SPECIAL REPORT

—OF—

PASSAIC VALLEY

SEWERAGE COMMISSIONERS

—TO THE—

GOVERNOR OF THE STATE OF NEW JERSEY.

Submitted June 8, 1903

WITH LETTER OF C. W. RAYMOND,

Lieut. Col., Corps of Engineers,

AND REPORTS OF

GEN. HENRY M. ROBERT,

G. S. GREENE, Jr., C. E.,

E. W. HARRISON, C. E.,

O. H. TITTMANN, Superintendent,

WILLIAM BARCLAY PARSONS,
Consulting Engineer,

And ALLEN N. SPOONER, C. E.

BAKER PRINTING COMPANY,
NEWARK, N. J.

INDEX.

SPECIAL REPORT

OF

Passaic Valley Sewerage Commissioners.

To His Excellency, Franklin Murphy,
Governor of New Jersey.

SIR.—By an act of the Legislature of this State, entitled "An act to relieve from pollution the rivers and streams within the Passaic Valley sewerage district, established and defined by an act of the Legislature, entitled 'An act to create a sewerage district to be called the Passaic Valley sewerage district,' approved March twenty-seventh, one thousand nine hundred and two, and for this purpose establishing therefor a district board of commissioners, defining its powers and duties and providing for the appointment, terms of office, duties and compensation of such commissioners, and further providing for the raising, collecting and expenditure of the necessary moneys," which act was approved April 22nd, 1903, it is provided in the fifth section thereof that "before any moneys expended or obligations are incurred for the construction of any trunk or outlet sewer which shall discharge into New York Bay, the said board shall carefully investigate whether said discharge is likely to pollute the waters of said bay within the jurisdiction of the State of New York to such an extent or in such a degree as to cause a nuisance to persons or property within said State, and shall present the result of their investigation to the Governor with their opinion thereon and the reasons for their opinion."

In obedience to the provision above quoted we, the Passaic Valley Sewerage Commissioners, respectfully report to your Excellency that we have, since the enactment of the said law, carefully investigated whether the discharge from the trunk or outlet sewer provided for in the said law is likely to pollute the waters of said bay, within the jurisdiction of the State of New York, to such an extent or in such a degree as to cause a nuisance to persons or property within said State. The result of our investigation is that the said discharge is not

likely to pollute the waters in said bay, within the jurisdiction of the State of New York, to such an extent or in such a degree as to cause a nuisance to persons or property within said State.

The undersigned recognized the fact that the question presented to them in the said law for solution was one for scientific investigation and careful research, and that it was necessary to call to our aid men who, through education and training, as well as from personal knowledge of tidal flow and current courses in the Bay of New York, were peculiarly qualified to supply the needed information. We were particularly fortunate in securing the services of engineers, not only of the highest personal character and professional reputation, but men who have made a study of the conditions existing in the Bay of New York. We directed these gentlemen to carefully investigate and report upon the identical question submitted to us for determination. Their reports, made after such investigation, are attached to this report and made a part of the same.

General Henry M. Robert is recognized as one of the most eminent engineers of this country. He is a graduate of West Point, has to his credit a service of forty-four years as an officer in the engineering department of the military branch of the service, and when placed on the retired list, in 1901, occupied the high position of Chief of Engineers of the United States Army. He was for many years a member of the Harbor Line Board of New York, and for a number of years he was president of the board. The performance of the duties imposed upon him by this position made him thoroughly familiar with the Bay of New York, its tidal flow, the courses and conditions of its currents, and similar conditions in adjacent waters. He is, and was at the time of his employment by the commissioners, perfectly acquainted with conditions existing in the Bay of New York at the point selected for the outfall of the trunk sewer.

Mr. George S. Greene, Jr., is an engineer of high standing in the profession. For many years he was a member of the Dock Department of New York city, and from 1875 to 1898, for a period of twenty-two and one-half years, he held the position of Engineer in Chief of the Department of Docks of that city, and while in that position he studied and observed the waters of the harbor and their movements, and the result of sewage discharged into the waters of the harbor and other matters concerning its welfare.

Mr. E. W. Harrison, of Hudson County, New Jersey, is an engineer of eminence. Prior to his employment by us he had made a personal study of the Bay of New York, with reference to the identical question before the commission.

We have also had the benefit of a report made by Engineers, Messrs. Rudolph Hering, J. J. R. Croes and William M. Brown to the State Sewerage Commission, and which is contained in the report of that commission to the Legislature of 1902.

Shortly after the appointment of this commission we communicated with the authorities of the general government, with a view of ascertaining if there was any likelihood of federal interference with the contemplated project. The matter, after passing through the various channels of the War Department, came to the hands of Lieutenant-Colonel C. W. Raymond, and his report, in the form of a letter, is attached hereto and made a part of our report.

We have also consulted with our engineer, Mr. Rudolph Hering, whose views on this particular question are given in his report which is included in the report made by the commissioners to the Legislature at its last session. An extract therefrom, with page reference, is attached hereto.

There has been brought to our consideration an article which we have ascertained was prepared by Mr. Alfred D. Flinn, managing editor of the *Engineering Record,* and published in that journal under date of May 2nd, 1903, a copy of an extract from which article is appended to this report.

There has also been obtained from Mr. O. H. Tittmann, Superintendent of the United States Coast and Geodetic Survey, Washington, D. C., a statement showing the tidal flow through the Narrows, East River, and Kill von Kull. A copy of this communication is also attached.

In addition to these inquiries and studies, we have made a personal inspection of the locality of the proposed outfall, and have noted the distance of the location from the various points of land in the vicinity, and from the territory of New York.

The distance at which the outfall pipe sewer is located from the territory of New York State; the character of the sewage to be discharged; the preliminary screening it is to be subjected to; the depth of water at the outfall; the insignificant quantity of sewage when compared with the immensity of the tidal flow as shown by the reports annexed; the opinions of the

eminent engineers consulted by us, and whose reports are appended; the facts stated by Mr. Hering in his report to the commission, which is included in the report made by the commissioners to the Legislature at its last session; the facts stated in the various reports, letters and articles to which reference has been made herein, and which are appended hereto; and the information which we obtained from an examination and inspection of the locality where it is proposed to locate the outfall sewer pipe, are the reasons for our opinion that the said discharge is not likely to pollute the waters in said bay, within the jurisdiction of the State of New York, to such an extent, or in such a degree as to cause a nuisance to persons or property within said State.

Respectfully submitted this eighth day of June, 1903.

JULIUS A. LEBKUECHER,
FRANCIS CHILD,
(SEAL) PETER HAUCK,
JOHN HINCHLIFFE,
WM. McKENZIE,
Commissioners.

Attest:
JOHN S. GIBSON,
Clerk.

REPORT OF GEN. HENRY M. ROBERT.

Haworth, N. J., May 19, 1903.

The Passaic Valley District Sewerage and Drainage Commissioners, Newark, N. J.

GENTLEMEN.—In compliance with your request for my opinion as to whether the discharge of the sewage of the Passaic Valley District into New York Bay, according to the plan of Mr. Rudolph Hering contained in your annual report of 1903 to the Legislature, is likely to pollute the waters of said bay within the jurisdiction of the State of New York to such an extent or in such a degree as to cause a nuisance to persons or property within said State, I have the honor to submit the following:

The present population of the Passaic Valley Sewerage District is nearly 510,000, and the sewage to be disposed of

daily amounts to about 107,000,000 gallons, on the liberal basis of a daily average of 210 gallons of sewage per inhabitant. The plans, however, provide for eventually disposing of three times this quantity of sewage, or nearly 330,000,000 gallons daily, accommodating a population of over 1,500,000.

The proposed point of discharge is in New York Bay about three-quarters of a mile north of Robbins Reef Light, where there is about seventy feet of water and a good current. It is proposed to place the outlet pipe 40 feet below mean low water. These arrangements are excellent to diffuse the sewage before it rises to the surface.

All the sewage enters the trunk sewer above the main pumping station, and is to be thoroughly screened before being pumped. This will ensure the removal of floating matter, which is not done with the sewage now discharged into New York Bay. It is also understood that means will be taken to keep out of the sewers a large amount of the silt removed from the streets by heavy rains.

As a result of all these measures the sewage will probably be more nearly free from impurities and objectionable matter than the average sewage of American cities, and will be discharged into New York Bay at the depth of forty feet where the water is deep and the current good.

The average ebb tide of the Hudson River at 39th street is about 7,000 million cubic feet, and the ebb at the Narrows (which includes East River) is about 13,800 million cubic feet, or twice as much as the Hudson alone. The full capacity of the proposed sewerage system is about 330 million gallons, or abount 44 million cubic feet.

The sewage will not be evenly distributed over the twenty-four hours, and so to be perfectly safe let us propose that the total amount of daily sewage has to be disposed of by one ebb tide, and that that tide is equal to the ebb tide of the Hudson River at 39th street. We would then have 44 million cubic feet of sewage to be carried away by 7,000 million cubic feet of water in the ebb tide, which would certainly be ample to prevent the sewage from proving a nuisance.

Before the sewage can reach any place where shell fish are cultivated it is believed that it will cease to be harmful.

In this connection it may be well to notice the fact that New York Bay now receives more than double the amount of sewage that the proposed sewerage system can possibly discharge into the bay, and that if the proposed plan were to-day

in operation it would not add fifteen per cent. to the sewage now discharged into the waters of New York Harbor.

In conclusion I would say, that it is my deliberate opinion that the discharge of the sewage of the Passaic Valley District into New York Bay according to the plan of Mr. Rudolph Hering contained in your annual report of 1903 to the Legislature of New Jersey, will not pollute the waters of said bay within the jurisdiction of the State of New York to such an extent or in such a degree as to cause a nuisance to persons or property within said State.

Respectfully submitted,

HENRY M. ROBERT.

REPORT OF GEORGE S. GREENE, JR.

New York, May 16th, 1903.

Hon. Julius A. Lebkuecher, Chairman Passaic Valley Sewerage Commission, 432 Prudential Building, Newark, N. J.

SIR.—In accordance with your request I have read and examined the report of Mr. Rudolph Hering, dated 13th December, 1902, to the chairman and members of the Passaic Valley Sewage and Drainage Commission, with the view of forming an opinion as to whether the discharge of sewage into the waters of New York Harbor would or would not create a nuisance to the inhabitants of New York or be in any way detrimental.

The maximum quantity of sewage, (and that only when the population is treble what it is now), estimated to be discharged at the outfall is 345,830,000 gallons, (page 39 of the report), equal to 46,110,666 cubic feet per day.

In U. S. Coast Survey Report of 1886, page 36, occurs the following:

TIDAL FLOWAGE N. Y. HARBOR.

Epitome of Results for Discharge 25th June, 1886.

East River (19th street.)	Cubic Feet.
Ebb (westerly)	4,454,937,257
Flood (easterly)	4,007,175,676
Excess of ebb	447,761,581

Hudson River, (39th street.)	Cubic Feet.
Ebb (southerly)	6,996,678,413
Flood (northerly)	6,225,985,545
Excess of ebb	770,692,868
Kill von Kull, (West New Brighton.)	
Ebb	1,790,103,372
Flood	1,712,415,362
Excess of ebb towards the Harbor	77,688,010
Narrows.	
Ebb (seaward)	13,819,895,144
Flood	12,703,616,481
Excess of ebb	1,116,278,663

Other sections concur remarkably well with these which are selected as the best.

	Cubic Feet.
Fresh water discharge of Hudson at 39th street, Aug. 11 and 12, 1865	385,346,424
Fresh water discharge of Hudson at Dobbs Ferry, Aug. 19 and 21, 1865	373,426,507

From the above the total flowage into and out of the upper harbor through the Narrows is about 13,800,000,000 cubic feet twice in 24 hours or a total of 27,600,000,000 cubic feet per day.

As the discharge or outfall of the sewage is to be on the westerly side of the main channel, and as there will be no sufficient force to push the sewage across the current of the channel, it is not proper to consider for localities above the Narrows this total volume of the water passing in and out of the upper harbor as that available for diluting or dissipating the sewage.

The North or Hudson River flowage may, however, fairly be taken as available for such purpose because the main if not the total volume of such flowage passes directly by the outfall or discharge pipe, and as the water of the ebb tide consists in large part of the water of the flood tide only the flowage of the ebb tide is taken into account.

The volume of flowage of the North River as given above on the ebb tide is about 7,000,000,000 cubic feet, or 14,000,000,000 cubic feet per day into which the sewage is to be discharged.

The volume per day of sewage discharged being 46,000,000 cubic feet and the volume of flowage per day being 14,000,000,000 cubic feet, the sewage is 1,304 or 0.00328 of the volume of flowage, in other words, less than 1-3 of 1 per cent. It is obvious, I think, that such a small amount of sewage in so large an amount of other water can have but little effect, if any, that is perceptible to the senses.

In Rafter & Baker's "Sewage Disposal of the United States," page 15, the average composition of sewage in the United States is given as 998 parts water, one part mineral matter and one part organic matter in 1,000. The mineral matter is carried for some time in suspension but finally settles to the bottom, while the organic matter is soon reduced to elements.

It is proposed in this sewage to use screens, to catch the floating material, and silt catchers to retain the heavier material, and therefore this sewage will probably have considerably less of mineral and of organic matter than the average sewage.

If it is considered the same, that is, 1 part in 1,000 of each mineral and organic material, the daily discharge of the sewage would contain 46,000 cubic feet of mineral or solid matter, which spread evenly over the bottom of 1,000 acres would make a layer about 1-1000 of a foot thick or 365-1000 of a foot per year. The area over which such material would be distributed would be many thousands of acres and the excess of 71,000,000 cubic feet of ebb tide flowage over flood tide flowage on the Hudson River, as shown in the Coast Survey Report quoted above, would carry much of it out to sea before falling to the bottom.

The area of the upper harbor (above the Narrows), of New York, is 26 square miles or about 16,640 acres.

Aside from the insignificance of the deposit of sewage, so far as New York interests is concerned, is the fact, that the outfall or discharge of the sewage is on the westerly side of the main channel and there is no sufficient force to push or carry the sewage across the axis of the current in the channel, and therefore the sewage, with whatever mineral or other matter it may contain, will be carried entirely along the shore of New Jersey, except for the short stretch of the Narrows, one side of which is Staten Island, where the current is strongest and will carry such matter past Staten Island and out into the lower bay or the ocean.

In addition to simple dilution by discharge into the large

volume of current I consider the plan of discharging the sewage at a depth of forty feet below the surface of value, because the sewage being fresh water and lighter than salt water has a tendency to rise, and in rising it will spread and be diffused, thereby increasing the dilution and dissipation of the sewage.

For the reasons above given I am of the opinion that the proposed discharge of sewage will not cause any nuisance to the people of New York or be in any substantial or consequential way detrimental to their interests.

Respectfully submitted,

(Signed) G. S. GREENE, Jr.

REPORT OF EDLOW W. HARRISON.

EARLE & HARRISON,
CIVIL ENGINEERS,
15-21 Exchange Place,
Jersey City, N. J.
FRANK H. EARLE,
EDLOW W. HARRISON.

May 29, 1903.

Hon. Julius A. Lebkuecher, Chairman, and Members of the Passaic Valley Sewerage and Drainage Commission, Newark, N. J.

GENTLEMEN.—In conformity with your request, contained in a letter from Mr. John S. Gibson, dated May 20, 1903, that I should make a report to you, and give my opinion as to the likelihood of the discharge of the contemplated sewer, proposed to be built under your direction, polluting the waters of New York Bay, within the jurisdiction of the State of New York to such an extent, and in such a degree as to cause a nuisance to persons or property within said State, I have the honor to say as follows:

I have made a careful study of the act approved April 22, 1903, authorizing said sewer, and also the report of your commission to the Legislature, Session of 1903, and the annexed report of your Chief Engineer, Mr. Hering, and the plans attached thereto.

As I understand the proposition, it is intended to receive

and convey all foul and polluted water now entering the Passaic River from near Great Falls in Paterson, to a point of final disposal into the waters of the upper bay of New York, near Robbins Reef Light, within the State of New Jersey, and, to quote the terms of Section 4 of the act "which place, or places of deposit, discharge, or outfall shall be, at least, one and one-quarter miles, measured at right angles in an easterly direction from the exterior line for solid filling in New York Bay as now established by the Riparian Commission of this State, and in a tidal channel of not less than forty feet in depth at mean low water."

I find, by producing the line shown upon the map accompanying your engineer's report, into the waters of New York Bay, in the direction called for by the act, that the depth of forty feet in the main channel of the bay, will be reached at a distance approximately 7,500 feet, or 1.42 miles outside of the exterior line for solid filling, and this point is about 2,000 feet, measured upon the same line produced, from the State line, and within the boundaries of the State of New Jersey. Between the boundary line of the State of New Jersey and the point of outfall, lies the main channel of the bay, which is here seventy-five feet deep at low water.

I also understand that the works contemplated by you, are to have a maximum capacity sufficient to accommodate a population of 1,500,000 people, and are to be capable of discharging into the bay, when completed, 326,000,000 gallons each twenty-four hours, but that the first outfall pipe under New York Bay is only to have a maximum capacity of 120,000,000 gallons per day.

It is also understood that all except the first flow of the street washings in a rain storm, and all ground waters, as far as possible, are to be excluded from this sewer, and that the plant is to be provided with silt catchers and screens to hold back, break up, or remove any floating matter which might pass into the bay.

The upper bay of New York, with the East River, and the lower reaches of the Hudson River in front of the City of New York, now receive sewage from a population of approximately 4,500,000 people.

By the consummation of your plans, there will be added to this sewage, at once, sewage from, approximately, a population of 500,000 more.

The proper consideration of the problem presented, requires—first, that the present effect of the discharge of this large quantity of sewage in the rivers and bay, be studied; also the effect of the present addition proposed by your plan, and lastly, the probable effect of a large increased discharge from all sources in the same basin with the future growth of population, and the probable limits beyond which such increase cannot go without danger of creating a general nuisance.

In this study, the tidal basin and all the sewerage systems now, or proposed to be made tributary to it, must be considered as a whole. After this is done, the more limited, or local effect of the system contemplated by your commission, upon the situation, may be studied.

In order to arrive at a basis of comparison, the amount of sewage per head, may be taken at the average water supply per head per diem in the communities served. This is about 100 gallons per person.

Your engineer has designed your sewer on a basis of about 217 gallons per person per diem, for a maximum service of 1,500,000 persons. A maximum discharge is provided for, of 326,000,000 gallons per day, but this computation allows for foul street washings and a certain proportion of ground water which cannot be prevented from reaching the sewers.

Experiments and experience have shown that in the sewage of eastern American cities, this 100 gallons per head will contain about 1-1000 part of organic matter and about the same of inorganic or mineral matter, or about a little less than one pound of organic matter to each person per day, this including the discharge from water closets, privies, sinks, and other house drainage, and a proportionate amount of the organic matter from the foul water of the street and manufacturing establishments, any increase in liquid tending to reduce the proportionate amount of organic matter.

A very large part of the sewage to be expected from the drainage district of the Passaic Valley, especially in the upper section, will be discharge from manufactories, but a very large proportion of this discharge is inorganic.

Accepting for computation, this basis of 100 gallons per head, we find there will be, on completion of your works, discharged into the rivers and bay forming the harbor of New York, from the cities of New York, Jersey City, Hoboken, and other towns in Hudson County, N. J., and the area drained by the proposed sewer, about 500,000,000 gallons of sewage per

day, based upon 100 gallons per head, carrying with it rather less than 5,000,000 pounds of organic matter.

Almost all of the present sewage now reaches the outfall of the river or bay, practically fresh, and the plans proposed for your sewer are such that this will be the case for the sewage from the Passaic Valley district. The sewage will have such a velocity in the sewers, as to reach the outlet before any extensive bacterial action has operated upon it. Having reached the outlet, its final disposal depends upon the action of several distinct circumstances or forces.

And here it should be noted that a discharge into a tidal estuary of the character of New York Bay, open to the free movement and influx of the salt water of the ocean, presents an entirely different proposition from the discharge of sewage into a running fresh water stream, no matter what the volume of that stream may be; and the limitations as to allowable proportion of sewage to the volume of flow, the rapidity of current, depth of stream, conditions as to use of water below for potable purposes, and the variations of freshet and low water flow, do not apply.

The final disposal of sewage delivered into New York harbor is accomplished by a number of forces and influences:

First—Dilution by the salt water.

Second—Chemical; the antiseptic effect of salt water upon the organic constituents of the sewage, and their oxygenation by the dissolved oxygen in the water, and the precipitation of these constituents by the salts contained in the sea water.

Third—The consumption of the organic matter in the sewage, as food, by the marine life with which the water teems, and

Fourth—Transportation from the point of discharge into the great reservoir of the ocean, by the tidal current.

DILUTION.

As to the measure of dilution—we have seen that, including the first works to be built by you, the discharge of sewage of standard strength into the harbor of New York, will amount to 500,000,000 gallons per day. That is, reduced to cubic feet, about 67,000,000 cubic feet.

The tidal estuary of New York bay, considered as a reservoir basin, within the Narrows, omitting the Kill von Kull and waters west thereof, may be considered to be made up of

the upper bay, from the Battery to the Narrows; the East River from the Battery to Hell Gate, and the Hudson River from the Battery to 140th street.

The area of the upper bay is about 551,000,000 square feet.

The area of the East River to Hell Gate, is about 98,000,000 square feet.

The area of the Hudson River to 140th street, is about 224,000,000 square feet, making in all 873,000,000 square feet, or about 30.5 square miles. The average depth of the bay at low water is 26 feet; of the East River, about 38 feet, and of the Hudson River, about 31 feet.

There is contained in this basin, to the plane of mean high water:

In the upper bay, about 17,000,000,000 cubic feet.

In the East River, 4,264,000,000 cubic feet, and

In the Hudson River, 8,000,000,000 cubic feet, making in all 29,264,000,000 cubic feet.

The ebb discharge through the Narrows, each tide, as computed by the U. S. Coast Survey, and contained in report of 1886, pp. 36, was, in the month of June, after all spring freshet flow of the tributaries had ceased, 13,820,000,000 cubic feet, or, in twenty-four hours, twice this amount, or 27,640,000,000 cubic feet.

Thus it will be seen that each day there is discharged from the harbor of New York, into the great expanse of the lower bay and the ocean, a volume of water almost equal to the total cubical contents of the bay and two rivers south and west of Hell Gate and 140th street; that is, an amount of water, practically equal to all the water contained in this great basin, moves out to sea each twenty-four hours.

Thus into this volume of water, amounting to 29,264,000,000 cubic feet, which is practically changed and refreshed each day, we will have a discharge of standard sewage at 100 gallons per head per person, of about 67,000,000 cubic feet; that is, for each part of sewage, we have 431 parts of river and bay water. Carrying the comparison further, each pound of organic matter will be diluted with 43,100 gallons of salt water.

It may be contended that this comparison is unfair because, by the oscillation of the tides, a certain proportion of the sewage polluted water is carried back into the Narrows and up streams by the action of the flood tide, and the discharge, during the flood tide, is carried up stream and does not start on its journey seaward until the next ebb, and then from a point

far above its point of discharge. This, of course, is correct to a certain extent, but this enormous quantity of slightly polluted water, amounting to nearly one-half of the total volume of the basin, which passes through the Narrows in the ebb current, at once mingles with the great body of water in the lower bay and the adjacent ocean. The lower bay, inside of the bar between Coney Island and Sandy Hook, has a tidal prism of about 14,000,000,000 cubic feet, and approximately contains a volume of water, up to the elevation of high tide, exceeding 75,000,000,000 cubic feet.

This water is practically all changed once a day, by the entrance and reflux of the tidal wave of the ocean coming up the coast.

Thus it will be seen that the incoming tide through the Narrows must be largely made up of new water, and such a portion of the sewage polluted water of the upper bay which has passed out in the preceding ebb, and is brought back on the flood, will be so enormously diluted as to be practically ocean water.

CHEMICAL ACTION.

The second influence acting upon the sewage, is the chemical action of the antiseptic effect of salt water upon the organic constituents, and the oxygenating of the organic matter by the dissolved oxygen in the water, and the precipitation of these constituents by the salts contained in the sea water.

The effect of salt water upon sewage is to retard bacterial action and putrefaction. To a certain extent the organic matter is pickled, and the nuisance arising from its decomposition materially reduced.

This fact has been illustrated for years in the sewers of Jersey City and Hoboken. Practically all of the sewers of these cities on the low lands adjoining the river, are necessarily placed with water runs approximating to the elevation of low water, and with little fall except that secured by the slope of the water surface.

The tide ebbs and flows through the sewers, and at certain periods of the rising tide, the sewage water is locked and held back by the incoming salt water from the river.

Up to a recent period, before the meadows back of the river at the foot of Bergen Hill were filled in, or built upon, many of these sewers discharged their contents, mingled with salt water, into the ditches and meadow creeks, and at the ebb

tide, this reservoir of accumulated salt water and sewage flowed back through the sewers to the river.

By reason of the stagnation during the greater portion of the time, the sewers are always filled for about one-third of their capacity, with sludge of house sewage and washings from the streets, and are only cleaned by manual labor, the deposits being taken out through the manholes. Such a condition of affairs, if the flush water was fresh, and bacterial and septic action could be given free scope, would produce an intolerable nuisance, and the stench arising from the sewer manholes, which are provided with ventilating holes open to the street, would be noticeable, but, thanks to the salt water flushing, these sewers, as far as the nuisance created by the stench is concerned, are not at all offensive. That this result is due almost entirely to the salt water flushing, is shown by the fact that, of late years, since the meadow creeks have been closed up and the lots on the meadows, to a large extent, filled up or built upon, and the upper ends of the sewers closed so that the tide no longer discharges upon the meadows and into the ditches, the nuisance arising from decomposed sewage which finds its way into the lower and unimproved portions of the meadows, is much more offensive than was the case when the sewers very often discharged at both ends at once for certain periods of the day.

The salt water also, to some extent, preserves the constituents of the sewage which become food for the marine life in the bay. Certain forms of this life feed upon putrid and septic matter, but other, and higher forms, feed upon the portion of the organic matter which has not yet commenced to undergo putrefaction.

The salt water, by delaying putrefaction during the carriage and dissemination of the small particles of organic matter, bring it fresh to the reach of a large number of such marine life, and allow of its easier, and more general and rapid consumption as food, by them.

OXYGENATION OF THE ORGANIC MATTER BY THE ACTION OF THE DISSOLVED OXYGEN IN THE WATER.

A hasty test was made a few days ago, of the sample of Hudson River water, taken from a slip about 250 feet away from the principal sewage outlet in Jersey City, where the sewage of about 75,000 people, or about one-third the total population, is discharged at the bulkhead at the end of a long nar-

row slip, flanked by closely piled piers, extending 1,100 feet into the river. The sample was taken at the beginning of ebb tide. There was little current movement; in fact there is seldom any noticeable current at this point, except that created by the rush of the sewage.

The sample showed 4.2 c.c. of oxygen per litre, or 0.6 parts by weight per 100,000. This is more than one-half the quantity found in pure river water, and sixteen times the quantity found in the Thames at Woolwich, near the outfall of the London main drainage.

A sample from the channel of the river would certainly show very much better. Thus it appears that, even while loaded with sewage of 4,500,000 people, these waters still contain a very large proportion of oxygen, and are far from being saturated with sewage.

PRECIPITATION OF ORGANIC CONSTITUENTS BY THE SALTS IN THE SEA WATER.

The calcium and magnesium salts existing in sea water will decompose and precipitate the soluble soaps in the sewage in the form of soap curds, which are carried to the bottom. This action in a shallow channel, has, at times, caused inconvenience, but in the outfall selected for the proposed sewer, the depth, 75 feet, is so great as to do away with any danger of shoaling before the deposits are destroyed by slow decomposition, and the action of micro-organisms, on the bottom.

CONSUMPTION OF THE ORGANIC MATTER BY MARINE LIFE.

The waters of the bay and river swarm with a multitude of forms of marine life, from the lower micro-organisms up to the shrimp and small fish, and a microscopic examination of the water, at the mouth of the sewer above mentioned, showed that, at every atom of organic sewage, some of the variety of scavengers was busily engaged in breaking it up and devouring it, while, at the outfall, many small fish can be seen stemming the current of sewage and darting forward to seize a tempting morsel. Only the masses of sewage too large to be broken up readily by these little scavengers, are allowed to go very far from the mouth of the sewer, and even those, when they reach the influence of the tidal and wave currents, soon break up.

Microscopic examinations made of the water 500 and 1,100 feet from the sewer mouth, showed proportionately lessened number of micro-organisms, and much less proportion of dead organic matter.

The screening and pumping which the Passaic sewage will be subjected to, will, by breaking up the solids, aid greatly in facilitating this mode of disposal, which is thus commented upon by Dr. H. C. Sorby, in a paper, *Jour. Roy. Micr. Soc.*, 1884, pp. 988-991, reprinted in "Sewage Disposal in the United States," Rafter and Baker, 1894, pp. 77-79.

Dr. Sorby, after describing his investigation of the work of marine animalculæ in the consumption of organic pollution, says:

"Taking the above facts into consideration, it appears to me that the removal of impurities from rivers, is more of a biological than a chemical question; and that in all discussions of the subject it is most important to consider the action of minute animals and plants which may be looked upon as being indirectly most powerful chemical agents."

TRANSPORTATION TO THE OCEAN BY TIDAL CURRENTS.

While the sewage discharged in New York harbor is being largely diluted, and the proportions and power for offense of organic matter materially reduced by the united action of the salt water, micro-organisms, crustacea, and fish, it is subjected to the action of the tidal currents flowing in and out through the Narrows, and though for a few hours, while within the bay and rivers, oscillating back and forth with the changing tides, carried surely down into the great reservoir of the ocean.

The ebb flow, through the Narrows, as before mentioned, is 13,819,895,144 cubic feet. The flood flow is 12,703,616,418 cubic feet. The excess of ebb being 1,116,278,663 cubic feet. The cross section of the Narrows is 271,480 square feet. Assuming the tidal periods to be equal, and six hours in duration, these figures show a mean velocity for the whole section of 1.61 miles per hour, or 9.66 miles in six hours of ebb, and 1.48 miles per hour, or 8.89 miles in six hours of flood. The maximum velocity in the channel at ebb tide, as measured under the direction of General Newton, U. S. Engineers, in 1872, was 4.5 miles per hour. The ebb flow of the Hudson at 39th street is given by the U. S. Coast Survey Report, 1886, pp. 36, as 6,996,678,413 cubic feet, and the flood volume as 6,225,985,545 cubic feet, the excess of ebb volume being 770,692,868 cubic feet. The approximate cross section of the Hudson at 39th

street, contains 173,000 square feet. The above figures give a mean velocity for the ebb current for the period, taken at six hours, and the whole cross section, as 1.26 miles per hour, or 7.56 miles in six hours, and for the flood as 1.13 miles per hour, or 6.98 miles for six hours.

The above measurements of tidal flow were made in June. The excess of ebb indicates an average discharge of about 1.15 cubic feet per second per square mile of drainage area of the river, or about sixty-five per cent. of the average for a year, due to a total run off of 24 inches on the water shed.

A freshet discharge of ten cubic feet per second per square mile may be expected several times a year from this watershed; such a freshet would much more than double the ebb volume, greatly increase its velocity and duration of flow, and by pushing back the flood, retard its flow, and reduce the time of its influence.

In periods of such freshets, the Hudson River runs ebb for a very large proportion of the time.

The ebb volume of the East River at 19th street, as given in the same Coast Survey Report, is 4,454,937,257 cubic feet, and the flood volume, 4,007,175,676 cubic feet, the excess of ebb volume being 447,761,581 cubic feet.

This is the balance of the discharge of Long Island Sound and the rivers tributary thereto, westward through New York bay and the Narrows to the ocean.

Assuming a mean progress of the tidal section along the axis of the channel, as eight miles for each ebb tide, and six miles for each flood tide, which figures for the ebb is much less than the velocity given above for the river and Narrows, but probably justified by the slower progress and cross currents in the broad expanse of the upper bay, and also less than same figures for flood velocity in river and Narrows, but also justified because of the same causes, and the fact that the ebb from the East River continues for some time after the flood is running strong from the Narrows, cutting across the bay from Governor's Island to the Jersey flats, retarding and complicating the flow, and some portion probably passing up the Hudson River with the direct current; an approximation can be reached at as to the average rate at which the sewage deposited in this basin is discharged into the lower bay, and also as to the average proportion of sewage waters present in solution in the upper bay and rivers.

It is probably well within the facts to say that the actual

reduction of organic constituents in the sewage, by the action of the several causes already enumerated, and the enormous dilution taking place in the lower bay, justifies the assumption that the flood waters entering the Narrows, are practically free of sewage pollution, and that the sewage once outside of the Narrows, may be considered as finally disposed of.

This statement will not apply to the floating corks, wood and other debris discharged by the sewers, which, while of a character to resist the effect of dilution, chemical forces, and marine life, and are not offensive to the senses, some portions may be returned by the tidal flow.

Your plan wisely contemplates the removal and destruction of all floating bodies, before the sewage reaches the outfall.

A study made of the oscillations of the bodies of sewage delivered during the period of each successive tide, at the proposed point of outfall, which is about four miles within the gate of the Narrows, using an average ebb velocity of eight miles in six hours, and an average flood velocity of six miles in six hours, shows that, on an average, at the end of each period of ebb tide, there will be, approximately, twenty-five per cent of the volume of sewage water discharged in the twenty-four hours preceeding, still in solution in the basin of bay and rivers within the Narrows, and at the end of each flood period, fifty per cent. of the sewage water discharged during the preceeding twenty-four hours, remain in solution.

A similar study of sewage deposited in the Hudson River, at about Castle Point, or ten miles within the Narrows, indicates that, at the end of each ebb tide, there will be one hundred and sixty per cent. of an average twenty-four hours' discharge of sewage water, delivered at this point, still in solution in the basin, and at the end of each flood tide, one hundred and ninety per cent. of an average twenty-four hours discharge. That is, the sewage water delivered by your proposed sewer, will remain on the average, only nine hours in the basin before disposed of outside the Narrows, while New York sewage water, discharged at Twenty-third street, remains in the basin an average of forty-two hours.

These figures are, of course, approximate only as to time, but the relative proportions between the storage periods of sewage for each locality will be about as above given, through a wide variety of change in velocity of ebb and flood currents.

A freshet will shorten the period, and may scour the basin

clean in one tide; an easterly gale, with spring tides, may hold back the ebb and increase the time of storage.

The comparison is also somewhat unfair to the Passaic sewer, as its discharge will be into the strongest and most direct current of the channel, and not into embayed slips, or at the shallow edge of the river.

It must also be taken into consideration that, in the future, an increase in the population of New York is not likely to result in a proportionate increase in the volume of sewage discharged in the basin under consideration. The areas of the city, tributary to this basin, are now thickly built up and populated. The growth is already greater in proportion in the Bronx, draining east of Hell Gate, and the portions of Brooklyn and Queens lying east and south of the Heights, and draining into the sound or toward the lower bay and the ocean. The greater portion of Richmond will also, probably, drain into the lower bay and Arthur Kills.

In view of these facts, and the physical conditions existing, I am of the opinion that the discharge of the sewage, contemplated by your plans, into New York Bay at present, and up to the full extent covered by the plans of your engineer, will not now, or within any reasonable future time, alone, or in connection with the present and future discharge of sewage from the communities now utilizing this place of disposal, cause any noticeable general nuisance to any persons or property whatever, and furthermore, that the harbor of New York is capable of receiving and disposing of the sewage of from three to five times the population at present utilizing it for such disposal, or from fifteen to twenty-five million people, by properly constructed and distributed outfalls, without becoming so polluted as to become a noticeable nuisance.

POSSIBILITY OF LOCAL NUISANCE.

Though there be no danger of general nuisance, is there any likelihood of the creation of a local nuisance at the point of discharge?

There are many large sewers discharging into the rivers from New York City and the other communities surrounding the harbor, serving populations of upwards of 100,000 people and over. Experience has shown that, practically, the only noticeable nuisance caused by these sewers, has been in cases where the outfall has been above tide level at a bulkhead, where

the free action of the tidal currents has been restricted by the obstructions of piers, cribs, and ferry racks, or by vessels drawing from twenty to thirty feet of water, four hundred to six hundred feet long, and acting as caisson dams across the tidal flow.

Sewers discharging at the bulkheads, into water of slight depth, and carrying large quantities of foul street washings, with sand and detritus, produce deposits against the bulkhead and in shallow water, forming in time, foreshores exposed at low water.

At many such places, nuisances have been complained of, circumscribed by limited areas, and periods of noticeability, and depending largely for their intensity upon the state of the atmosphere, temperature, and tide, and stirring up of the sludge deposits by the churning of propellers or paddles.

In all the new piers erected by the city in the past few years, timber flumes have been carried beneath the pier floors, out to the tidal currents and deep water, twenty-five to thirty-five feet, at the ends of piers, with the result that no further nuisance has been experienced.

In Jersey City and Hoboken, the necessity for extension of sewers has not yet been felt. The large outlet above mentioned, at the foot of Thirteenth street, discharges at the bulkhead into an embayed slip about seven hundred feet north of Pavonia Ferry and the Erie depot. In the frontage between Essex street and Fourteenth street, Jersey City, six thousand feet long, and occupied by busy piers and wharves, and two large grain elevators, besides the ferry slips and depots of the Pennsylvania and Erie Railroads, the sewage of a population of about 125,000 persons is discharged at the bulkheads.

Beneath the Lackawanna passenger station, in Hoboken, a large main, draining about one-fourth of the area, and the most densely populated portion of Hoboken, discharges.

No complaints have ever been made to the city authorities as to nuisance arising from these outfalls.

The first outfall proposed by your plan will be situated about one mile southeast, and outside of the outer ends of the new Pennsylvania piers at Greenville, the nearest point connected with the New Jersey shore; about one and one-half miles northeasterly from the nearest point on the Staten Island shore; about one and three-quarter miles from the nearest point on the Brooklyn shore, and about three and one-half miles south of the Battery, New York. The nearest point in the State of New

York will be 2,000 feet away, and covered with thirty-five feet of water. Between this point and the outfall is the main channel of the bay, seventy-five feet deep.

The discharge will be below the surface at least forty feet at low water, into this channel.

The experience at Boston has been that, with a much shallower discharge, no appreciable nuisance is noticeable at the point of outfall, and within less than two miles, the presence of sewage cannot be distinguished by chemical tests.

The good effect of the discharge under water, is well illustrated by the experience at the abattoir at the Hackensack River, and at the stock yards in Jersey City. At both these establishments, an intolerable nuisance, noticeable to leeward for a long distance, was caused by the stench from the discharge of the steam and hot water from the rendering tanks into the open air. After some experiments, the discharge was changed to outlets as far below the surface of the rivers, as the depth of water would permit, and the nuisance entirely removed.

In an average hour, the proposed sewer, as first constructed, will discharge an equivalent of about 340,000 cubic feet of standard strength sewage, viz: at the rate of one hundred gallons per head per day, and containing one part in a thousand, of organic matter. In the same hour there will flow past the outlet, a total current in a prism having a volume, limited to a cross section from the surface to the bottom of the bay, and not more than one hundred feet wide outside of point of sewage discharge, of about 31,000,000 cubic feet. It can be well understood how thoroughly the sewage will be diluted before it can reach the surface and become noticeable to the senses of sight and smell.

In the light of all these facts, I am of the opinion that there is not the least likelihood of the discharge of the contemplated sewer, proposed to be built under your direction, polluting the waters of New York Bay, within the jurisdiction of the State of New York, to such an extent, and in such a degree as to cause a nuisance to persons or property within said State.

Respectfully submitted,

EDLOW W. HARRISON,
Consulting Engineer.

REPORT OF WM. BARCLAY PARSONS.

WM. BARCLAY PARSONS,
Consulting Engineer.

320 Broadway, New York, 25 June, 1903.

Cable Address, Claybar.

Passaic Valley District Sewerage and Drainage Commissioners, The Honorable Julius A. Lebkuecher, Chairman, Newark, New Jersey.

SIRS.—In accordance with your instructions, I have carefully examined the report of Mr. Rudolph Hering on the proposed methods of sewage disposal for the district under your care, in order to express an opinion as to whether the sewage can be delivered, as proposed by Mr. Hering, at a point in the main channel north of Robbins' Reef Light, without its being an offensive nuisance. On this point Mr. George S. Greene, under date of May 16, has reported to you that the volume of sewage discharge, when it reaches the maximum capacity of your proposed sewer will amount to only one-third of one per cent. of the outward flow of the Hudson River, and would therefore be inappreciable. I have studied the figures on which Mr. Greene bases his opinion, and, after such examination, I fully concur with him that the tidal flow is amply sufficient to remove, without offense, the discharge of the sewage contemplated by you, even after the flow reaches the maximum capacity of such sewer.

There are, however, two other questions to be considered: First, the sufficiency of Mr. Hering's allowance for the sewage flow of the district; second, the conditions of pollution now existing and the comparative effect of the discharge of your sewage as proposed. According to the last census of 1900, and after making an allowance for growth in the meantime, the area included within the district of your board has a population of about 550,000 persons. What the actual amount of sewage flow from the district is can be estimated only. In the city of New York the amount of water consumed is about 110 gallons per person per diem. At this rate the water supplied in your district would be about 60,000,000 gallons daily, and with an allowance for such storm water and leaks from ground

water as enters the sewers, but with no allowance for cesspools and other sources of water disposal other than cesspools, the sewage flow of your district should not exceed 75,000,000 gallons. On the basis of a population of 1,617,000, or, say, three times the present population, the amount of sewage disposal would be 225,000,000 gallons daily, as against 345,830,000 gallons allowed for in Mr. Hering's plan. His allowance would seem, therefore, to be very generously ample to provide against an increase in population for many years to come—especially as the district authorities will undoubtedly take all measures to curtail the sewage flow as much as possible, in order to avoid great expense of pumping.

It is at present the custom of all communities situated along the shores of the harbor of New York and the rivers flowing into it, to discharge into such waters raw sewage, without any attempt at either purification or screening. The Hudson River which, except for a short distance on one side near its mouth, is wholly within and under the jurisdiction of the State of New York, is a great gathering outlet for all sewers from Troy southward, a distance of over 150 miles. Omitting, however, everything north of a line drawn east and west at the northern boundary of the city, and thus excluding such growing centres of population as Yonkers and Ossining with their sewage delivery, there lies south of such line what may be termed the Metropolitan District, including the city of New York and the cities of Jersey City and Hoboken. The area of this district that drains into the Hudson, East River and the bay of New York north of the Narrows, is about 162 square miles, and the population living within such area is to-day nearly four millions. The amount of water consumed within this district is about 425,000,000 gallons daily. On a basis of 42 inches rain fall per annum, the average amount of rain fall would be 324,000,000 gallons daily. On the basis of allowing 50 per cent. of this total to reach the sewers, the total amount of sewage flow for the portion of the Metropolitan District above considered would be 162,000,000 gallons daily, or a total average daily sewer discharge of about 587,000,000 gallons, or nearly eight times the present discharge from your district. As the streets of New York carry a heavier traffic than those in the Passaic District, so will the rain fall portion of the sewage be more polluted, and the communities in the Metropolitan District make no attempt to remove the solid material from the sewage before the discharge.

Finally, there remains to point out the difference in effect on the harbor between the proposed method and the method now in vogue. In the proposed method the sewage would first have all solid matter removed, and would be discharged within the limits of the State of New Jersey at a point in the main channel, and at a depth of about fifty feet below the surface of the water. At present the sewage from this district is turned into the Passaic River, and is discharged by that river into the narrow straits of the Kill von Kull, whence it has to find its way, as best it may, to the sea.

My examination of this question leads me to draw the following conclusions:

1st—Mr. Hering has made a generous allowance for the present and future needs of the Passaic Valley for some time to come.

2nd—That the proposed plan of discharge is much less objectionable than the present method of discharge into the New York harbor via the Passaic River.

3rd—That New York City and other communities located on the shores of the harbor and the tributary rivers, discharge raw and unscreened sewage into such waters.

4th—That at present the volume of Passaic discharge is about one-eighth of the discharge of the Metropolitan district, and will, of course, always remain much less.

5th—That the composition of the Passaic discharge being screened, will be much less offensive than the sewage discharge of the Metropolitan District.

6th—That the tidal flow at the proposed point of outfall is amply sufficient to carry the discharged material seaward and prevent a nuisance.

Respectfully yours,

(Signed) WM. BARCLAY PARSONS.

REPORT OF ALLEN N. SPOONER.

NEW YORK CITY, June 11th, 1903.

Hon. Julius A. Lebkuecher, Chairman, and Members of the Passaic Valley District Sewage and Drainage Commission, Newark, N. J.

GENTLEMEN:—In obedience to your direction of May 29th, 1903, I beg to report that I have approximated the amount of sewage being emptied into the North and East Rivers from Manhattan Island, which eventually finds its way into New York Bay.

These approximations have been based upon, primarily, the amount of water supply, since statistics are not available as to the volume of sewage emptying into the North and East Rivers, the department of Sewers never having procured any data on this subject except as to the sizes of local sewer openings, where gauging and velocities have been taken. Such figures are of no considerable value, inasmuch as they were taken a number of years ago, and, as the water supply per capita has varied greatly within the last ten years, it would seem best to use the water supply as a basis for present calculation.

I propose to show:

First—What volume of sewage is deposited daily in the North and East Rivers and emptied into New York Bay, as the direct resultant from water supply sources.

Second—The amount of sewage which is the resultant of the average daily rainfall throughout the year, which would also enter the North and East Rivers and empty into the New York Bay.

Third—The volume of all other sewage entering New York Bay from other than fresh water sources.

Fourth—The total volume of all sewage, of every description, from Manhattan Island entering the North and East Rivers and emptying into New York Bay.

Fifth—The present method of discharging sewage in tide water, and its local and general effect upon the river waters.

Section 1. From the Department of Water Supply of New York City the following figures were obtained as to the amount of fresh water delivered into the city daily from all

sources for the month of January, 1903. During this month 282,000,000 gallons were delivered daily, and, with a population of 2,350,000, the amount per capita was 120 gallons.

From "Sewers and Drains" (page 36) by Julius W. Adams, former Chief Engineer of the Board of City Works, and Consulting Engineer for the Board of Health of Brooklyn, it is estimated that twenty gallons of the per capita amount does not enter the sewers, but is lost in leakage, absorption and evaporation, and in such processes as the extinguishing of fires, street and garden sprinkling, building construction, and in shipping and manufacturing industries. We, therefore, will assume that one hundred gallons of the per capita amount enters the sewers, and, for a population as stated above, would give a total of 235,000,000 gallons discharged daily through the various outlets.

All the sewage deposited during the ebb tides in both the North and East Rivers finds its way into New York Bay; but, on the flood tide, a large proportion of that which finds its way to the East River would be carried into Long Island Sound through Hell Gate, Little Hell Gate and the Bronx Kills. We may assume that for twelve hours each day, all the sewage on the east side of Manhattan, between the Battery and Hell Gate, flows into the Sound, and, although the acreage of this portion of the city is not one-half its total area, it is the most densely populated, and I have estimated that one-half the population, 1,175,000 is within this district. As there are twelve hours ebb tide and twelve hours flood tide daily, one-half the volume of the sewage from this section of the city would be discharged into the river and emptied into Long Island Sound. Hence, on the basis of 100 gallons of sewage per capita, there would be 117,500,000 gallons discharged from this east side territory during the twenty-four hours, of which 58,750,000 gallons, as a maximum, would pass into the Sound. In other words, one-quarter of the total amount of Manhattan Island sewage passes into Long Island Sound and three-quarters of it, 176,250,000 gallons, enters New ork Bay; the latter figure representing 75 gallons per capita for the total population of 2,350,000.

Sec. 2. The average yearly rainfall in Manhattan may be taken as 42.58 inches, uniformly distributed over its area of 12,576 acres, which amounts to 14,572,158,868 gallons, one-half of which, 7,286,079,434 gallons, finds its way into the sewers. (Reference "Sewers and Drains," page 33, by Julius W. Adams, who refers to Mr. Wm. Hayward, engineer, Met-

ropolitan Board of Works, London.) This amount, of course, is not uniformly distributed for each day in the year, as the times and volumes of the storms vary. This amount of rain, however, is deposited as sewage into the rivers, as it carries with it soot, dust, rust, paint scales from roofs of houses, street sweepings, and also scours the bottoms of the sewers and catch basins, and cannot be considered other than sewage. Therefore, the daily volume of this class of sewage must be reckoned with in addition to the amount of house sewage. By dividing the yearly rainfall by 365 days we obtain a daily volume of 19,961,861 gallons flowing into the North and East Rivers. On the same assumption, as above outlined, only three-quarters of this amount, or 14,971,395 gallons, will enter New York Bay.

Sec. 3. Along the rivers of Manhattan there is a congested state of shipping, and I would estimate that for deck flushing, and from table refuse, bilge waters, toilets, etc., there are at least 500 vessels using not less than 2,000 gallons daily, or a total of 1,000,000 gallons. To this must added the salt water used for cleaning purposes in slaughter houses, gas houses, electric plants, oil depots, breweries, grain elevators, dye houses, print works, and various other establishments.

To summarize in regard to this last item, there are five electric plants which use 5,000,000 gallons; five slaughter houses, 500,000 gallons; ten breweries, 1,000,000 gallons; 100 manufacturies, 2,500,000 gallons, and gas plants, 1,000,000 gallons—making the estimated amount of salt water used in manufacturing purposes and discharged into the rivers as sewage 11,000,000 gallons.

Sec. 4. Adding together the quantities thus estimated we have:

Sewage from the water supply per day....	176,250,000	gals.
Rainfall per day	19,950,000	"
Other sources	11,000,000	"
Total.....	207,200,000	"

This total is the estimated average of daily volume of sewage from Manhattan Island entering New York Bay through the North and East Rivers.

Sec. 5. Within recent years, the sewage which was formerly discharged at the exterior line of solid filling—commonly called the "bulkhead," has been carried out to within about 25

feet of the exterior line of the piers by means of creosoted flumes of divers shapes, such as the circle, ellipse and rectangular modifications, which have been adopted to meet the type of sewage openings at the bulkhead.

It is apparent that this method of discharging sewage in a deep and rapid current near the pier head line has removed a nuisance, caused formerly by the discharge at the line of solid filling; for at the latter place the river water is obstructed to such an extent that in a great many of the slips there was so little current that the sewage, deposited on the surface, was not rapidly intermingled with the river water and gave off noxious odors, besides being of an unsightly appearance.

At present, from my personal observation, either when the tide is running strong flood or ebb, the discharge of sewage in the current is not at all perceptible beyond a radius of 500 feet outshore from the pier head line, and is only slightly noticeable even in the adjacent slips. To show you the importance of this, I would advise you that many of the public baths in New York City are within 500 feet of sewer openings and adjacent to the piers under which the sewage is carried out. Furthermore, I would call attention to the fact that even where the sewage is perceptible adjacent to the point of discharge, the water is not contaminated to any great depth, inasmuch as the live teredo (ship worm) has been found in the timbers, used as braces to the piers within 250 feet of sewer openings; also, at certain seasons of the year, a small fish, called the "Lafayette" is at some places caught immediately over the openings of sewers of considerable magnitude. From this it will be seen that, in the case of the teredo, which it is claimed will not attack wood in unclean water, the sewage does not pollute the water sufficiently at a distance of 250 feet to annoy them. In the case of the small fishes, which are caught at the mouths of sewers in the tideway, it would show that the water is not contaminated below a few feet sufficiently to prevent the fishes from inhabiting it.

From a rough estimate, I have calculated that there is about one cubic foot of sewage deposited in about 300 cubic feet of clean river water at the mouths of sewers, and that in a current moving 4 miles per hour, there is a mixture, at a point 300 feet from the mouth of a sewer, of about one cubic foot of sewage to 10,000 cubic feet of clean river water. Of course, this is only a rough approximation as to the mixture, but it is ample to state that, from a close observation, in no case have

I ever been able to detect, at the distance of 300 feet, except at slack water, any material amount of discolored water, which would denote sewage. I might state as an exception that this does not apply to floating solid matter, which can be traced for some distance at times. However, at 500 feet distance whatever solid material there may be is floating in clean salt water and is not, in any way, deleterious. Although we have estimated the daily amount of sewage going out into New York Bay at 207,200,000 gallons, at Castle Williams, on Governor's Island, there is nothing that I have ever been able to notice which would indicate that the waters were at all polluted by sewage, yet at this point, the waters of the North and East Rivers meet, and, as the sewage naturally keeps close to the shores, it would be manifest at this place if at all.

In my discussion, I have treated Manhattan Island alone to make certain that I might be right in deducing the fact that the volume of over 200,000,000 gallons of sewage showed no pollution in the tide water even less than a mile from its shore. In connection with this argument, however, and adding not a little to its force, it must also be assumed that there are at least 100,000,000 gallons of sewage being deposited from the Brooklyn side, which is carried into the same currents.

As it has been estimated by your Chief Engineer, Mr. Rudolph Hering, that, with the present population and its normal increase, the initial volume of sewage reaching New York harbor from the Passaic Valley Drainage Sewer would be 75,000,000 gallons, discharged at Robbins' Reef, it would be my judgment, from observations of the sewers emptying into the rivers about Manhattan, that there would be no actual noxious pollution of the water in New York Bay beyond 1,000 feet from your proposed outlet. For an estimated amount of 150,000,000 gallons, I do not believe that beyond 1,500 feet from the proposed outlet any sewage would be perceptible, or that the waters would give off any noxious odors.

Inasmuch as there will be an enormous volume of sewage concentrated at the opening of your proposed sewer, and even though it is discharged at a considerable depth below the surface, I cannot conclude that there will not be some noxious conditions immediately adjacent to the mouth of this sewer, but, as this is an isolated portion of the bay, I cannot conceive that the sewer would ever be a nuisance to any of the adjacent premises, and it is my opinion that beyond the areas mentioned for the two estimated volumes, the pollution would be practically imperceptible, and that none of the sewage would ever reach any of the adjacent shores in sufficient quantity to be noticeable even in the slightest degree.

Yours very respectfully,

ALLEN N. SPOONER,
C. E.

Extract from the report of Messrs. Rudolph Hering, J. J. R. Croes and William M. Brown, engineers of the State Sewerage Commission, and contained in the report of that commission to the Legislature of 1902, on pages 54 and 55.

"The sewage should, therefore, be partially purified, *i. e.*, as far as is practicable, by works on the Newark meadows before being discharged into Newark bay, or it must be carried five miles further and discharged in its raw or crude state into deep water of the upper bay of New York, where there is a large volume of water and a strong current, ensuring thorough dilution and inoffensive disposal. * * * * * * * * *

The outfall pipe would leave the shore at an elevation of about twenty feet above high-water, and extend about two miles into the bay, to a point north of Robbins' Reef ledge, practically in the center of the bay, in the vicinity of which the channel is seventy feet in depth."

LETTER OF LIEUT.-COL. C. W. RAYMOND.

ENGINEER'S OFFICE, U. S. ARMY,
815 Witherspoon Building,

PHILADELPHIA, PA., October 18, 1902.

Mr. John S. Gibson, Secretary, State Sewerage and Drainage Commissioners, Newark, N. J.

DEAR SIR:—Since I had the pleasure of conferring with the Sewerage and Drainage Commissioners of New Jersey, on the 1st instant, with reference to a project under consideration for the sewerage of the Passaic Valley District, I have considered the project in its relations to the interests of navigation, and now submit the following suggestions.

As you are doubtless aware the law provides that no changes shall be made nor structures erected in navigable waters of the United States until the plans therefor have been approved by the Secretary of War. In the present case it appears that the plan is to be submitted to the State Legislature, and cannot be submitted to the War Department as an adopted plan until the legislature has approved it. You explained to me that the object of your conference with me was to ascertain, before perfecting a plan, what would probably be the views and requirements of the War Department. As I was instructed by the Chief of Engineers, in his indorsement, dated September 11, 1902, on your letter to him dated September 8, 1902, to confer with you on this subject, I feel at liberty to give you my personal views with reference to the project; but it should be noted that I am not authorized to express the views of the War Department, and it cannot be assumed that I shall have any part in the final action of the department upon the perfected plan.

The plan with reference to which my views are desired proposes to take the sewage now emptied into the Passaic River from Newark and Paterson and intervening territory, and convey it to New York Bay. It is given in detail in the report of Messrs. Hering, Croes and Brown, dated December 2, 1901, and the accompanying map, which are published in the report of the Sewerage Commission for 1902. The features of the plan requiring consideration in the interest of navigation are as follows:

1. A trunk sewer near the west bank of the Passaic River from the southerly line of the City of Paterson to near the southerly boundary of the City of Newark, to convey all domestic and manufacturing wastes and a portion of the storm water to a point on the westerly shore of Newark Bay.

2. Cross sewers passing under the bed of the Passaic River to convey the sewage for communities on the east bank of the river to the intercepting trunk sewer on the other side.

3. A pumping plant at the lower end of the trunk sewer near the west shore of Newark Bay and force mains laid under the bed of Newark Bay to force and convey the sewage into a gravity sewer on the Bayonne shore.

4. A gravity sewer from the Bayonne shore to a point in the upper bay of New York near Robbins' Reef ledge to convey and deliver the sewage into the bay.

These features, so far as they relate to the interests of navigation, will now be considered separately.

1. *The Trunk Sewer.* The elevation of this sewer at different points does not directly affect any navigation interest, but since it must be placed so as to receive the sewage from the cross sewers extending under the bed of the river from the east shore, it should evidently be placed low enough to conform to the levels of these sewers under all probable future conditions of an improved navigable channel. When once established it would be very difficult, if not practically impossible, to lower the trunk sewer.

2. *The Cross Sewers.* These must be placed below the bottom of the channel, as it will exist when the river has been improved in accordance with the adopted project of the War Department. This project provides for a depth of 12 feet at mean low water through Newark Bay and the Passaic River to the Nairn Linoleum Works in the City of Newark; thence a depth of ten feet to the Montclair and Greenwood Lake Railroad bridge; and thence to the City of Passaic a depth of 7½ feet. The sewers should be several feet below this bottom for their own protection. It is, of course, possible that future projects may provide for increased depths, but I suppose these cross sewers could be lowered without undue expense in case of necessity. In granting a permit for construction, the War Department will probably impose the condition that this lowering, if required, shall be done without expense to the United States. In determining the depth at which these cross sewers should be placed in the upper part of the river, it should be noted that a considerable lowering of the level of mean low water will result from the improvement of the channel.

3. *Pumping Plant and Force Mains.* The mains passing under Newark Bay must, of course, be established below the bottom of the projected navigable channel. It is understood that the sewage will have to be cleared from grit and heavy insoluble matter before it is pumped, to prevent the destruction of the pipes and pumping machinery.

4. *The Outfall in New York Bay.* The outfall pipe extends about two miles into the bay to a point where the natural channel has a depth of about 70 feet. There is no artificial channel, existing or projected, in the near vicinity. In view of the fact before noted, that the sewage is to be cleared from grit

and heavy matter before it is pumped under Newark Bay, I am of the opinion that its delivery into New York Bay at the point selected will not injure the channels or be detrimental to the interests of navigation. The outflow pipe, however, should be established as low as possible in order to avoid interference with channels of moderate depth, which it may be found desirable to form in the future to furnish means of communication with wharves on the New Jersey shore.

I hope these suggestions may be of service to the commissioners in perfecting the details of the plan, and it will give me great pleasure to furnish you with any further information in my power. Respectfully yours,

C. W. RAYMOND,
Lieut. Col., Corps of Engineers.

Extracts from the report of Rudolph Hering, Engineer of the Passaic Valley District Sewerage and Drainage Commissioners, contained in the Report of the Commissioners to the Legislature at its last session, on pages 22 and 39:

"The waters of the Hudson River and the tidal flow from the Lower New York Bay and the East River, together furnish such a large quantity of water that the proper discharge of sewage into the same from a population of many millions cannot be noticed by the senses."

* * * * *

"Based on the facts and comparisons above given, I recommended to you a trunk sewer for the joint disposal of the sewage of your entire district into New York Bay as the most economical and satisfactory project for adoption."

Extract from an article prepared by Mr. Alfred D. Flinn, managing editor of the *Engineering Record*, entitled "The Discharge of Sewage into Harbors and Lakes," and published in that journal under date of May 2, 1903, on page 453:

"There are places on the seaboard, however, where the direct discharge of sewage may be practiced with impunity. For example, the tidal flow of New York harbor is so great, estimated at billions of cubic feet per day, and the direction of the currents are such that, if the sewage be screened, a very large quantity may be carried off without offence. Engineers who

have studied this case have concluded that the sewage of 30,000,000 people could be put into the bay from properly located outlets without becoming objectionably apparent. Large volumes and areas of water are not alone adequate to prevent nuisance; the directions, velocities and volumes of surface currents and the action of wind are also controlling elements. Experience has taught that if locations for outlet can be found where the currents are always favorable, it is better to discharge the fresh sewage continuously, rather than to store it in tanks for intermittent discharge, although the latter practice is sometimes necessitated by the unfavorable directions of currents at certain times.

"A few years ago the State Board of Health of Massachusetts studied the discharge of sewage into Boston Harbor and arrived at some conclusions of more or less general application. The discharge of sewage into frequented waters should be so made that the sewage will be quickly lost to the senses and even to chemical tests, which may be accomplished by discharging into quick currents of large volumes where the dispersion will be rapid and the dilution great. It was found that the sewage being of less density than the sea water tended to float, spreading out with but slight depth. At a surface outlet the sewage mingled with the sea water in a small area so as to be detected at depths of 4 or 5 feet, but over a much larger area the depth at which it could be plainly detected was only about 2 feet, beyond which the depth diminished gradually towards the borders of the area affected, where the sewage formed merely a surface film which gave to the water an oily appearance. Analysis of samples taken from the area covered by the film and from the discolored area showed that the portion of the sewage tract which contained a considerable amount of organic matter was substantially identical with the area of discoloration, and that the amount of organic matter in the film is so minute as not to be a source of offence. The discoloration on a comparatively calm day, was objectionable to the sight over only about two-thirds of the area, and the offensive odors were confined to a relatively small portion.

"If the sewage is discharged below the surface the tendency of the light particles to rise will cause a more rapid dispersion and disappearance of color than when discharged at the surface. The deeper the submergence of the outlet, the more thorough is the dispersion. Where, in addition, a strong current prevails comparitively large quantities of sewage could be thus dis-

charged without even becoming noticeable at the surface of the water. One of the outlets in Boston Harbor is under about 10 feet of water at high tide, and another, which is being constructed, will be at a depth of more than 30 feet. The present temporary outlet of the Honolulu sewer system is in 30 feet of water and is to be extended into water 100 feet deep, because there are no suitable strong currents in the harbor. The proposed Passaic Valley trunk sewer, in New Jersey, is to discharge into New York Bay at a depth of 40 feet. Discharge under a considerable depth, wherever feasible, seems to possess decided advantages."

LETTER OF O. H. TITTMAN.

TREASURY DEPARTMENT,

E. C. H. Office of the Coast and Geodetic Survey.

All communications should be forwarded under cover to the "Superintendent U. S. Coast and Geodetic Survey, Washington, D. C."

Washington, June 1, 1903.

Mr. J. A. Lebkuecher, Chairman, Passaic Valley Sewerage Commission, Prudential Building, Newark, N. J.

SIR.—I have the honor to transmit additional data of the discharge through New York Harbor, from computations made a year later than the ones previously transmitted.

EPITOME OF RESULTS FOR DISCHARGE.

June 25, 1886.

	Cubic Feet.
East River ebb (westerly) 19th street	4,454,937,257
Flood (easterly)	4,007,175,676
Hudson River ebb (southerly) 39th street	6,996,678,413
Flood (northerly)	6,225,985,545
Kill von Kull, ebb (toward the Harbor)	1,790,103,372
Flood (W. New Brighton)	1,712,415,362
Narrows, ebb (seaward)	13,819,895,144
Flood	12,703,616,481

The volumes of discharge given above should supercede the data previously furnished.

Very respectfully, O. H. TITTMAN,
Superintendent, W. M. P.

NOTE.

The reports of William Barclay Parsons, consulting engineer, and Allen N. Spooner, C. E., were received too late to be submitted to the Governor with the report of the Commissioners.