion of both these ores is used at the Oxford furnace mixer with about 10 per cent. of Lake ore to bring up the manganese content of the basic pig produced. The balance goes to the Pennsylvania furnaces of the company. The production in 1902 was 8,551 tons. Franklin "calcite" (crystalline limestone) is used at the Oxford furnace for flux.

### THE BASIC IRON ORE COMPANY MINE.

The Basic Iron Ore Company, operators; R. L. Ahles, President; Erskine Hewitt, Secretary, Buttzville, N. J.

Active development work has been continued at this mine during the past year. No. 1 shaft is now 135 feet deep. Levels have been driven 460 feet west and 300 feet east on the vein. The eastern end of the level terminating at No. 2 shaft. Another shaft, No. 3, is now being sunk still farther to the east; it is now something over a hundred feet down, and it is planned to go some 250 feet before tunneling is commenced.

The plan for working this mine is a radical departure from methods heretofore used in New Jersey. The "caving" system, that of the Fayal mine in the Mesabi Range of Minnesota,* being used as a type. The shafts above mentioned are to go well to the bottom of the deposit. Levels are then drifted into the ore and timbered raises are sent to the top of the deposit. The ore

* See U. S. Geo. Sur. Mon. XLIII, p. 282.

is then blocked out in 28-foot parallelopipeds. Starting from the top a block is caved down to the main level and taken up the main shaft, and so on, always working from the top down. The overburden of glacial trash is then allowed to fall in, being kept from the ore by planking. This method saves an immense amount of timber, and allows of all the ore being removed. In this mine, with its heavy overburden of glacial debris and soft ore, this method can probably be worked to advantage.

The Ahles ore is markedly different in appearance from the greater proportion of the iron ore mined in New Jersey, which is compact magnetite with more or less pyrite through it. The ore from the Washington mine, which is near the Ahles mine, carries about 5 per cent. sulphur, which is removed by roasting. The Ahles ore contains practically no sulphur, and further differs from the Washington ore in a high water content, over 10 per cent., and is loosely pulverent. It is in reality a mixture of magnetite and limonite.

The occurrence of two such differently appearing ores in a restricted area, and with similar geological surroundings, may, perhaps, be explained by a chemico-geologic hypothesis. The Ahles body was, perhaps, originally a compact magnetite like other New Jersey ores, carrying a considerable percentage of sulphides. Possible dynamic movements allowed meteorologic waters to gain access to the ore where the dissolved oxygen reacted with the sulphides, changing them to soluble sulphates and limonite. It is probable that the surface waters on their way through the ore deposited the manganese noted in the analysis.

The following analysis furnished by the producers, illustrate the possible alterations and hydration.

| | *Washington.* | *Ahles.* |
|---|---|---|
| Silica, | 10.18 | 10.72 |
| Iron, | 59.54 | 46. |
| Sulphur, | 4. | nil. |
| Manganese, | .07 | 4. |
| Phosphorus, | .43 | nil. |
| Titanium, | .10 | nil. |
| Combined water, | nil. | 10 to 12. |

During the past year the only ore taken from these mines has been that removed in the process of development. This has amounted to some 30,000 tons, of which 20,605 tons 12 cwt. were used in the Pequest furnace, mixed with the ore from Ringwood, N. J. It produced a high-grade pig.

### HUDE MINE, STANHOPE, N. J.

Musconetcong Iron Works, Elizabethport, N. J., lessees; John S. Kennedy, Stanhope, Manager.

These mines continue to be worked steadily in a small way. The ore occurs in irregular lenses in hornblendic gangue, from which it is readily cobbed by hand. As noted in the Annual Report for 1901, molybdenite is found disseminated through the ore, and is frequently found altered to canary-yellow and orange coatings of molybdite and possibly ilsemannite. The hornblende where exposed to the weather has altered to a golden vermiculite, which might be referred to the vermiculite derived from hornblende, and described by Lewis* as philadelphite. The ore, like that at Oxford Furnace, is a close-grained magnetite with massive pyrite through it. The magnetite is often found here with slickensided surfaces, so that it resembles a natural mirror. Such a specimen, weighing about 150 pounds, is in the State Museum at Trenton.

During the past year about 9,000 tons of ore were hauled some one and one-half miles by team to the Stanhope furnace, where it is mixed with Lake and Cuban ore and made into a high-grade foundry pig. The slag from this furnace is consumed by the United States Mineral Wool Company, whose plant adjoins the furnace.

### IRONDALE MINES, WHARTON (PORT ORAM), N. J.

New Jersey Iron Mining Company, 72 Elliott street, Dover, owners; Peter Penaluna, manager.

During the past year nothing has been done in the Sterling mine, operations being confined to the Hurd slope.

* Pro. Acad. Nat. Sci. Phila., 1877, p. 269.

Two new sinks, each 60 feet, have been put down during the past year. Stoping has been continued east on a six-foot vein 57 feet high. Stope No. 5, West, has a five-foot vein, and has been stoped 57 feet also. Stope No. 4, West, shows a seven-foot vein, and has been stoped to a height of 45 feet. The present total depth of the mine on the incline is 1,070 feet.

The output of this mine is sold on the open market, and goes principally to the furnaces of Pennsylvania.

During the past year about 15,000 tons have been produced.

### THE RICHARD MINE, MT. PLEASANT.

The Thomas Iron Company, B. F. Fackenthal, Jr., President, Easton, Pa., owners; James Arthur, Superintendent, Wharton, N. J.

During the past year a new central-power plant has been installed at these mines, consisting of two new Harrisburg automatic engines of 200 horse-power each, direct connected to 150 K. W. General Electric generators. The power is to be conveyed to shafts No. 4, No. 5 and No. 6, each of which is furnished with new Ledgewood electric hoists of 80 horse-power each. Any surplus power will be utilized for crushing and pumpage.

No. 2 shaft has been abandoned, and is at present being actively "robbed" before permanently closing.

No. 5 shaft is now 875 feet below the surface, and has been worked 400 feet to the southwest, which brings the present workings nearly under the old No. 2 shaft. From No. 5 shaft work has been pushed northeast about 100 feet, where there is a 25-foot breast of ore. Operations are at present suspended in this drift owing to the danger of tapping a large body of water in the old workings. However, two new air-lift pumps, each capable of raising 1,000,000 gallons 1,000 feet in twenty-four hours, are being installed, and as soon as they are running, work will be pushed.

Operations during the past year have been confined to the Mt. Pleasant vein, which dips 52° to the southeast. No. 4 shaft cuts the vein at 900 feet, where it is six to ten feet in width. No.

5 shaft penetrated it at 500 feet, where it is five to fifteen feet wide. No. 6 shaft again at 900 feet, where the width varies from five to fifteen feet.

From January, 1902, to January, 1903, 100,656 tons 2 cwt. was mined.

### TEABO MINE, MOUNT HOPE, N. J.

Joseph Wharton, owner; Edward Kelly, manager.

The new shaft mentioned in last year's report was continued to 300 feet, mostly through the old workings. At a depth of 60 feet good ore was encountered and again at 200 feet. The shaft now terminates in rock, but it is expected that another shoot of ore will shortly be found. Work has been suspended at this mine awaiting more favorable conditions in the iron market.

### MOUNT HOPE MINES, MOUNT HOPE, NEW JERSEY.

Empire Steel and Iron Company, Catasauqua, Pa., owners and operators; S. B. Patterson, General Manager; Duke Peckitt, Superintendent.

Both the Taylor and Elizabeth mines have been kept working to some extent during the past year. Both mines have reached bed rock in the southwest portions.

In the Elizabeth mine a hole was bored with a diamond drill 505 feet in the foot wall but no ore was found.

No work has been done at the Hickory Hill mines for many years.

The total output for 1902 was:

| | |
|---|---|
| Taylor mine, | 5,835 tons. |
| Elizabeth mine, | 14,619 tons. |

### BEACH GLEN MINE, BEACH GLEN, N. J.

Benjamin Nicoll, 59 Wall street, New York City, owner.

The double skip-way shaft* was continued to 517 feet. At

* Rept. 1901, p. 144.

475 feet a rich vein, 14 feet wide, was encountered. This was worked about 50 feet on each side of the shaft in a northeasterly and southwesterly direction, and about 7,000 tons of ore removed. The ore runs 56 to 60 per cent. iron, low in sulphur, 0.003 to 0.009 phosphorus and no titanium. This mine is now closed but with higher prices in the iron market will be reopened.

### HIBERNIA MINES, HIBERNIA, N. J.

Joseph Wharton, Philadelphia, owner; Edward Kelly, Manager, Wharton (Port Oram), N. J.

*The Andover Mine* (formerly Lower Wood, Crane and Church mine). This mine has been sunk from the 23 to the 24 level, a distance of about 45 feet, and has been worked southwest to the "lean ground." A drift was driven through this lean ground 62 feet, at which point a body of ore was encountered 8 feet in width. The miners then raised and formed a stope. Twenty-four level has been worked to De Camp line, a distance of about 800 feet.

This mine is now some 1,200 feet below the surface or about 600 feet below sea level. The total amount of ore raised was 40,185 tons 9 cwt. in 1902.

*De Camp Mine.* The skip-way in this mine has been extended about 100 feet farther, making it in all about 600 feet. During the year 1902 about 11,000 tons were taken from this mine.

*Upper Wood Mine.* Number six level of this mine has been stoped to the southwest, a distance of about 650 feet or nearly underneath De Camp shaft No. 4. In a northeasterly direction the stope of No. 6 level has been driven about 500 feet to the Wharton line. The sink in the Upper Wood has been continued to No. 8 level, which has been worked southwest 300 feet and northeast 560 feet to the Wharton line. The shaft was then further continued to No. 9 level about 60 feet.

*The Wharton Mine* has now a total depth of 1,500 feet from the surface or nearly 600 feet below tide. It has the same number of stopes as mentioned in the last report but the installation of new machinery has facilitated the work greatly.

During the past year at No. 9 shaft a similar cobber and separator to that in use at shaft 11, has been installed and gives entire satisfaction.

In No. 12 (prospect) shaft the pitch has been changed from 37° to 76° southeast. It has been sunk to 680 feet, at which point a cross cut in the foot wall revealed a vein 7 feet in width.

The total production of the Wharton mine was 97,596 tons, 6 cwt., during the past year, 1902.

*The Magnetic Separator* at the foot of the hill has been in continuous operation with good results during the past year, 11,562 tons, 11 cwt., of concentrates having been shipped.

The material coming to the separator is magnetite intimately mixed with hornblende and feldspar,* carrying from 22 per cent. to 30 per cent. metallic iron. It is first crushed to about 2-inch cubes, when it is passed to the magnetic cobber and all particles containing iron are picked up and passed to the fine crushing rolls, which reduces it to ¼-inch mesh, after which it is passed to the magnetic separator. After separation the heads run from 58 per cent. to 62 per cent. metallic iron, and the tails from 8 per cent. to 11 per cent. With hand cobbing 15 to 30 per cent. iron is found in the tailings. A further advantage of the Wharton separator is that the cobber tails (2½ inches in diameter), and the concentrator tails (sand), are salable at from $0.75 to $1.00 a ton.

PETERS MINE, RINGWOOD, PASSAIC CO., N. J.

Cooper, Hewitt & Co., owners; Frank L. Nason, consulting engineer, in charge.

Mr. Nason reports that during the year 1903 the new shaft has been completed to a depth of 265 feet. In sinking this shaft three new ore shoots were passed through. Number 4 shoot, 40 feet high by 16 feet wide, and two others, each 16 feet high by 10 feet wide. The ore in these three shoots is very high grade, over 65 per cent. Fe., but they are too small to work

* See An. Rept., 1890, p. 72, for account of rocks associated with the iron ores.

independently. In the hanging wall of No. 2 are shoot, at the bottom of the shaft, a new ore shoot was struck 8 feet in. At the point of cutting, the shoot was 8 feet thick, and the ore will probably run 65 to 68 per cent. iron. This shoot is being developed with the idea of determining its size.

During the summer of 1903 the water in the open cut was pumped out. This was done for two reasons. First, no surveys of the old Peters workings are extant, and it was not deemed safe to work in the shaft, only 100 feet distant, with this large body of water an unknown distance through possible drifts from the shaft.

Second, in case development warranted, it is planned to put down a permanent incline through the open cut and on No. 2 slope, so that ores from No. 2, No. 3 and No. 4 ore shoots can be raised with only one handling.

Since November 1st, a ladderway has been installed in the shaft, so that miners can have ingress and egress to the workings. A pump 12 x 16 x 12 feet has also been sunk at the foot of the shaft, a pump station has been cut out, a large pump installed and pipe and steam lines placed. This will enable pumps to deliver water to the surface with a single column.

It is also intended to come up on the slope of No. 2 ore shoot to the open cut, and to take the water there to the shaft and from there to the surface.

No ore is being shipped from the mine now. No ore is being broken except what is necessitated in pushing development work. This development work is being carried on and will be until such time as an ore reserve is opened up, sufficient to insure mining for one year. When this work is completed, the mine will be closed unless the market for iron ore brightens.

A 150 horse-power boiler, a large Ingersoll-Sargent air compressor and four large pumps have been added to the plant during 1903.

### THE THATCHER HEMATITE MINE.

The Thatcher mine, between New Village and Stewartsville, is being pumped and otherwise made ready for work. The ore is hematite of excellent quality, it is said.

## The Zinc Mines.

James B. Tonking, Superintendent of the New Jersey Zinc Company's mines at Franklin Furnace, has kindly furnished the following notes regarding their operations during the year. It is gratifying to observe the steady increase in the production of these mines during the last few years.

Throughout the whole year the work of development has been prosecuted for the purpose of still farther blocking out the ore body. The usual irregularities in the country rock formation, causing the walls to bend in and out both on strike and dip, have continued, and the usual variations of lean and rich ore have been passed through, together with masses of garnet and rock intrusions here and there.

The developments in the Parker mine, which represents the northeasterly end of the deposit, have been of interest, owing to the installation of a diamond drill for the purpose of exploring below the lowest point in the deposit and in an easterly direction. Nothing was found in either direction indicating any new ore bodies.

In the Taylor mine, which represents the southwesterly end of the deposit, the work of most interest was that of extending a raise from the 700-foot level in the direction of Trotter mine No. 4 shaft, and the turning off from this raise the 50-foot levels as elevation for each one was reached. During the coming year it is anticipated that connection will be completed, giving these mines a third outlet, which is always desirable in a property of this kind.

The open work was continued through a large portion of the year. A considerable quantity of the ore in the direction of the large dike on the west leg above the old tunnel level was removed. Nothing was done below the tunnel level in this connection.

The total product mined for the year was 279,419.03 gross tons, a gain of 70,033 tons over 1902.

The Trotter mine at Franklin Furnace, N. J., and the Stirling Hill mines at Ogdensburg, New Jersey, were inactive throughout the year.

## Copper Mining.

The New Jersey copper mines and minerals noted in previous Annual Reports have been steadily kept in view during the past year by the various groups of business men. At present New Jersey does not contribute to the world's copper supply, although there is some prospect of copper being produced in New Jersey shortly.

The following notes have been obtained from owners of the mines mentioned:

### AMERICAN COPPER MINE, SOMERVILLE, N. J.

The following details of work at this mine during the last two years have been furnished by Josiah Bond, General Manager, with the permission of J. C. Reiff, President.

The main incline shaft has been sunk from 1,110 to 1,240 feet, and some work was done in the drifts to the amount of 240 feet, making the mine a total of 1,400 feet slope and 2,040 feet of side drifts, not including portions of the old work.

The showing made by this new work, all in the deeper part of the mine has been the most encouraging. The values are now practically all in native copper, other forms being confined to joint faces, etc., along which percolating waters have had readiest passage, and constitute only about one-quarter of one per cent. of the whole. As indicated in the last report the copper has increased in size, pieces weighing one-half to three-quarters of a pound in weight having been found. The ore nodules have increased in size and in copper content, one mass of large size running 30 per cent. copper.

In order to relieve the pumps during heavy rains by drawing away the surface waters where they run down through the broken trap near the outcrop, a drainage tunnel, starting at a point 130 feet down the main slope and draining a vertical depth of 24 feet, has been completed through the red shales beneath the trap. It has proved a very successful economy, handling at flood times as much as 125 gallons of water per minute, all of which formerly had to be pumped. In driving it copper was encountered about

8 feet beneath the trap in nodules, and in a fissure three-sixteenths of an inch wide about 15 feet below the trap. This last was a solid sheet of red oxide coated with sillicates. After the completion of the drainage tunnel, exploratory work was done on the outcrop between the main shaft and Chimney Rock, four miles distant. At one spot a shaft was sunk, and the ore proved to be 28 inches in thickness, with every evidence of having been rich in copper. This shaft was carried down on the ore about 25 feet, and the showing, as anticipated, was most satisfactory.

Development work has also been done at Chimney Rock gorge where the ore body has been uncovered at three different places, covering 500 feet of the outcrop, and found to be exactly the same as at the main shaft. It shows good values in copper and silver. An adit under the floor of the quarry and on the ore bed was started, but was so much interfered with by falls of stone from the quarry face, that it was discontinued after going about 50 feet. But the showing here, as expected, from its depth on the ore body (from the outcrop), was very fine; specimens of native copper of half to one and a half pounds being encountered, and five hand specimens carrying leaves of native silver. The vein holds its thickness and is in nowise different from the other localities.

This exploratory work gives us the certainty of a strong continuous lode, and the copper values are shown to be continuous also. For general purposes the past summer's work was the most valuable ever done to prove the wide extent of payable ore.

Experiments have been carried on in the laboratory in leaching and treating ores. Mr. Bond reports that the copper has been found to carry about 50 oz. silver and $15.00 gold to the ton, making a respectable addition to its value. The copper is asserted to be very fine, and will command a price slightly higher than market.

### GRIGGSTOWN MINE.

Owners, Isaac D. Gabel, Bordentown, N. J., Robert Dixon, of New York.

This mine is two and a half miles from Rocky Hill station, Pennsylvania Railroad.

The grandson of Capt. Rule, who was first manager of the mine, states that miners from Wales worked this property in Colonial times and carried the ore back to England to be treated. It is stated that at one time 160 miners were employed at the mine, but the Revolutionary War put an end to operations.

The present owners have drained and cleaned out one old shaft to the 100-foot level. They also sunk a shaft at 45°, with a cable skip-way to 100-foot level. So far no ore has been either shipped or treated, although there is said to be considerable in sight. Numerous assays made for the owners are said to run considerable values in gold and silver, as well as promising well in copper, but these have been made on selected samples. One sample collected by a member of the Survey from the so-called gold-vein failed to show upon analysis any values in gold and silver. There should be a systematic sampling of the mine by a disinterested expert, supplemented perhaps by diamond drilling to determine better the extent of the ore, before any considerable sum is expended in attempting to put the mine on a commercial basis.

### PAHAQUARRY MINE.

Montgomery Gold Leaf Mining Co., owners; office, Belvidere; H. D. Deshler, Secretary.

During the past year we are informed development work has been carried on. The company are now experimenting with various methods of treatment and expect to erect a plant shortly. However, a tunnel has been started near the level of the Delaware river intending to cut the vein which has a 45° dip. This has now penetrated 240 feet.

The ore is chalcocite impregnating sandstone which is changed to the basic carbonates of copper near the surface.

### THE ARLINGTON COPPER COMPANY.

Addison Ely, Rutherford, N. J., informs us that no work has been done during the past year, but that it is intended to begin operations the coming year. The company has been reorganized.

## Portland Cement Industry.

The New Jersey Portland cement industry is in every way in a most flourishing condition. Practical experience of the manufacturers has confirmed the studies of the State Geological Survey, that there is a practically inexhaustible supply of excellent cement rock in this State.

New Jersey still holds second rank as a producer of Portland cement, being exceeded only by Pennsylvania. Furthermore, New Jersey cement brings as high a price as any cement in the open market—a practical demonstration of the excellency of the natural rock and the skillful, scientific and technical treatment accorded it by the manufacturers. The works are all administered in the utmost progressive spirit, all manner of labor-saving machinery being in use and everything planned, so that a hand scarcely touches the material from the quarry to the car of shipment.

A prominent feature of the current year is the putting in operation of the huge Edison plant, at New Village, the lamentable explosion in the coal pulverizing plant having necessitated extensive alterations and delays. This plant is a radical departure in cement manufacture, and the results of this huge automaton will be watched with interest by the whole technical world.

So far no new plants have been begun in New Jersey, and it is well that a certain amount of caution is exhibited.* The care not having to be with lack of raw material, but rather with the danger of over production.

### THE ALPHA PORTLAND CEMENT COMPANY.

Works at Alpha, N. J. (Lehigh Valley R. R.); office, First National Bank Building, Easton, Pa.

In 1891 Thos. D. Whitaker commenced the manufacture of Portland Cement on advice and information furnished by the

* See "Stone," N. Y., Vol. XXVI, No. 4, p. 343.

QUARRY AND WORKS OF THE ALPHA PORTLAND CEMENT COMPANY.

New Jersey Geological Survey. In 1895 the present operators purchased the plant, which then had a capacity of from 500 to 700 barrels per day. The rock at Alpha produced such an excellent cement that the plant was gradually increased until in 1900 there were ten kilns with a capacity approximating 2,000 barrels per day. In 1901 a new mill of the same capacity was erected; the former being known as Mill No. 1 and the latter as Mill No. 2. In the summer of 1903 four more kilns were added to Mill No. 2, making 14 kilns for this plant. This company is now manufacturing at Alpha about five thousand barrels daily. Since the Survey's report of the Portland Cement industry in 1900, in which the distribution of the cement rock was delineated, the company has increased its holdings from 40 acres to 200 acres. The quantity of cement manufactured by this company since its inception is, in round numbers, 6,000,000 barrels.

A boring made by the company showed the rock to extend 325 feet from the surface.

| | | |
|---|---|---|
| 1894, | 100,000 | barrels. |
| 1895, | 120,000 | " |
| 1896, | 215,000 | " |
| 1897, | 325,000 | " |
| 1898, | 350,000 | " |
| 1899, | 380,000 | " |
| 1900, | 500,000 | " |
| 1901, | 830,000 | " |
| 1902, | 1,180,000 | " |
| 1903, | 1,400,000 | " |

The rock used at Alpha is a soft, friable argillaceous slate or shale, which is referred to the Trenton epoch. The strata dips steeply to the south. Its upturned edges are irregularly eroded and overlaid by from four to ten feet of heavy yellow clay. Percolating surface waters, of course, have found easy access to the almost perpendicular strata, and on their downward way have removed the calcium carbonates as bicarbonate by means of the carbonic acid in them, $H_2CO_3 + CaCO_3 = H_2Ca\ (CO_3)_2$. Farther down, with increased pressure, the calcium carbonate has been re-deposited as normal crystallized calcium carbonate or calcite. Large masses of this mineral with rhombohedral cleavages two or three inches on the faces are found, as well as rounded scalenohedrons thickly studding fissures and lining cavities with mammalary crystalline surfaces. These last-mentioned crystals with their confused groupings are often covered with a thin film, giving them an amberoid appearance, with the iridescent sheen of an oily film on water.

The upper portions of the shale are not only poorer in lime, and, consequently more aluminous than the lower sections of the same strata, but are white and free from carbon, while the same layer as it increases in depth also increases in color, passing through leaden gray almost into a black graphitic slate. It seems reasonable to assume that percolating meteorologic water carried considerable dissolved oxygen with it. That as the water worked downward through the upturned rock the dissolved oxygen reacted with the carbonaceous matter in the rock thus:

$$n\,H_2O_2 + C = CO_2 + n\,H_2O.$$
$$CO_2 + H_2O = H_2CO_3.$$

and that the carbonic acid ($H_2CO_3$) reacting with the calcium carbonate content of the shale formed, as before indicated, bicalcium carbonate, which in lower levels was again precipitated as the normal salt in the form of calcite.

The method of quarrying at the Alpha is to drill across the strata with steam drills and break down the rock with dynamite, and load it on mine cars with a steam shovel. These cars are then hauled up an inclined railroad by a cable. Four tracks are in use at Alpha, two for each mill. In practice it is found necessary to bring up the lime content by the addition of limestone (so-called calcite) imported from Pennsylvania. The exact ratio of "calcite" to cement rock is determined by chemical analysis and calculation continuously, a number of chemists being employed. The proper blend of "calcite" and "cement rock"* is dumped into Gates crushers and reduced to less than an inch. The crushed "blende" is next dried in continuous rotary dryers. After drying

* For a brief outline of the chemistry of cement see Annual Report of the State Geologist for 1900 or further in "The Cement Industry" reprinted from Engineering Record, N. Y., 1900.

it is ground in tube and ball mills and then fed to the continuous rotary kilns of the conventional type, using pulverized coal with air under pressure as fuel. The constant flow of "clinker" (as the burned mass is called), is partially quenched as it passes in the link belt conveyor to the cooling towers. The product is finally ground to an impalpable powder in Griffin mills and allowed to "age" in ample warehouses. The whole works are equipped with automatic conveyors of the screw and link belt type, and a hand rarely touches the material from quarry to warehouse.

### THE VULCANITE PORTLAND CEMENT COMPANY.

Works at Vulcanite, N. J. (Central R. R. of N. J.); office, Real Estate Trust Building, Philadelphia, Pa.

In 1894 the directorate of the Vulcanite Paving Co. of Philadelphia, in order to be assured of an adequate supply of first quality cement to use in their paving contracts, commenced the erection of a plant close to the Alpha works. The original mill* had 5 rotary kilns. Later No. 2 mill, with 6 kilns, was erected. Finally an additional factory of 10 more kilns was installed. Since the report on the Portland Cement Industry, 1900, the company has increased its holdings of cement rock land from 205 to 250 acres.

The output to date is given as follows:

| | BARRELS. |
|---|---|
| 1895 (6 Mos.), | 14,000 |
| 1896, | 60,000 |
| 1897, | 125,000 |
| 1898, | 218,000 |
| 1899, | 513,000 |
| 1900, | 690,000 |
| 1901, | 725,000 |
| 1902, | 975,000 |
| 1903, | 1,460,000 |

* Plant described in "The Cement Industry," New York, N. Y., 1900, p. 94. Also see handsome brochure issued by the company, no date.

The rock of the Vulcanite quarries as pointed out in 1900 by Dr. Kümmel* (where analyses are given which are similar to these to-day) is like that at Alpha. However, the same chemical changes due to percolating meteorologic waters have not taken place on so extensive a scale as at Alpha. The planes of slaty cleavage are not so open, and the rock is firmer and less altered. No calcite was found deposited as crystals, although in the eroded uptorn portions of the rock, which had been stripped of residuary clay, remains of what Dr. Kümmel considered crinoids were observed.

Two quarries, utterly independent of each other, are operated as pits. The rock, broken down by dynamite, is hoisted and conveyed by wire cable tramways to the mills. Two independent cableways are operated at each pit.

THE EDISON PORTLAND CEMENT COMPANY.

Works at New Village, D., L. & W. R. R.; office, Girard Building, Philadelphia.

The plant mentioned in this annual for 1900† was put in operation in October of this year, and to date has made about 80,000 barrels.

The quarries are some two miles from the works and are connected therewith by a standard gauge railroad. Both "cement rock" and limestone occur in close proximity. The rock in a general way resembles that of the quarries already mentioned, although of course the excavations are not nearly so extensive as yet. A rather radical departure from quarrying methods is being inaugurated in the form of a movable roof over each quarry. This is of corrugated iron on light steel frames resting on wheels which in turn run on a T-rail track. By thus covering the quarry it is intended to work it in all weathers, the roof being moved as quarrying proceeds. After being blown down the rock is loaded into cars with steam shovels.

* Loc. Cit., pp. 22 and 43.

† P. 29.

The mill is a radical departure from most cement mills. The rock is dumped on a train of corrugated rolls, the first pair being five feet wide by five feet in diameter. The other two pair in the series are three feet wide with corrugations decreasing in width. A rock weighing five or six tons will be reduced to one-half inch and less by this treatment.

A belt conveyor takes the crushed rock to a dryer, which is a tower heated from a furnace at the bottom. The crushed rock, entering the top of the tower, is allowed to fall on a series of opposite plates having a reciprocating motion; the material in its downward course is alternately held and dumped from plate to plate. Reaching the bottom of the drying tower, the now steaming rock is taken by conveyor to the rock stock house, which is maintained at a high temperature, and exhausted with a fan. On its way thither the "crush" is automatically sampled for chemical analysis. From the rock store house the crushed rock is conveyed by link belt as needed to the weighing and mixing house where the amount of limestone required to bring up the calcium content, as determined by analysis and calculation, is added. The blended rocks are automatically conveyed to the "chalk grinding house," where, by passing them through rolls, the half-inch "blende" is partially reduced to an impalpable powder.

Another radical departure is the treatment accorded the ground "chalk" when it reaches "blower house, No. 1," by belt conveyor from the grinding house. Here by means of air blasts the very finely divided material is blown from the coarser particles which are returned automatically to the grinders. The fine chalk is stored until required at the kilns. So far two kilns only have been installed and one only is in operation. They are of extraordinary construction, being 9 feet in diameter and 150 feet long. (The usual practice is not to use rotary kilns over 60 feet long.) The finely ground coal used in a blast of compressed air as fuel in the kilns, was formerly ground and winnowed as described in the treatment of the "chalk," but a lamentable explosion occurred in this department when the plant was first put in operation by the sparking of an electric motor igniting the explosive mixture of air and coal dust. At present the coal is ground in ball and tube mills. As the clinker leaves the kiln proper it passes through a revolving drum which serves to partially cool it. It is then received by a bucket and chain conveyor, slightly quenched and passed on to the clinker store house from whence it is drawn as required to the "clinker grinding house." This contains two sets of fine grinding rolls. The material issuing from these rolls is separated by winnowing in "blower house, No. 2," just as is done in the "chalk" grinding house and the material that has not been sufficiently reduced is returned to be re-ground. It is stated that 85 per cent. of the finished product will pass through a two hundred mesh screen.

The bagging and barreling is all done automatically, and we are informed that so automatic is the plant in every respect that only six more men are required to increase the output of from 1,200 to 2,500 barrels per day.

# Mineral Statistics

## For the Year 1903.

### IRON ORE.

The total production of the mines, as reported by the several mining companies, was 289,323 tons.

The table of statistics is reprinted, with the total amount for 1903 added.

TABLE OF STATISTICS.

| *Year.* | *Iron Ore.* | *Authority.* |
|---|---|---|
| 1790 | 10,000 tons | Morse's estimate. |
| 1830 | 20,000 tons | Gordon's Gazetteer. |
| 1855 | 100,000 | Dr. Kitchell's estimate. |
| 1860 | 164,900 tons | U. S. census. |
| 1864 | 226,000 tons | Annual Report State Geologist. |
| 1867 | 275,067 tons | " " " |
| 1870 | 362,636 tons | U. S. census. |
| 1871 | 450,000 tons | Annual Report State Geologist. |
| 1872 | 600,000 tons | " " " |
| 1873 | 665,000 tons | " " " |
| 1874 | 525,000 tons | " " " |
| 1875 | 390,000 tons | " " " |
| 1876 | 285,000 tons* | " " " |
| 1877 | 315,000 tons* | " " " |
| 1878 | 409,674 tons | " " " |
| 1879 | 488,028 tons | " " " |
| 1880 | 745,000 tons | " " " |
| 1881 | 737,052 tons | " " " |
| 1882 | 932,762 tons | " " " |
| 1883 | 521,416 tons | " " " |
| 1884 | 393,710 tons | " " " |
| 1885 | 330,000 tons | " " " |
| 1886 | 500,501 tons | " " " |
| 1887 | 547,889 tons | " " " |
| 1888 | 447,738 tons | " " " |

* From statistics collected later.

| *Year.* | *Iron Ore.* | *Authority.* |
|---|---|---|
| 1889 | 482,109 tons | Annual Report State Geologist. |
| 1890 | 552,996 tons | " " " |
| 1891 | 551,358 tons | " " " |
| 1892 | 465,455 tons | " " " |
| 1893 | 356,150 tons | " " " |
| 1894 | 277,483 tons | " " " |
| 1895 | 282,433 tons | " " " |
| 1896 | 264,999 tons | " " " |
| 1897 | 257,235 tons | " " " |
| 1898 | 275,378 tons | " " " |
| 1899 | 300,757 tons | " " " |
| 1900 | 342,390 tons* | " " " |
| 1901 | 401,151 tons | " " " |
| 1902 | 443,728 tons | " " " |
| 1903 | 289,323 tons | " " " |

* The figures, 407,596 tons, given in the report for 1900, included 75,206 tons of crude material which should have been reduced to its equivalent in concentrates.

## ZINC ORE.

The production of the New Jersey Zinc Company's mines is reported by Mr. James B. Tonking, Superintendent, to be 279,419 gross tons of zinc and franklinite ore. It was chiefly separated at the company's mills. This report shows a gain in production over 1902 of 70,033 tons.

The statistics for a period of years are reprinted from the last annual report.

ZINC ORE.

| *Year.* | *Zinc Ore.* | *Authority.* |
|---|---|---|
| 1868 | 25,000 tons† | Annual Report State Geologist. |
| 1871 | 22,000 tons† | " " " |
| 1873 | 17,500 tons | " " " |
| 1874 | 13,500 tons | " " " |
| 1878 | 14,467 tons | " " " |
| 1879 | 21,937 tons | " " " |
| 1880 | 28,311 tons | " " " |
| 1881 | 49,178 tons | " " " |
| 1882 | 40,138 tons | " " " |
| 1883 | 56,085 tons | " " " |

†Estimated for 1868 and 1871. Statistics for 1873-1890, inclusive, are for shipments by railway companies. The later reports are from zinc-mining companies.

| Year. | Zinc Ore. | Authority. |
|---|---|---|
| 1884 | 40,094 tons | Annual Report State Geologist. |
| 1885 | 38,526 tons | " " " |
| 1886 | 43,877 tons | " " " |
| 1887 | 50,220 tons | " " " |
| 1888 | 46,377 tons | " " " |
| 1889 | 56,154 tons | " " " |
| 1890 | 49,618 tons | " " " |
| 1891 | 76,032 tons | " " " |
| 1892 | 77,298 tons | " " " |
| 1893 | 55,852 tons | " " " |
| 1894 | 59,382 tons | " " " |
| 1895* | | |
| 1896 | 78,080 tons | " " " |
| 1897 | 76,973 tons | " " " |
| 1898 | 99,419 tons | " " " |
| 1899 | 154,447 tons | " " " |
| 1900 | 194,881 tons | " " " |
| 1901 | 191,221 tons | " " " |
| 1902 | 209,386 tons | " " " |
| 1903 | 279,419 tons | " " " |

* No statistics were published in the Annual Report for 1895.

# Publications.

The demand for the publications of the Survey is continuous and active. So far as possible requests for the reports are granted.

It is the wish of the Board of Managers to complete, as far as possible, incomplete sets of the publications of the Survey, chiefly files of the Annual Reports in public libraries, and librarians are urged to correspond with the State Geologist concerning this matter.

By the act of 1864 the Board of Managers of the Survey is a board of publication, with power to issue and distribute the publications as they may be authorized. The Annual Reports of the State Geologist are printed by order of the Legislature as a part of the legislative documents. They are distributed by the State Geologist to libraries and public institutions, and, as far as possible, to any who may be interested in the subjects of which they treat.

Five volumes of the Final Report series have been issued. Volume I, published in 1888, has been very scarce for several years, but all the valuable tables were reprinted in an appendix of Volume IV, of which a few copies still remain.

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.*

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 are undistributed.

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

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. Very scarce.

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part I. Mineralogy. Botany. Trenton, 1889, 8vo., x + 642 pp. (Postage, 25 cents.)

FINAL REPORT OF THE STATE GEOLOGIST. Vol. II. Part II. Zoology. Trenton, 1890, 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. (Scarce.)

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.)

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.) (By express.)

GASTEROPODA AND CEPHALOPODA of the Raritan Clays and Greensand Marls of New Jersey. Trenton, 1892, quarto, pp. 402, plates L. (Paleontology, Vol. II.) (By express.)

PALEOZOIC PALEONTOLOGY. Trenton, 1903, 8vo., xii + 462 pp., plates LIII. (Paleontology, Vol. III.) (Postage, 20 cents.)

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. It is the purpose of the Survey gradually to replace Sheets 1-17 by a new series of maps, upon the same scale, but somewhat differently arranged so as not to overlap. The new sheets will be numbered from 21-37, and will be subject to extensive revision before publication. These sheets will each cover the same territory as eight of the large maps, on a scale of 2,000 feet per inch. Nos. 2, 4, 5, 7, 11 and 12 have already been replaced as explained below.

*No. 1. Kittatinny Valley and Mountain,* from Hope to the State line.

*No. 3. Central Highlands,* including all of Morris county west of Boonton, and Sussex south and east of Newton.

*No. 6. The Valley of the Passaic,* with the country eastward to Newark and southward to the Raritan river.

*No. 8. Vicinity of Trenton,* from New Brunswick to Bordentown.

*No. 9. Monmouth Shore,* with the interior from Metuchen to Lakewood.

*No. 10. Vicinity of Salem,* from Swedesboro and Bridgeton westward to the Delaware.

*No. 13. Vicinity of Barnegat Bay,* with the greater part of Ocean county.

*No. 14. Vicinity of Bridgeton,* from Allowaystown and Vineland southward to the Delaware bay shore.

*No. 15. Southern Interior,* the country lying between Atco, Millville and Egg Harbor City.

*No. 16. Egg Harbor and Vicinity,* including the Atlantic shore from Barnegat to Great Egg Harbor.

*No. 17. Cape May,* with the country westward to Maurice river.

*No. 18. New Jersey State Map.* Scale, 5 miles to the inch. Geographic.

*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. 22. Eastern Sussex and Western Passaic counties.* Replaces Sheet 4.

*No. 24. Southern Warren, Northern Hunterdon and Western Morris counties.* Replaces Sheet 2.

*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. 31. Vicinity of Camden,* to Mount Holly, Hammonton and Elmer. Replaces Sheet 11. (Ready in February or March.)

*No. 32. Part of Burlington and Ocean counties,* from Pemberton and Whitings to Egg Harbor City and Tuckerton. Replaces Sheet 12. (Ready in February or March.)

Other sheets of the new series, Nos. 21-37, will be printed from time to time, as the older sheets become 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 recent 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 Paterson, Hackensack, Morristown, Newark, Jersey City, Plainfield, Elizabeth, New York Bay, Amboy, Navesink, Long Branch, Shark River, Trenton East, Camden, Mount 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.

## 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. Very scarce.

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, 8vo., 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. Scarce.*

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

ANNUAL REPORT of the State Geologist of New Jersey for 1885. Trenton, 1885, 8vo., 228 pp., with maps.

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

ANNUAL REPORT of the State Geologist of New Jersey for 1887. Trenton, 1887, 8vo., 45 pp., with maps.

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

ANNUAL REPORT of the State Geologist of New Jersey for 1889. Camden, 1889, 8vo., 112 pp.

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. (Postage, 10 cents.) Scarce.*

ANNUAL REPORT of the State Geologist of New Jersey for 1892. Trenton, 1893, 8vo., x+368 pp., with maps. (Postage, 10 cents.)

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.)

ANNUAL REPORT of the State Geologist of New Jersey for 1897. Trenton, 1898, 8vo., xl+368 pp. (Postage, 12 cents.)

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.)

ANNUAL REPORT of the State Geologist for 1900. Trenton, 1901, 8vo., xl+231 pp. (Postage, 10 cents.)

* These reports can be supplied only to libraries.

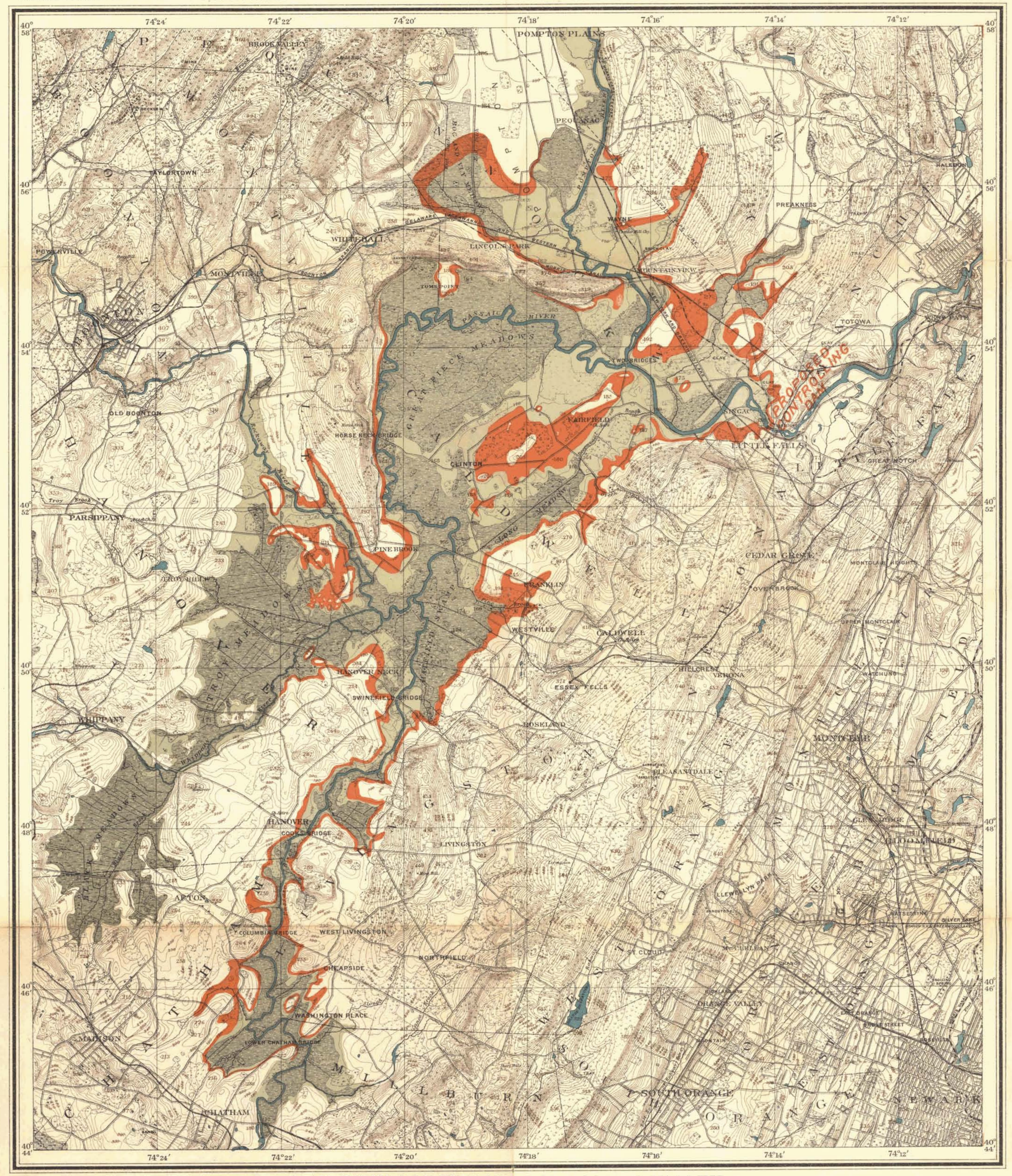
ANNUAL REPORT of the State Geologist for 1901. Trenton, 1902. 8vo., xxviii+178 pp., with one map in pocket. (Postage, 8 cents.)

ANNUAL REPORT of the State Geologist for 1902. Trenton, 1903. 8vo., viii+155 pp. (Postage, 6 cents.)

ANNUAL REPORT of the State Geologist for 1903.

# INDEX.

GEOLOGICAL SURVEY OF NEW JERSEY.
Henry B. Kümmel, State Geologist.
SURVEY
for a
TIDE WATERWAY
between
BAY HEAD AND MANASQUAN INLET.
Authorized by Act of the Legislature.
Approved April 7, 1903.
Scale of Feet
To Accompany Report of
C. C. Vermeule
Consulting Engineer
Section through Twilight Lake
Section, Baltimore Ave.
MEAN SEA LEVEL
POINT PLEASANT
BAY HEAD
BARNEGAT BAY
TWILIGHT LAKE
PROPOSED TIDE WATERWAY
MAXONS POND
LITTLE SILVER LAKE
COOKS POND
MANASQUAN RIVER
NEW YORK & LONG BRANCH RAILROAD
ELECTRIC RAILROAD
Squan Beach Excursion House
WASHINGTON AVE.
NEW JERSEY AVE.
ST. LOUIS AVE.
CHICAGO AVE.
FORMAN AVE.
TRENTON AVE.
LAUREL AVE.
ARNOLD AVE.
CENTRAL AVE.
BALTIMORE AVE.
PHILADELPHIA AVE.
NEW YORK AVE.
BOSTON AVE.
OCEAN AVE.
SEA AVE.
OSBORN AVE.
DIVISION AVE.
MOUNT ST.
HOWE ST.
BRIDGE AVE.
LAKE AVE.
MAIN AVE.
EAST AVE.
Note.
Figures show elevation in feet, of the earth's surface above or below mean sea level, + indicates above − indicates below.
ATLANTIC OCEAN
Barnegat Bay
Twilight Lake
Maxon's Pond
Bottom of Canal
HIGH WATER AUG. 30, 1903.
MEAN HIGH WATER
MEAN LOW WATER




# MAP OF FLOODED LANDS IN PASSAIC VALLEY

Scale one inch to a mile.

*The Blue Tint shows Lands submerged Oct. 10, 1903.*
*The Red Tint shows additional Lands which would have been submerged with Controlling Dam.*