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TRI-STATE TREATY COMMISSION

(NEW YORK - NEW JERSEY - CONNECTICUT)

FOR ABATEMENT OF POLLUTION
OF HARBOR AND COASTAL WATERS
WITHIN THE METROPOLITAN AREA

FINAL REPORT

OF THE

RESEARCH AND ENGINEERING COMMITTEE

DECEMBER 16, 1931

FINAL REPORT

RESEARCH AND ENGINEERING COMMITTEE

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RESEARCH AND ENGINEERING COMMITTEE

This Committee was given two main objectives:-

1. To determine the Treaty Area, to recommend standards of purity for the inter-State tidal waters and to recommend minimum degrees of treatment for sewage discharged in the waters of the Treaty Area.

2. To assemble and interpret all available data and statistics relating to the pollution of the Inter-State tidal waters.

PART I

REPORT ON THE FIRST OBJECTIVE

We submit the following recommendations as to subjects to be included in the Treaty:

I. Treaty Area

The definition of the treaty area to be included in the treaty should be in the following terms:

"The coastal and estuarial waters and tidal streams coming within the jurisdiction of the Commission are designated herein as the Treaty Area and shall comprise all those portions of the signatory States which are covered by tidal waters and adjacent to the shore-lines described as follows:

"(a) In Connecticut,—the tidal shore-line of Long Island Sound from the easterly side of New Haven Harbor at Morgan Point to the Connecticut-New York State Boundary.

"(b) In New York,—all of the tidal shore line of Greater New York City; the northerly tidal shore of Long Island Sound from the New York City line to the New York-Connecticut State Boundary; the southerly tidal shore of Long Island Sound from the New York City line to the easterly side of Port Jefferson Harbor; the Atlantic Ocean shore of Long Island from the New York City line to the easterly side of Fire Island Inlet; the easterly bank of the Hudson River from the New York City line to the New York-New Jersey Boundary extended.

"(c) In New Jersey,—the westerly bank of the Hudson River and New York Upper Bay from the New York-New Jersey Boundary to Constable Point; all of the tidal shore-lines of Kill van Kull, Newark Bay, Arthur Kill, Raritan Bay, and Sandy Hook Bay to the Atlantic Ocean; and the Atlantic Ocean shore-line from Sandy Hook to the southerly side of Manasquan Inlet.

"Non-tidal streams flowing into the tidal waters described in this Article, and those portions of tidal streams which are inland from their intersection with the shore-lines described herein, (together with the non-tidal portions of such tidal streams) shall be considered as Tributary Waters of the Treaty Area."

II. Object of Treaty

We suggest the following Article:

"This Compact between the sovereign States of New York, New Jersey and Connecticut is

entered into to provide for the abatement of pollution in the tidal and coastal waters in the adjacent portions of the signatory States, defined herein as coming within the Treaty Area, and consistent with such object to enable each of the signatory States to put and maintain the waters thereof in a satisfactory sanitary condition; and particularly (a) to protect public health, (b) to render safe such waters as are now used or may later become available for bathing and recreational purposes, (c) to permit the maintenance of major fish and shellfish life in waters now available or that may by practicable means be made available for the developing of such fish or shellfish life, (d) to prevent unsightly floating oil, grease or solids from being carried on the surface of the water, (e) to prevent the formation of sludge banks along the shores or in the waterways, and (f) with the fulfillment of these objectives, to abate and avoid unnecessary economic loss by safeguarding the rights of the public in its varied legitimate uses of the Treaty waters."

III. Standards of Purity:

The following clauses should be included in the Treaty:-

"It is recognized that where tidal waters are used for such varied purposes as bathing, navigation, shellfish culture, the development of fish life and the disposal of wastes, no uniform standard of purity is practicable in all parts of the Treaty Area. In order to attain the objects of this Compact, therefore, the Commission, after proper study and after conducting public hearings upon due notice, shall group the designated waters of the Treaty Area into classes. This classification of the waters of any signatory State shall not become effective unless approved by the representatives of said State on the Commission. Where local conditions shall have changed in the future to such an extent that changes in the classification become necessary, the Commission may, after conducting public hearings upon due notice, adopt such changes, subject to approval by the representatives of the interested States on the Commission.

"Two general classifications shall be used:

(1) Class "A", in which the designated water areas are not expected to be used primarily for recreational purposes, shellfish culture or the development of fish life.

(2) Class "B", in which the designated water areas are expected to be used primarily for recreational purposes, shellfish culture or the development of fish life.

"No sewage or industrial wastes or other polluting matters shall be discharged or permitted to flow into or be placed in or permitted to fall or move into the tidal waters of the Treaty Area, except under the following conditions and restrictions:-

"1. All sewage discharged or permitted to flow into the waters of Class "A" shall first have been so treated as

(a) to remove all floating solids and at least 10% of the suspended solids, or such additional percentage as may by reason of local conditions be necessary to avoid the formation of sludge deposits in the Class "A" waters of the Treaty Area; and

(b) to effect a reduction in the oxygen demand of the sewage effluent sufficient to maintain an average dissolved oxygen content in the waters of the Treaty Area and in the general vicinity of the point of discharge of the sewage into those waters, at a depth of about five feet below the surface, of not less than 30% saturation during any week of the year.

"2. All sewage discharged or permitted to flow into the waters of Class "B" shall first have been so treated as

(a) to remove all floating solids and at least 60% of the suspended solids; and

(b) to effect a reduction of organism of the B. Coli group (intestinal bacilli) so that the probable number of such organisms shall not exceed one per cubic centimeter in more than fifty per-centum of the samples of sewage effluent tested by the presumptive method; and

(c) to effecet a reduction in the oxygen demand of the sewage effluent sufficient to maintain an average dissolved oxygen content in the waters of the Treaty Area and in the general vicinity of the point of discharge of the sewage into those waters, at a depth of

about 5 feet below the surface, of not less than 50% saturation during any week of the year.

"3. If the Commission shall determine, after investigation, that owing to topography or other local conditions, either natural or artificial, in a part of any municipality discharging sewage into the waters of the Treaty Area, it would be impossible or impracticable to meet the above requirements in either Class "A" or "B" waters with respect to suspended solids and oxygen demand, a modification of these requirements may be permitted; provided, however, that the sewage discharged from adjoining areas in such municipality shall be given the additional treatment necessary to effect an average reduction of suspended solids and oxygen demand of all the sewage discharged from such contiguous areas (including the portion of the area of the municipality where the requirements have been modified) equal to the requirements stated above.

"4. All sewage discharged or permitted to flow into any Tributary Water of the Treaty Area shall be treated to that extent, if any, which may be necessary to maintain such Tributary immediately above its confluence with the tidal waters of the Treaty Area in a sanitary condition at least equal to that existing in the tidal water of the Treaty Area into which it discharges. The waters of the Hudson River, immediately above the New York-New Jersey State Boundary extended, shall be maintained in a sanitary condition at ebb tide at least equal to the sanitary condition prevailing in the waters of the river immediately below said boundary at flood tide.

"5. No oil or oily wastes, and no garbage or refuse of any kind liable to produce floating solids of an objectionable nature or dangerous to navigation or bottom deposits detrimental to navigation shall be discharged into the tidal waters of the Treaty Area, or into the Tributary Waters where they may be carried into such tidal waters.

"6. Nothing in this Article shall be construed to repeal or prevent the enactment of any legislation or the enforcement of any requirement by any signatory State imposing any additional conditions and restrictions to further lessen or prevent the pollution of waters within its jurisdiction."

IV. Time for Putting Remedies Into Effect

The following clauses should be included in the Treaty:

"Subject to the provisions of this Compact, the Commission shall set up a schedule aiming to establish certain dates on or before which all communities related to the designated waters of the Treaty Area shall have taken the necessary steps to bring about the construction of works needed for treating their sewage or industrial wastes in accordance with the standards of purity specified in this Compact. Any portion of such schedule affecting any signatory State shall require the affirmatime vote of the representatives of said State on the Commission.

"The administration of the laws enacted under this Compact shall be undertaken by the duly authorized officers or agents of the signatory States; provided, however, that the Commission shall have authority to investigate and determine if the requirements of the Compact are complied with and to bring action in the proper court or courts having jurisdiction to sue for the enforcement of any and all of the provisions of this Article."

V. Permanent Commission

We recommend that a permanent commission be established by the Treaty to consist of three members from each signatory State, each signatory State having only one vote. One member from each State should be an engineering representative of the State Board or Department of Health.

VI. Proposals Not Recommended

We do not recommend giving the Commission the power to issue bonds for construction purposes, to prepare plans for sewage treatment projects, nor the right to approve or disapprove plans for new projects of the alteration or extension of existing plants. Such powers and duties should be left with the State or Local Authorities or, if necessary, be enforced through the State or Federal Courts.

TRI-STATE TREATY COMMISSION

FINAL REPORT

RESEARCH AND ENGINEERING COMMITTEE

PART II

REPORT ON THE SECOND OBJECTIVE

STUDIES OF EXISTING CONDITIONS OF POLLUTION IN THE INTER-STATE TIDAL WATERS

Introduction

The second objective of the Research and Engineering Committee was to assemble information and data necessary to enable a clear understanding of existing conditions of pollution in the tidal waters of the adjacent portions of the three States. The following report includes only a summary of the pertinent data collected, and the conclusions based on the voluminous material reviewed.

With the short time and limited funds available elaborate and independent studies of the general problem of tidal water pollution were impossible. Such limitations, however, did not obstruct the work of the Committee since many thorough and excellent studies of the general problem have been made in past years by various commissions and authorities and it remained only for the mass of existing information to be compiled, compared and thoroughly reviewed. The detailed work of the Committee, therefore, embraced an exhaustive study of all reports and published records that could be located and which were pertinent to the subject, and the collection and assembling of additional unpublished data from the files of the respective Departments of Health of the several States, and from other public bodies.

Acknowlegments

Acknowledgment is gratefully made for the assistance rendered to the Committee through the cooperation of the Departments of Health of the respective States, the Sanitation Department of New York City, the Westchester County Sanitary Sewer Commission, the Passaic Valley Sewerage Commission, the Hackensack Sewerage Commission, the Federal Government, the Conservation, Water and other Departments of the several States, and various other regional and local authorities.

Previous Studies of the Problem

Although the Tri-State Commission is the first public body that has studied the question of pollution of the tidal waters from the viewpoint of the three States, various phases of the problem have been under examination for many years. In 1902, the U. S. Geological Survey published a paper discussing the pollution of the Passaic, Raritan and Hudson Rivers, in addition to other water areas (Water Supply and Irrigation Paper No. 72). The pollution of the waters of New York Harbor was brought to public attention in the 1905 and 1906 reports of the New York Bay Pollution Commission, which had been created by the New York State

Legislature in 1903. As a result of the work of that Commission, in 1906 the legislature created the Metropolitan Sewerage Commission of New York, which remained in existence until 1914.

The Metropolitan Sewerage Commission carried out elaborate and detailed studies of pollution in all of the New York Harbor waters, and published extensive reports in 1910, 1912 and 1914. Although the intention of the legislature was that the Commission should carry out its investigation in cooperation with the State of New Jersey, the efforts of the Commission to obtain this cooperation were without result. Consequently, the costs of this investigation were carried entirely by the City of New York, although the studies were extended to include pollution of the harbor waters from sources in New Jersey. The Commission also made recommendations as to a general plan for main drainage, sewage collection and disposal for the whole of New York City.

In its 1914 report, the Metropolitan Sewerage Commission summarized conditions at that time as follows:

"At the present time, the crude sewage of a population of over 6,000,000 persons is discharged through several hundred outlets into the harbor without purification, regulation or control of any kind. The discharges, all of which take place at the shore line or beneath the docks and piers, discolor the water, pollute the shores, produce offensive deposits and cause solid matters, plainly recognizable as of sewage origin, to float about in plain sight. Bathing and the taking of shellfish for food are no longer safe north of the Narrows.

"The pollution, objectionable as it is at the present time, is rapidly increasing. Within the next thirty years the population will be about double what it is today and the quantity of sewage will increase in proportion. The pollution is most objectionable in summer when it is desirable that the water should be cleanest; it is most intense in those sections where the density of population and the congestion of water traffic are greatest.

"The members of the Commission feel that they cannot state the need of improvement too strongly. The public has been made aware of the situation through the numerous reports which the Commission has issued from time to time. Among great cities, New York is practically alone in not possessing either a system of main drainage and sewage disposal or a plan and policy for the sanitary conservation of its water highways."

The reports of the Metropolitan Sewerage Commission have been under discussion and study by the officials of New York City ever since 1914 and various reports have been issued recommending steps to be taken to alleviate the pollution of the harbor waters. Although considerable planning had been carried on in the succeeding years, little progress in the matter of providing physical works for the removal of pollution from harbor waters had been made, up to the past year. On February 25, 1931, the Sanitary Commission of New York City submitted to the Mayor a report on the General Plans for Sewage Disposal for the City of New York, recommending a program for construction of sewerage and disposal works which would require a number of years to complete and which would greatly improve the sanitary conditions in the harbor. As a result of this report, steps were taken to start work on the first project for this program,—i. e., the Ward's Island Sewage Treatment Plant,—construction of which was commenced during the past summer. It is recognized by the Sanitary Commission that it will require a number of years to overcome the condition of pollution from New York City's sewage, and that satisfactory results can only be obtained through cooperative treatment of pollution from the other communities now discharging sewage into the harbor waters.

The U. S. Engineer Offices of the First and Second Districts, New York City, in 1925 reported upon their investigations of the pollution of the nagivable waters and tributaries within the Metropolitan District, including the Hudson River up to Poughkeepsie. These investigations included a survey of pollution by sewage, industrial wastes and oil and also dis-

cussed the existing laws and jurisdiction of the several authorities. The reports of the U. S. District Engineers have been of great assistance to our committee as noted elsewhere in our report.

Steps to alleviate pollution from sources outside of New York City have been taken in several localities. In Westchester County, the Westchester County Sanitary Sewer Commission has been in existence since June 27, 1926. This Commission has studied the problem of sewage disposal in the entire county, and has constructed several trunk sewers and disposal plans. When its general program is completed, the conditions of pollution in the tidal waters adjacent to Westchester County should be considerably improved.

Studies of conditions in Nassau County, New York, have been made by the Governor's Special Long Island Sanitary Commission, which submitted a report on May 15, 1931. This report recommended the appointment of a county sanitary commission to provide and operate trunk and outlet sewers and sewage treatment plants where required in Nassau County.

The Passaic Valley Sewerage Commission was established by law passed in 1902 which was revised in 1907. The district covered by this commission includes the greater portion of the Passaic River Valley in New Jersey, from the Great Falls above Paterson to the mouth. The Commission has constructed a trunk sewer which is designed to receive all the sewage from the district, a pumping plant and sedimentation basins located near the shore of Newark Bay, and an outfall sewer discharging into New York Upper Bay near Robbins Reef. These sewerage and sewage treatment works were placed in operation on August 2, 1924, and have resulted in considerable improvement of conditions in the Passaic River and to some extent also in Newark Bay.

The Hackensack Sewerage Commission has been studying the problem of eliminating pollution on the Hackensack River, in New Jersey, since January, 1931, and is preparing a report to be submitted to the Boards of Chosen Freeholders of Hudson and Bergen Counties. The Commission plans to eliminate pollution on the river by a comprehensive project which will provide for the sewage from all the communities in the Hackensack watershed, and will propose legislation to enable the financing and construction of this project.

The Joint Outlet Trunk Sewer, originally constructed in 1902, serves several towns in the Elizabeth and Rahway River watersheds. This sewer delivers at a treatment plant in Elizabeth, with discharge into Arthur Kill. The Rahway Valley Trunk Sewer, now under construction, will receive the sewage of a number of towns in the Rahway Valley. It will have a treatment plant in Woodbridge Township, with discharge into the Rahway River. These two trunk sewers were constructed by joint action of the interested municipalities, for the purpose of handling the sewage from the greater portion of their respective watersheds.

In the Raritan River Valley, extensive studies have been made, and various trunk sewer and sewage treatment projects are under consideration. The several municipalities have been ordered by the State Board of Health to take steps leading to the elimination of pollution of the river, but no final plans have as yet been adopted.

In Connecticut:- Stream pollution in Connecticut has been under investigation for a period of about forty-five years, and while some of the municipalities have contributed to the solution of this problem by carrying on local investigations, the most important studies have been made by the State Health Department and other State commissions. The earliest official investigation of stream pollution in Connecticut was authorized in 1886 and reports on these studies were made by the State Board of Health. In 1887 a Sewage Commission was appointed, and between 1899 and 1902 submitted reports on sewage disposal in the State. Other studies under the direction of the State Board of Health were published during the period of 1909 to 1912. These investigations were confined principally to setting down records of the stream pollution conditions of the times,

and comparisons with pollution in other States and foreign countries.

In 1915, the State Board of Health submitted a report on an investigation of pollution of waters within the State by sewage, with recommendations for such legislation as would lead to the control of such pollution. Following the publication of this report, the Industrial Wastes Board was appointed in 1917, and submitted reports between 1918 and 1921. These reports represent an important addition to the literature of Connecticut problems and include the results of a considerable number of investigations on methods for the treatment of industrial wastes, made under cooperative agreements between the industries and the State Industrial Wastes Board. Subsequent to the final report of this board, in 1921, and after further investigations under authority of the General Assembly, the State Water Commission was created in 1925. This Commission has the duty of protecting the waters of the State from pollution by sewage or industrial wastes, and has accomplished a great deal towards the elimination of such pollution within the past five years. The State Board of Health has also made numerous investigations on public health problems involving the protection of shellfish areas and bathing beaches. A very careful study of the shellfish areas and bathing beaches along the entire shore line of Connecticut, covering three years' work, is ready for publication and should be of considerable interest to the Tri-State Commission, as it gives a fair picture of existing conditions.

In addition to the work done in the several states by these various commissions, the problem has also been studied by various legislative committees and municipal authorities, whose work cannot be covered in this brief summary.

With the exception of the Metropolitan Sewerage Commission and the Federal Government, the work done by the various regional or district commissions has been chiefly for the purpose of eliminating conditions of pollution on particular drainage areas, or to improve certain streams. They have not been interested in any general elimination of pollution of the inter-State tidal waters. Notwithstanding the work of the Metropolitan Sewerage Commission, whose final report was submitted in 1914, no very definite progress in the actual construction of works to carry out its recommendations appears to have been made until 1931.

The summary of existing conditions given in the present report will show that proper progress has not been made, that pollution has increased in spite of all the investigations and reports that have been prepared, and that conditions in many localities will become intolerable unless steps are taken in the near future to obtain joint action by all communities which share in the responsibility for the pollution of the inter-State tidal waters.

Population and Sewage Flow

The accompanying Tables 1-3 contain a summary of statistics which we have assembled to show the sewage flow which reaches the streams flowing into the Treaty Area, or which is discharged directly into the tidal waters of the Treaty Area. We have also shown the population which contributes this sewage.

In preparing these statistics, population figures were tabulated by towns or incorporated places; but in New York City the data were further subdivided into assembly districts in order to obtain a more accurate distribution of the population. Estimates were made of the population contributing sewage in the year 1970, by a study of the growth of population as shown by the census reports.

For areas outside of New York City, the extent of sewage treatment in future years was assumed to increase only in proportion to the estimated increase of population contributing sewage.

In estimating future conditions for New York City, it was found advisable to give consideration to the probable development of sewage treatment works. For this purpose, it was assumed that, by 1970, the "Plan A" sewage disposal system proposed by the Sanitary Commission in their report dated February 25, 1931 would be in operation. This involves a rather

complete re-alignment of the population and sewage statistics for areas tributary to various portions of the harbor. The results are shown in Table 4.

The data on sewage flow and population are summarized in the tables by watersheds in order to show more clearly the extent to which pollution from sewage is concentrated at various points in the tidal waters. In general, the figures show the population located on a given watershed, and the sewage contributed by that population. In certain cases, however, an artificial re-alignment of drainage areas was necessary because the sewage from certain communitities on the watershed was transferred through a trunk sewer to some other watershed. As an example, the Passaic Valley Trunk Sewer collects the sewage from a number of municipalities in the Passaic River watershed in New Jersey and discharges this sewage into New York Upper Bay. The population and sewage so affected are therefore grouped with the New York Upper Bay watershed instead of with the Passaic River watershed. (For location of watersheds, see Fig. 2).

In estimating the total sewage flow from a given watershed, some consideration must be given to the extent to which the sewage is treated in the various communities. To combine the rate of flow from a town providing no treatment of its sewage with that from another town where the sewage was highly purified before final discharge would not indicate the true situation. The degree of purification varies greatly in different towns; but for purposes of comparison three classifications were used:-

(1) Untreated sewage.
(2) Partially treated sewage—includes sedimentation with or without screening.
(3) Fully treated sewage—includes both sedimentation and some form of filtration.

In combining the sewage flows, untreated sewage was given a "weight" of 100%, partially treated sewage was given a weight of 67%, and fully treated sewage was given a weight of 15%. The resulting figures are described as "equivalent untreated sewage" flow.

A similar method was used to determine the "equivalent contributing population." This may be considered as the population whose raw sewage would be equivalent in polluting strength to the sewage actually discharged on the watershed, after making allowance for the various degrees of treatment that are provided in the several communities. The figures for equivalent population and equivalent sewage are not directly proportional, due to the fact that the rates of sewage flow per capita are not the same in all places.

While the estimates of population and sewage flow are based on conditions existing in 1930, in making allowances for the treatment of sewage in the various communities the treatment plants in operation or under construction in 1931 were included.

In the tables, sewage flow is given as the annual average flow, in million gallons per day. Population estimates are based on the number of permanent residents as shown by the census tabulations. In some localities the summer population is considerably greater than that shown by the census, and in New York City there is a large transient population which is not included in the estimates but which contributes a considerable amount of sewage; but no allowance for these conditions was made in the estimates.

Minimum Streamflow

In estimating the extent to which sewage is diluted by the fresh water flowing into the tidal waters, it was necessary to determine the minimum flow in the various streams. It was decided to make this estimate on the basis of the average flow in the driest month expected. There might be short periods when the actual streamflow is less than this amount, but these would not have any signficance as to dilution of sewage in the tidal waters on account of the effect of the large drainage areas and of the large basins of tidal water in smoothing out these short-time minimum flows.

The estimates were based on a study of all extising records of streamflow within the general limits of the drainage areas involved. These records were extensive enough to permit a fair estimate of probable future conditions. The adopted rates of flow, in c. f. s. per square mile, are not uniform, but vary according to the hydrologic conditions in the several watersheds as indicated by the streamflow records. Allowance was made, as far as possible, for the effect on minimum streamflow caused by diversion of water for municipal water supplies. On the Hudson River watershed a special factor was the regulating effect on minimum flow caused by the operation of the Sacandaga Reservoir at Conklingville. This is operated so as maintain a minimum average flow in the Hudson River at Spier Falls of 3,000 c. f. s., and consequently causes a decided effect on the minimum flow of the entire Hudson River watershed below that point.

The estimated minimum streamflow on each watershed is given in Tables 1 to 3.

Total Pollution by States

Table 5 gives a summary of the data on population and sewage flow for the three States, and the percentages of the total attributed to each State. The portions of the States included in this summary are as follows:

(a) In New Jersey—all drainage areas tributary to the Treaty Area, as defined in the recommended draft of the Tri-State Treaty. (See Fig. 1).

(b) In New York—all drainage areas tributary to the Treaty Area, and including the Hudson River watershed upstream as far as Newburgh. Although the Treaty Area extends only up to the N. Y.-N. J. State Boundary, it was believed that the sewage from communities as far upstream as Newburgh might have some influence on pollution below the inter-State boundary.

(c) In Connecticut—all drainage areas tributary to the Treaty Area, but excluding the Housatonic River watershed above Shelton. The Housatonic River watershed is so sparsely populated with respect to the flow of the stream that the effect of pollution from that territory upon the river at Shelton was considered to be negligible.

Pollution of the Waters of New York Harbor

An attempt has been made to show the total effective pollution of the waters of New York Harbor, caused by the various communities in the States of New Jersey and New York. In Table 6 is given a summary of the "equivalent population contributing untreated sewage" and the "equivalent untreated sewage flow" in various parts of the harbor. These values are given for 1930, and for 1970 with New York City's Plan "A" for disposal in effect. The figures are intended to indicate the total equivalent pollution carried by the harbor waters at various points. In making this summary the following assumptions as to the flow of the tidal waters were adopted:-

(a) Sewage discharged into the Harlem River is carried equally to the Hudson River and the East River.

(b) All sewage discharged into the East River is ultimately carried into New York Upper Bay.

(c) Water discharged into Newark Bay is carried as follows:-

To Kill van Kull and Upper Bay	83.7%
To Arthur Kill	16.3%

(d) All sewage carried into New York Upper Bay is ultimately carried into the Lower Bay through the Narrows.

(e) All sewage discharged into Jamaica Bay is carried into the Atlantic Ocean and does not reach the Lower Bay.

These assumptions are based on extensive tests and investigations that have been made by the Metropolitan Sewerage Commission and by the U. S. Coast and Geodetic Survey.

In estimating the amount of sewage brought into the harbor by the Hudson River, four assumptions were made:-

(1) That all the sewage discharged on the entire watershed of the Hudson River reached the harbor waters.

(2) That only the sewage discharged at Newburgh or below reached the harbor waters, the sewage from above Newburgh being assumed to be purified by natural processes as it comes down the river.

(3) That only the sewage from below the N. Y.-N. J. State boundary reached the harbor.

(4) That only the sewage from below the New York City boundary reached the harbor.

Dilution of Sewage in New York Harbor

In studying the possibility of dilution of sewage in the harbor waters, it is obvious that attention must be given to tidal action. The volume of water carried into and out of the harbor at each tide is very great, and the interconnection of the different branches of the harbor provides an opportunity for the transportation of sewage from one part of the harbor to another. Dilution of the sewage is brought about by the fresh water flowing into the harbor from the rivers, notably from the Hudson, and by considerable volumes of clean sea water which are carried back into the harbor on each flood tide.

The river water available for dilution, in the driest months expected, has been estimated from studies of streamflow records, as shown in Tables 1-3. But the determination of the volume of sea water available for dilution is much more complicated. A study of this question was made for the Metropolitan Sewerage Commission, to obtain the volume of diluting sea water in months of average streamflow. We have corrected these results to obtain the amount of sea water available for sewage dilution at the time when the streamflow is reduced to the minimum adopted for this report. The results are given in Table 7.

In this table the amounts of land water and sea water available for dilution of sewage are given at several points in the harbor. The rates of flow are given in c. f. s. (cubic feet per second) and in m. g. d. (million gallons daily). The total of land and sea water combined is also given. The total equivalent sewage flow at these points is given together with the equivalent contributing population. The portion of the table showing conditions as existing in 1930 gives the results (a) including all sewage from the entire Hudson River watershed, or (b) including only the sewage from below the N. Y.-N. J. State boundary. The table for 1970 includes only the sewage from below the N. Y.-N. J. line, and is also based on "Plan A" development of the sewage disposal project for New York City.

The table shows the ratio of diluting water to the sewage flow, and the rate of flow of the diluting water (either land water alone, or land and sea water combined) in c. f. s. per 1,000 population. In interpreting these results, it may be considered that with fresh water streams, the minimum ratio of dilution of untreated sewage to avoid nuisance should be about 40:1, or that the diluting water should be available at a rate of about 6 c. f. s. per 1,000 population. With sea water, the amount of dilution should be increased about 20%.

Any estimates of dilution of sewage by sea water in the harbor must be considered very approximate as the volumes of diluting sea water cannot be accurately determined. Moreover, an estimate of dilution based on total volumes of sewage and diluting water in a branch of the harbor does not tell the whole story. For the sewage and harbor water seldom have adequate opportunity for proper mixing and there will be local areas where the concentration of sewage will be much greater than that indicated by the average figures. Also, the sea water estimated as available for dilution of sewage in the different branches of the harbor is generally not clean sea water except off places near the ocean; at other points the "new sea water" is really water which has not been at the place on the previous tide, but comes from some other part of the harbor. However, in spite of these limitations, it is believed that this study warrants the following conclusions:

(1) If the "land water" only is considered available for dilution of sewage, no branch of the harbor above the Narrows has a sufficient capacity for the disposal of the sewage discharged into it, under present conditions.

(2) If sea water as well as land water can be considered for dilution, the only part of the harbor providing sufficient dilution at present is the Hudson River.

(3) The worst branches of the harbor as regards dilution of sewage at present are the Harlem River, East River (particularly the lower East River south of Hell Gate), Newark Bay, Arthur Kill and Kill van Kull. This is also verified by results of tests for dissolved oxygen as discussed elsewhere in this report.

(4) Under conditions estimated to exist in 1970:

(a) If no further work is done to provide for treatment of the sewage now reaching the harbor waters, future conditions will be intolerable in all parts of the harbor.

(b) If New York City carries out the proposed plan of construction for Sewage disposal (Plan "A" of the Sanitary Commission), conditions in the Hudson River, Upper Bay, Harlem River and East River will be somewhat improved over the present conditions, even after making allowance for the increase in population during the intervening forty years. However, it is doubtful whether conditions in the harbor would be satisfactory at that time unless plans are carried into effect to treat also large parts of the sewage discharged into the Hudson River above New York City as well as that contributed to the River and Upper Bay from New Jersey.

(c) To maintain Newark Bay and the Kills in a satisfactory condition in the future will require the introduction of a large degree of purification of sewage in the New Jersey communities tributary thereto, to provide both for the present untreated sewage and for the increasing population.

Dissolved Oxygen Tests in the Tidal Waters

One of the most satisfactory methods for determining the degree of pollution existing in a body of water is by the dissolved oxygen test. In discusisng the significance of this test, the Metropolitan Sewerage Commission of New York stated (1912 Report, pg. 626): "The amount of dissolved oxygen which is present in a natural body of water affords the best means available for measuring the burden of pollution which has been put upon the water and gives a basis upon which to form an opinion as to maximum quantity of sewage which the water can properly absorb. So far as future conditions are concerned, the test has reference chiefly to the possibility that the sewage materials in the water may putrefy and produce offensive odors. If there is much oxygen, this probability is remote; if these is but little, the danger is imminent. . . . The scientific value of the analysis depends on the fact that the oxygen which is normally present in the water is used up by the processes of nature in changing the decomposable substances of the sewage into harmless and inoffensive compounds. This change has been termed 'digestion'."

The amount of oxygen that can be dissolved in clean water varies with the temperature, and with the salinity of the water; it is less for warm than for cold water, and is less with salt water than with fresh water. The maximum amount that can be dissolved under any given conditions is taken as 100% saturation. The actual amount of oxygen present in a given sample of water is then given as a percentage of possible saturation under the existing conditions.

When the water contains organic matter, as in sewage, the dissolved oxygen will be consumed by the "digestive" processes at a rate which depends on the concentration of the organic matter in the water. As the digestion proceeds, the rate of consumption of oxygen gradually decreases. When the dissolved oxygen drops below 100% saturation, the water begins to absorb oxygen from the atmosphere. The rate at which this oxygen is absorbed increases as the percentage of oxygen in the water decreases. A point is reached, therefor, when the rate at which the organic matter consumes oxygen may equal the rate at which additional oxygen is absorbed from the atmosphere, in which case as long as other conditions do not change the percentage saturation will remain constant at the depressed value. If the rate of oxygen consumption exceeds the rate of oxygen supply, the percentage saturation will decrease and dissolved oxygen may become depleted resulting in the creation of offensive conditions.

The digestive processes are most active during warm weather, at which time the amount of oxygen in the water is the least. It is dur-

ing the summer months, therefore, that the greatest deficiencies in dissolved oxygen will occur.

Tests for dissolved oxygen in the tidal waters of the Treaty Area have been made by several agencies. In the accompanying diagrams and tables are given summaries of some of these tests. Where possible, averages are given of all tests made between June 1st and September 30th, as it is believed that these averages give the most accurate picture of relative conditions. Individual tests are affected by many conditions, such as wind velocity, depth at which sample is taken, stage of the tide, etc.; whereas these variable effects are absorbed by using the seasonal averages.

New York Harbor and Newark Bay:- Extensive tests in New York Harbor and Newark Bay have been made by the Metropolitan Sewerage Commission and by the engineers of the Board of Estimate and Apportionment. The results as taken from the reports of the Chief Engineer of the Board of Estimate and Apportionment are plotted in Figure 3. The curves on this diagram show the average dissolved oxygen percentages for the main branches of the harbor for the summer months during the years 1909-1931. While there is considerable irregularity in the individual curves, there is a marked decrease in oxygen shown between 1909 & 1916, with a more gradual decrease since that year. This is also shown by the five-year averages given in the following table, which indicate a continual decrease in all parts of the harbor, except at the Kill van Kull:

Percentage of Dissolved Oyygen

Averages of Samples Analyzed between June 1st and September 30th.

	1911 to 1915	1916 to 1920	1921 to 1925	1926 to 1930
Hudson River below Spuyten Duyvil	54	44	39	36
Harlem River	33	24	24	23
Upper East River	58	45	44	44
Lower East River	54	25	23	21
Upper Bay	69	53	45	36
Kill van Kull	63	42	45	37
Narrows	72	59	56	47
Combined Average	56	43	40	35

It is believed that fluctuation in the average figures from year to year is due largely to variations in the flow of upland water through the rivers and also to variations in the air temperature in different years — low streamflow and high temperatures tending to cause low oxygen percentages.

The diagram also shows that, since 1920, the average dissolved oxygen in summer months has not gone above 50% in any part of the harbor except at the Narrows and the Upper East River and even at those points it has seldom reached 50% since 1925.

The Harlem and lower East Rivers show the worst results, remaining below 30% since 1915, and reaching a low value of about 14% in 1926.

The branches of the harbor in their relative degree of pollution may be listed as follows, giving the most badly polluted sections first:

Lower East River
Harlem River
Hudson River (below Spuyten Duyvil)
Kill van Kull
Upper Bay
Upper East River
The Narrows

Table 8 gives minimum observed oxygen tests for 1909 and 1931, and shows the serious conditions now existing in the Harlem and Lower East Rivers. This table also illustrates the great increases in pollution which have taken place in the last 20 years in all the harbor waters except Jamaica Bay.

The Passaic Valley Sewerage Commission have made dissolved oxygen tests in New York Harbor and Newark Bay since 1923, which are shown graphically in Fig. 4. This shows summer averages at certain points in the Upper Bay, and for Newark Bay and adjacent waters. The curves for New York Harbor are reasonably consistent with the average curves in Fig. 3. They show a tendency to a gradual decrease in dissolved oxygen in the Upper Bay and adjacent waters in the last few years. The effect

of the Passaic Valley Sewer discharge at Robbins Reef is apparently to reduce the dissolved oxygen at that point at a slightly greater rate than it is being reduced at other parts of the harbor.

A marked improvement in the Passaic River is shown in 1924, when the Passaic Valley Sewer commenced operation. This effect is also shown at the mouth of the Hackensack River, and in the averages for the Bay. In spite of this local improvement, however, the general tendency at present is towards a reduction in oxygen content, indicating a continuous increase in pollution in these waters.

The Arthur Kill is shown to be considerably more polluted than the Kill van Kull. All of the waters in Newark Bay and adjacent waterways are badly polluted, and at no point has the average summer oxygen content been above 50% since 1927.

Hudson River above Spuyten Duyvil:—Available tests for this portion of the tidal waters are not as extensive as for the various branches of New York Harbor. In September 1924, the U. S. Engineer Office, 1st District, New York City, tested samples of river water at various points from Poughkeepsie to New York City. Average results, omitting samples which were taken from tributary streams or were taken near the shore and affected by local pollution, are summarized below:

Location	Distance from N.Y. City Hall	Average Dissolved Oxygen	% Sea Water
Poughkeepsie	74 Mi.	72%	6%
Low Point	63	82	8
Storm King Mt.	54	70	8
Verplanck	39	59	12
Croton Point	33	64	14
Ossining	32	61	20
Scarsboro	30	61	20
Tarrytown	27	58	28
Irvington	24	45	30
Dobbs Ferry	22	55	32
Yonkers	17	50	46
Mt. Saint Vincent	15	48	50

The District Engineer's Report on Investigation of Pollution of Navigable Waters and their Tributaries (1925) states:—

"Poughkeepsie to Peekskill:—Dissolved oxygen samples were taken on two consecutive days in September at 15 points within this area. The center portion (of the river) showed higher values between 75% and 82% but along the city waterfronts at Poughkeepsie, Newburgh, Beacon City and Cornwall, results were obtained between 55% and 72% due to the effect of the sewage discharge at these towns. It is very probable that lower values would be obtained at other times and from a series of more extensive observations."

The latter statement can be further verified by the fact that the stream flow in the Hudson River watershed during September, 1924, was probably as much as twice the minimum monthly flow.

"At the time of our inspection, no visible evidence of extensive pollution could be detected in the Hudson River in this area by the general appearance of the water surface, with the exception of small areas of light oil often seen, and the floating domestic sewage along the city waterfronts.

"Microscopic examinations of bottom samples along the Poughkeepsie waterfront showed sludge deposits were being formed and not being carried away. At Newburgh, the sewage deposits are largely forming above the low water line and only an oily scum was observed on the surface.

"Peekskill to New York City:—Determinations of dissolved oxygen value of the waters in this area were made at 22 points on two successive days in September 1924. An average for such determinations was 54%. A cross section at Verplanck gave an average of 59%, while one taken at Mt. St. Vincent gave 48%. The other samples were taken generally from ¼ to ¾ of a mile offshore from the larger communities along the river, and vary between a minimum of 42% and a maximum of 72%. It is quite probable that observations taken during July or August would furnish appreciably lower values.

A personal inspection of the physical condition of the waters gave ample proof of extensive pollution."

Nassau and Suffolk Counties:—The U. S. District Engineer's Report (noted above) records 52 dissolved oxygen determinations in October 1924, with average results as follows:

Manhasset Bay	87%
Hempstead Harbor	83
Cold Spring Harbor and Oyster Bay	87
Huntington Harbor and Northport Bay	79

"Long Island included in the counties of Nassau and Suffolk presents no serious problem from the standpoint of pollution. There are no trade waste discharges of any consequence, and over 20% of the sewage from the north shore is treated effectively. About 3.22 m.g.d. of sewage are discharged along the north shore from the city line to Montauk Point. However, this is run into large bodies of water, which are flushed by tidal action, with the clean waters of the Atlantic Ocean through Long Island Sound. All of the towns on the south shore discharge their sewage into cesspools, the effluent reaching the bay through the ground waters."

Referring to the reports of the New York State Dept. of Health, the District Engineer's report states:—"There are no public sewer systems discharging into Great South Bay, and the pollution is concentrated in two areas. At Bay Shore, local discharges pollute the bay. At Patchogue similar conditions exist, though in a more aggravated form. West of Great South Bay are a number of small bays, creeks, inlets and marshlands which constitute Hempstead Bay. A considerable number of private sewers, drains and overflowing sewers, located all along the shore, discharge into these waters."

The only public sewer systems now discharging into Great South Bay are at Patchogue and Ocean Beach, both of which serve small communities and also have partial treatment of the sewage. There are no public sewers discharging into Hempstead Bay. The only public sewerage systems discharging into the Atlantic Ocean east of New York City are at Long Beach and Atlantic Beach.

Long Island Sound:—Extensive tests of dissolved oxygen in Long Island Sound are not available. The limited data at hand indicate that the waters of the Sound contain relatively little polluting matter, except in the immediate vicinity of outfall sewers, and in the larger harbors. The western end of the Sound, between New Rochelle and Throgg's Neck, is subject to some pollution from New York City. Since the East River flows into Long Island Sound during each flood tide, some of the sewage discharged into the Upper East River will be carried into the Sound. But on the following ebb tide the direction of current will be reversed, and the water flowing from the Sound into the East River will carry some of this sewage back into the East River. Under average conditions, the total volume of water carried by the ebb tide is greater than that on the flood tide; hence the only portion of the East River sewage which could remain in the Sound after ebb tide would be that which is lost due to diffusion.

From an examination of the float experiments of the Metropolitan Sewerage Commission, it is believed that little if any sewage discharged into the Upper East River west of College Point will reach Long Island Sound on the flood tide. We have estimated the volume of sewage discharged into the East River east of College Point and Clason Point, for 1930, as follows:

Contributing Population	317,645
Sewage Flow — m.g.d.	38.70

Since the river is flowing towards the Sound only one-half of the time, it may be assumed that about 20 million gallons of sewage reach the Sound from New York City each day, (equivalent to 2.67 mill. cu. ft. per day or 1.38 mill. cu. ft. per tide). Some of this sewage will remain in the Sound, as a result of diffusion with the large bodies of water, and the remainder will be carried back into the East River and eventually into the Upper Bay. We have no data on which to base an estimate of

the amount of sewage lost into the Sound by diffusion, but the above figures indicate that the quantities involved must be small, particularly in relation to the total volumes of water flowing on each tide.

Industrial Wastes

The inter-State tidal waters receive considerable quantities of polluting material originating as trade or industrial waste products, which are disposed of by the industries by discharging into the sewers or water courses. These wastes may be grouped into four classes, according to the manner in which they pollute the waters:—

(1) Solids which tend to form deposits in the waterways, or floating solids which may be dangerous to navigation.
(2) Organic material,—such as the waste from creameries or slaughter houses,—which has a polluting effect very similar to that resulting from domestic sewage.
(3) Chemicals which may be carried in solution or suspended in the water in the form of an emulsion.
(4) Oils and oily products.

Detailed information as to industrial wastes in the Metropolitan District is difficult to obtain. No regular reports on this matter are submitted to the various governing bodies by the industries involved, and the only way such data can be obtained is by original surveys and examinations of all the industries in the District. The only extensive survey of this nature which we have been able to find is included in reports by the U. S. Engineers of the First and Second Districts, in New York. Some study of this question has also been made in the Hackensack, Passaic and Raritan River Valleys, in New Jersey. The State Water Commission of Connecticut has made a study of industrial wastes on the principal rivers discharging into Long Island Sound.

The question of industrial wastes which are injurious to navigation is not considered herein, as this matter is under the jurisdiction of the Federal Government and it is believed that it can be kept under control through adequate enforcement of existing laws and regulations. Organic wastes can generally be handled effectively through the regular sewage treatment plants. Their effect as to pollution of the tidal waters is equivalent to a certain increase in the population contributing sewage. What this increase should be can only be determined by special study in each community. No general attempt has been made to express the equivalent population of the industrial wastes in preparing the statistics on sewage flow presented in this report, as the necessary information was not available. However, in localities where industrial development is extensive, the data on sewage flow include some allowance for pollution by industrial wastes.

Chemical wastes, and particularly acids, cannot generally be handled in the sewage treatment plants. In fact, if present in large quantities, they may partially or wholly destroy the effectiveness of the purification process. Their presence in any large amounts in the tidal waters would probably be very injurious to fish or shellfish life; but, in most cases, the great dilution by the tides or streamflow will prevent the accumulation of the chemicals to a dangerous extent. Moreover, since the tidal water is generally alkaline, the tendency will be to neutralize the acid wastes to a considerable extent. Oil wastes are discussed in more detail below.

New Jersey

In the Hackensack River valley, great quantities of industrial wastes are discharged into the river between Hackensack and Newark Bay. A joint commission has been formed to solve the sewage disposal problems of this valley, and efforts are under way to bring about the proper treatment of trade wastes.

In the Passaic River valley, there is extensive industrial activity between Paterson and Newark. Practically all domestic sewage in this area is carried in the Passaic Valley Sewer which discharges into New York Upper Bay at Robbins Reef and has been in operation since August 2, 1924. The sewer commission

is attempting to bring about the treatment of all objectionable wastes at their source before they are discharged into the trunk sewer, and it is expected that eventually all such wastes in the Passaic Valley will be eliminated from the river by this means.

In the Raritan River valley, it has been estimated that industrial wastes discharged directly into the river courses are equal to 10 million gallons daily, and to be equivalent to the sewage discharged from a community of not less than 50,000 people. Plans are under way to secure proper treatment for these wastes.

On the shores of New York Upper Bay, Newark Bay, Kill van Kull and Arthur Kill there are numerous manufacturing plants and several large oil refineries.

New York

On the Hudson River, above New York City, there is a considerable amount of manufacturing. The plants are distributed among the various towns and the resulting industrial wastes are sufficiently diluted by the river flow to avoid any general nuisance, except in the immediate vicinity of the larger towns.

In New York City, the principal industrial development is in Manhattan, Brooklyn and Queens. The distribution of manufacturing plants is not uniform, though most of the trade wastes come from factories located in a relatively narrow strip along the waterfront. In Manhattan, the greater portion of such plants are located on the East River and Harlem River. Most of the wastes in Brooklyn originate along the waterfront from a point about two miles south of Gowanus Canal to the head of Newtown Creek. Long Island City and Astoria are the industrial centers of Queens. A large portion of the trade wastes in New York City are discharged directly into the sewers.

There is no serious pollution of tidal waters from industrial wastes on the north shore of Long Island Sound in Westchester County, nor on the shores of Long Island Sound from New York City as far east as Port Jefferson and Fire Island Inlet.

Connecticut

A recent survey by the State Water Commission is the basis of the following summary.

Quinnipiac River.—Rises in central Connecticut and flows southerly into New Haven Harbor. It receives some industrial waste from the plant located in Meriden. The sewage in Meriden receives partial treatment, which is to be increased in the near future. The Wallingford Steel Co. produces a considerable volume of acid pickle liquors which are now discharged into the stream; this is under laboratory study and is to be corrected.

Naugatuck River.—Rises in northwestern Connecticut, and, flowing southerly, joins the Housatonic River at Derby. This is perhaps the most heavily polluted stream in Connecticut. The Naugatuck Valley is the seat of the brass and copper industry of Connecticut, and the stream receives the industrial wastes of all large brass and copper plants along its course. Extensive research work in the form of laboratory studies, looking toward the solution of this industrial waste problem, has been carried out at Yale University. In the meantime, changes in plant processes during the past two years have resulted in material reduction of the volume of strong acid liquors discharged into the stream.

Housatonic River. — Constitutes the principal watershed of western Connecticut, rising in Massachusetts and, flowing southerly, enters the Sound east of Bridgeport. It receives the Naugatuck at Derby, a few miles above its mouth. It is a relatively clean stream, above Derby. Most of the sewage entering the river above that point is treated, and the diluting and natural purifying effects of the river flow practically eliminate all effects of pollution as far downstream as Derby. Below Derby, all the pollution of the Naugatuck River is carried by the Housatonic.

Pequonnock River. — This stream passes through the City of Bridgeport just before entering the Sound. The lower reaches of the Pequonnock are heavily polluted, with both domestic sewage and industrial wastes.

Norwalk River.—This river has been greatly improved recently. The only large metallurgical plant on the river now treats the acid pickle liquors by neutralization and precipitation of the iron. The City of Norwalk has recently put in operation a modern sewage disposal plant, including sedimentation, sludge digestion and chlorination of the effluent.

Noroton River. — Relatively clean down to Stamford, where there are a number of industrial plants. During the past three years a great deal of progress has been made in correcting pollution from these plants. The City of Stamford has installed sewage treatment consisting of Imhoff tanks, with chlorination of the effluent. New Canaan, further upstream, is just completing an activated sludge plant for treating its sewage.

Byram River.—Flows into the Sound between Portchester and East Portchester. It is a relatively clean stream. One felt manufacturing plant has been the source of complaint due to its wastes, but a treatment plant now approaching completion will neutralize the acid wastes and remove the fiber formerly reaching the stream.

Oil Pollution

The pollution from oil is widespread, as it is not limited to the vicinity of the point of discharge but is carried great distances by the action of wind and tide. Moreover, it is not self-purifying but persists for long periods of time (though it is claimed that an extremely thin film of oil on the surface of the water will be consumed by natural processes within a few hours). Oily discharges are of two types, —light oil with specific gravity less than that of water, and heavy oil. It is the light oil which is carried about and appears in the form of patches and streaks on the water surface. In general, the heavy oil is not visible to the eye but forms an oily sludge on river and harbor bottoms.

The principal effects of oil pollution are:—

(1) By collecting on sewage solids, it interferes with their oxidization.

(2) Floating oil interferes with absorption of oxygen by the water from the atmosphere.

(3) It may render fish and shellfish unfit for food.

(4) It increases fire hazard of docks and bulkheads.

(5) It makes beaches unfit for bathing.

(6) It interferes with pleasure boating.

The sources of oil pollution are:—

(a) Oil originating from shipping.—The discharge of oil from ships, barges, etc., is prohibited by Federal statutes within territorial waters. This source may also include oil discharged from vessels at the shipyards and drydocks. It is believed that the control of this source of pollution should be left in the hands of the Federal authorities.

(b) Oil discharged directly into the water from industrial plants.—This originates chiefly at oil refineries, oil storage and distribution stations located on shore, and gas manufacturing plants. These plants generally have recovery installations to remove oil from their waste waters. The American Petroleum Institute has issued a Manual on Disposal of Refinery Wastes, outlining methods to be followed by the oil industry for the prevention of pollution from this source. Improvement of conditions in this respect should be brought about through effective enforcement of existing laws and regulations.

(c) Oil entering the waterways through the sewers.—This represents oil from garages, industrial plants and street washings. It was estimated in 1924 that about 7,000,000 gallons of crank case oil are dumped into the harbor yearly through the sewers. The American Petroleum Institute recommended the elimination of this source of pollution by urging all large cities to let contracts covering the collection of crank case drainings and other garage wastes.

Fishing and Shellfish Industries

We have made an investigation of records of the fishing and shellfish industries in the three States to determine, if possible, what effect pollution of the inter-State tidal waters has had upon these industries. It was found that few detailed statistics have been published and the available information is quite limited and

scattered. However, there are certain facts and trends relating to the industries which are discussed below.

Fishing Industry

Data furnished by the U. S. Bureau of Fisheries, by the Fish and Game Commission of New Jersey and the Conservation Department of New York show signs of a decided falling off in fishing within the last 30 years in the lower reaches of the Hudson River, and in Westchester County, New York City, Nassau County and the New Jersey counties bordering on the harbor waters (Bergen, Hudson, Middlesex and Monmouth Counties). This decline has not always been continuous, nor does it apply to the entire area. For instance, the catch of shad in the Hudson River shows a great fluctuation from year to year, due, evidently, to causes quite distinct from pollution of the river water.

It is well agreed by authorities on the subject that excessive pollution is injurious to major fish life, due largely to reduction in the dissolved oxygen content of the water. The minimum dissolved oxygen content required for the maintenance of fish life is subject to some variation, depending not only on the species of fish but on other physical conditions. It is probable that 20% saturation of dissolved oxygen is the minimum allowable without causing serious injury to fish life. Of equal importance is the existence of sludge deposits on the bottom which would have a serious effect on the growth or survival of fish eggs deposited thereon. Industrial wastes of certain types, particularly acids and oils, are especially injurious to fish life if present in considerable quantities.

Statistics available for areas not influenced by pollution show that the fishing industry is subject to sudden changes. Hence, it would be difficult to prove that the apparent decline in this industry in the waters of New York Harbor is due entirely or even principally to pollution. However, it is believed that the great decrease or even total extinction of commercial fishing in certain portions of these waters must be directly influenced by their polluted condition.

Shellfish

Statistics furnished by the Conservation Department of New York State, and giving the number of acres of tidal water under lease or franchise in New York State for the propagation of oysters, are available from 1904 to 1930. These show a continuous reduction in acreage, starting at 33,956 acres in 1915 and dropping off to 10,728 acres in 1930. The rate of reduction, however, has been decreasing in recent years and indications are that a minimum point has now been reached. Whether this acreage will increase appreciably in the future remains to be seen. Similar statistics for New Jersey and Connecticut were not available.

This striking feature of the oyster industry has been attributed to several causes. There seems to be considerable doubt as to whether pollution in the tidal waters is a direct cause of this condition. The decline in New York State has been blamed on a failure in the "set" of young seed oysters in Connecticut during recent years. New York oysters were formerly raised from seed oysters (or "spat") brought in from other areas, particularly from Connecticut. The failure of the "set" in Connecticut is generally attributed to other causes than pollution from the rivers and communities along the shore of that State.

Measures are in force to overcome the troubles of the industry due to failure of the "set". These involve the propagation of seed oysters by artificial means, much as fresh-water fish are raised in fish hatcheries. It is anticipated that these methods will eventually result in the production of sufficient seed oysters to satisfy the needs of the local industry.

It is known that oysters will grow more rapidly in waters containing a moderate amount of polluting organic matter, and such oysters are not necessarily unhealthful for food. It is necessary, however, that they be properly cleansed of any polluting matter carried into them by the water before they can be con-

sidered safe for food. Regulations have been established, therefore, under which oysters raised in polluted areas must be transplanted to non-polluted waters some time before being placed on the market, in order that they may become thoroughly washed by natural processes.

Considerable areas within the tidal waters of the three States have been so restricted by their respective Health Authorities. In most of these areas, oysters may be raised but may not be taken for marketing purposes without additional treatment as explained above. These areas are said to be prohibited for market shellfish. This restriction, while only partial under the law, is, in effect, a complete barrier to propagation of oysters in many cases as the men in the industry find it uneconomical to market oysters under these requirements.

It may be stated, therefore, that pollution of the tidal waters has had an injurious effect on the oyster industry, and that improvement in conditions of pollution will be of considerable assistance to the industry.

Conclusions

1. The total population of the three States on the watersheds draining into the Treaty Area (excluding the Hudson River above Newburgh) was about 11,900,000 in 1930. Of these, about 1,100,000 were not provided with sewerage facilities, leaving a contributing population of about 10,800,000. This is expected to increase to 24,100,000 by 1970.

2. The total volume of sewage discharged into these watersheds in 1930, after making allowance for the treatment provided in various communities, was about 1,350 million gallons daily (m. g. d.) which is estimated to be equivalent to the untreated sewage of a population of about 9,600,000.

3. The sewage discharged to the Treaty Area is contributed by the three States in the following approximate proportions:-

New York	74%
New Jersey	20%
Connecticut	6%

4. The total equivalent untreated sewage reaching the waters of New York Harbor (including Jamaica Bay, Newark Bay, and the Kills) in 1930 was about 1,250 m. g. d., from an equivalent population of about 8,900,000. Of this, the portion originating in New York City was about 970 m. g. d. from an equivalent population of 6,900,000. New York City therefore furnishes about 77½% of the sewage reaching the tidal waters of New York Harbor.

5. The effects of pollution of the inter-State tidal waters are shown most conclusively by tests for dissolved oxygen in these waters. Such tests have been carried on in the waters of New York Harbor on an extensive scale for the last 22 years. The tests show that the dissolved oxygen in all the main branches of the harbor declined rapidly between 1909 and 1916, and at a less rapid rate since that year. The general tendency apparently is for this decrease to continue. Since 1920 the average dissolved oxygen in summer months has not gone above 50% in any part of the harbor except at the Narrows and Upper East River, and even at those points it has seldom reached 50% since 1925. The Harlem and Lower East River show the worst results. Minimum values of less than 20% have been noted in many parts of the harbor during the past summer, with zero per cent being observed in the Lower East River and Harlem River. Jamaica Bay shows only a slight degree of pollution. All the waters in Newark Bay and adjacent waterways are badly polluted, and the average summer oxygen content has not been above 50% since 1927.

6. Conditions in local portions of the harbor are already decidedly offensive, due to lack of opportunity for tidal action to flush out the sewage deposits. The Harlem and Lower East Rivers are rapidly approaching the conditions of open sewers. The slips between piers are collecting points for sewage sludge deposits, and must be dredged out at regular intervals at considerable expense.

7. Outside of New York Harbor and Newark Bay, the conditions of pollution are not so serious. The Hudson River shows very

little pollution at Poughkeepsie. Even as far downstream as Tarrytown, the dissolved oxygen is above 50%. Further south, evidence of pollution is more prominent, due partly to the sewage from New York City which is carried upstream on the flood tide. There is little evidence of pollution in the waters of Long Island Sound, except locally near outfall sewers and large towns, and at the extreme west end which is affected somewhat by New York City. There is no serious pollution of Great South Bay, except at one or two local points.

8. Pollution of the tidal waters from industrial wastes is a serious problem. Organic wastes can generally be handled through the sewage treatment plants. Other wastes, particularly oils and chemicals, must be eliminated at their source. There are extensive industries on the shores of the Harlem and East River, New York Upper Bay, Newark Bay, and the Staten Island Kills, as well as in the Connecticut towns along Long Island Sound. Efforts are being made to secure cooperative help from these industries to prevent discharge of untreated wastes into the waterways. Further strengthening of the hands of state authorities in this regard should be helpful.

9. Control of oil wastes from ships is in the hands of the Federal Authorities. Pollution from this source has been considerably reduced but strict enforcement of existing regulations is necessary.

10. The fishing and shellfish industries have fallen off considerably in the past 20 years, and the decline in the oyster industry is particularly noticeable. This is not due entirely to pollution, but the contamination of the tidal waters by sewage has necessitated prohibition of raising market shellfish in certain restricted areas. These restrictions apply to a maor portion of the waters of New York Harbor, the large harbors of Long Island Sound in Connecticut, and certain limited areas on the Long Island shore. The fishing industry has also been greatly reduced in certain parts of the waters of New York Harbor, but the Hudson River fishery above New York City apparently has not been seriously affected by pollution.

11. Disposal of sewage by dilution in the harbor waters was feasible in the past but the diluting capacity of the rivers and tides is already greatly depleted in nearly all parts of the district and in many sections this capacity is completely exhausted. Future growth of population will render these conditions still more serious. The plans for sewage treatment under consideration by New York City will go far to provide for present and future conditions but they will not produce the required improvement unless supplemented with treatment of sewage reaching these waters from other areas.

12. The problem of eliminating pollution of the tidal waters has been studied for many years but no extensive results have been attained. This is because the problem is one requiring cooperative action by all the communities whose sewage now tends to pollute these waters. To this end, we believe the enactment of a Treaty between the States of New York, New Jersey and Connecticut is of prime importance.

Respectfully submitted, December 16, 1931.

RESEARCH AND ENGINEERING COMMITTEE.

F. S. TAINTER, *Chairman*
Charles A. Holmquist
James A. Newlands
Thomas Parran, Jr.
William Schroeder, Jr.

TABLE 1.

NEW JERSEY WATERSHEDS

POPULATION, SEWAGE FLOW AND DILUTION

WATERSHED	Drainage Area Sq. Mi.	Minimum Stream Flow (Monthly Avg.) cfs.	Minimum Stream Flow (Monthly Avg.) m.g.d.	1930 Conditions Total Population	1930 Conditions Pop. Contrib. Sewage	1930 Conditions Equiv. Untreated Sewage m.g.d.	1930 Conditions Dilution Ratio	1970 Pop. Contrib. Sewage
Hudson River	) 25	2	1.3	215,149	214,389	25.81	--	301,000
Upper New York Bay	)	1	0.6	1,179,063	1,179,063	125.40	--	2,040,000
Newark Bay	21	3	1.9	302,444	302,444	36.45	--	528,000
Arthur Kill	26	4	2.6	356,875	356,875	32.58	--	760,000
Hackensack River	212	15	9.7	272,680	248,310	10.69	0.9/1	603,000
Passaic River	976	60	38.8	259,113	87,465	1.08	36/1	159,000
Elizabeth River	30	5	3.2	794	--	--	--	--
Rahway River	90	33	21.3	61,477	58,540	4.80	4.4/1	144,000
Raritan River	1120	165	106.8	286,037	192,660	17.77	6/1	423,000
Lower N.Y. Bay	66	10	6.5	36,913	21,747	2.20	--	46,000
Shrewsbury River	122	21	13.6	28,563	15,051	0.86	16/1	31,000
Atlantic Ocean (to Manasquan R.)	--	--	--	84,203	71,321	4.86	--	145,000
TOTALS				3,083,311	2,748,365	262.50		5,180,000
Including New York State				22,927	11,311	0.25		

TABLE 2.

CONNECTICUT WATERSHEDS

POPULATION, SEWAGE FLOW AND DILUTION

WATERSHED	Drainage Area Sq. Mi.	Minimum Stream Flow (Monthly Avg.) cfs.	Minimum Stream Flow (Monthly Avg.) m.g.d.	1930 Conditions Total Population	1930 Conditions Pop. Contrib. Sewage	1930 Conditions Equiv. Untreated Sewage m.g.d.	1930 Conditions Dilution Ratio	1970 Pop. Contrib. Sewage
New Haven Harbor	236	43	27.8	278,455	235,200	27.43	1/1	317,000
New Haven to Milford	42	6	3.9	15,820	500	0.07	56/1	15,000
Housatonic R. (incl. Naugatuck R.)	1930	347	224.5	[a]302,390	[b]175,000	25.44	9/1	[b]263,000
Bridgeport Harbor	54	8	5.2	166,588	146,000	21.90	0.24/1	219,000
Fairfield to Saugatuck	129	23	14.9	10,842	2,500	0.37	40/1	10,000
Norwalk R.	63	11	7.1	41,732	21,700	3.07	2.3/1	48,000
Norton Pt. to Shippan Pt.	36	5	3.2	12,407	3,100	0.34	9/1	10,000
Stamford Harbor	30	5	3.2	57,367	32,000	3.43	0.9/1	64,000
Sound Beach to East Portchester	82	15	9.7	35,652	27,600	2.12	4.6/1	48,000
TOTALS				921,253	643,600	84.17		994,000
Including New York State				13,396	--	--		

Note:- Minimum stream flow estimates have not been reduced to allow for storage and water supply diversions.

(a) Does not include population in Mass.
(b) Housatonic watershed above Shelton is not included.

TABLE 3.
NEW YORK STATE WATERSHEDS
POPULATION AND SEWAGE FLOW

Watershed	Drainage Area Sq.Mi.	Min. Stream flow Month. Aver.)	1930 Conditions				1970 - Estimated	
			Total Population	Pop. Contrib. Sewage	Equiv. Untreated Sewage mgd	Equiv. Untreated Contrib. Pop.	Total Population	Pop. Contrib. Sewage
HUDSON RIVER SYSTEM:		c.f.s.						
Mohawk River)			477104	342996	41.14	240346	625500	478500
Hudson above Troy)	12020	4815	185000	66445	12.58	64974	198000	77000
Hudson, Troy - Newburgh)			526281	297271	46.51	252371	662000	433500
Hudson, Newburgh - N.J.Line	1034	91	281215	113522	13.39	102537	570000	322500
Hudson East Bank - N.J. "	36	6	256431	213675	16.66	142450	600000	550000
extended to N.Y.C. Line								
Hudson E. Bank - N.Y.C.								
Manhattan	9	)	739700	739700	158.03	723000	851700	851700
Bronx	2	) 1	6000	6000	0.70	6000	30000	30000
Tot. Hud. N.Y. State Sect.	13101	4913	2471731	1779609	289.01	1531678	3537200	2743200
" " above N.Y.C.	13090	4912	1726031	1033909	130.28	802678	2655500	1861500
" " " N.J. Line	13054	4906	1469600	820234	113.62	660228	2055500	1311500
" " " Newburgh	12020	4815	1188385	706712	100.23	557691	1485500	989000
LONG ISLAND SOUND: Bronx	8	)	7800	7800	1.00	7800	34000	34000
Westchester County	69	) 12	147230	121495	8.88	77332	300000	275000
Nassau County			110501	21200	1.57	14467	300000	100000
Suffolk County			38637	6700	0.38	4467	100000	25000
TOTAL			304168	157195	11.83	104066	734000	434000
UPPER EAST RIVER:								
Bronx	27		570284	570284	70.60	570284	1721600	1721600
Queens	44		303439	303439	25.00	231960	1504000	1504000
TOTAL	71	8	873723	873723	95.60	802244	3225600	3225600
HARLEM RIVER:								
Manhattan	5		459460	459460	100.30	459460	560800	560800
Bronx	13		681174	681174	84.40	681174	1344400	1344400
TOTAL	18	2	1140634	1140634	184.70	1140634	1905200	1905200
LOWER EAST RIVER:								
Manhattan	8		668152	668152	146.30	668152	687500	687500
Brooklyn	14		848573	848573	94.50	848573	1215200	1215200
Queens	13		339997	339997	36.37	338797	1266000	1266000
TOTAL	35	4	1856722	1856722	277.17	1855522	3168700	3168700
UPPER NEW YORK BAY:								
Brooklyn	25		1045573	1045573	116.30	1045573	1917500	1917500
Richmond	3		44500	44500	8.40	44500	170000	170000
TOTAL	28	3	1090073	1090073	124.70	1090073	2087500	2087500
LOWER NEW YORK BAY:								
Richmond	20	2	22816	22816	4.00	21250	305100	305100
TOTAL			22816	22816	4.00	21250	305100	305100
NEWARK BAY & KILL VAN KULL:								
Richmond	11	2	66830	66830	12.60	66830	395900	395900
ARTHUR KILL:								
Richmond	26	4	24200	24200	4.50	24200	219000	219000
JAMAICA BAY:								
Brooklyn	34		666255	666255	63.30	568255	2367300	2367300
Queens	48		435693	435693	39.70	370693	1930000	1930000
TOTAL	82	10	1101948	1101948	103.00	938948	4297300	4297300
ATLANTIC OCEAN:								
Nassau County			192552	7317	1.10	4878	300000	150000
TOTAL			9145397	8121067	1108.21	7580323	20475500	18931500
TOTAL except N.Y. State above Newburgh			7957012	7414355	1007.98	7022632	18990000	17942500
TOTAL except N.Y. State above N.J. Line			7675797	7300833	994.59	6920095	18420000	17620000
TOTAL NEW YORK CITY			6930446	6930446	966.00	6676501	16520000	16520000

TABLE 4.

NEW YORK CITY

Population and Sewage in 1970

Plan "A" for Disposal in Effect

	Estimated Population	Equivalent Population	Equivalent Sewage (m.g.d.)
HUDSON RIVER			
Bronx	30,000	20,000	2
Manhattan	868,000	578,600	126
	898,000	598,600	128
UPPER EAST RIVER			
Manhattan	705,600	105,800	
Bronx	3,090,000	463,500	
Queens	2,100,000	315,000	
	5,895,600	884,300	105
LONG ISLAND SOUND (City Is.)			
Bronx	10,000	1,500	1
LOWER BAY			
Outlet Island			
Manhattan	526,400	350,900	
Queens	670,000	446,700	
Brooklyn	3,132,700	2,088,500	
	4,329,100	2,886,100	
Richmond	305,100	45,800	
	4,634,200	2,931,900	326
JAMAICA BAY			
Brooklyn	2,367,300	355,100	
Queens	1,930,000	289,500	
	4,297,300	644,600	71
UPPER BAY			
Richmond	170,000	113,300	25
KILL VAN KULL			
Richmond	395,900	263,900	50
ARTHUR KILL			
Richmond	219,000	89,800	17
GRAND TOTAL. . .	16,520,000	5,527,900	723

TABLE 5.

POPULATION AND SEWAGE FLOW

Summary by States
for Treaty Area

	1930 CONDITIONS			1970 CONDITIONS	
	Total Population	Population Contributing Sewage	Equivalent Untreated Sewage m.g.d.	Equivalent Population	Population Contributing Sewage
New York State (excl. Hudson R. above Newburgh)	7,979,939	7,425,666	1,008.23	7,023,612	17,942,000
New Jersey	3,060,384	2,737,054	262.25	2,014,356	5,180,000
Connecticut	907,857	643,600	84.17	570,300	994,000
TOTALS	11,948,180	10,806,320	1,354.65	9,608,268	24,116,000
Percentages:					
New York	66.8%	68.7%	74.4%	73.1%	74.4%
New Jersey	25.6	25.3	19.4	21.0	21.5
Connecticut	7.6	6.0	6.2	5.9	4.1
	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 6.

POPULATION AND SEWAGE NEW YORK HARBOR

	1930 Conditions		1970 N. Y. Disposal Plan A	
	Equivalent Population	Equiv. Untreated Sewage - mgd	Equivalent Population	Sewage mgd
East River - South End	3,228,083	465.12	885,800	106
Newark Bay & Kill van Kull	529,699	60.82	1,172,900	142
Hudson R. at Battery:-				
(1) Total Watershed	2,311,712	407.17	2,330,600	385
(2) Below Newburgh	1,754,021	306.94	1,550,600	245
(3) " N.J. Line	1,651,484	293.55	1,259,100	207
(4) " N.Y. City Line	1,509,034	276.89	891,600	164
Upper Bay at Narrows:-				
(1) Total Hudson R.	7,930,165	1,173.30	5,793,400	852
(2) Hudson R. bel. Newburgh	7,372,474	1,073.07	5,013,400	712
(3) " " " N.J. Line	7,269,937	1,059.68	4,721,900	674
(4) " " " N.Y.C. Line	7,127,487	1,043.02	4,354,400	631
Arthur Kill at Perth Amboy	404,507	51.79	920,000	121
Lower New York Bay				
(1) Total Hudson R.	8,503,567	1,249.92	9,967,300	1,345)
(2) Hudson R. bel. Newburgh	7,945,876	1,149.69	9,187,300	1,205)*
(3) " " " N.J. Line	7,843,339	1,136.30	8,895,800	1,167)
(4) " " " N.Y.C. Line	7,700,889	1,119.64	8,528,300	1,124)
Jamaica Bay	938,948	103.00	644,600	71

* Includes Outlet Island

TABLE 7.

DILUTION OF SEWAGE - NEW YORK HARBOR - 1930

Dilution in month of minimum average streamflow (1 m.g.d. = 1.5472 cfs)

	Hudson R. off Ft. Wash. Pt.	Hudson R. off Battery	East R. South End	Upper Bay Narrows	Newark Bay	Arthur Kill at Perth Amboy
Water Available for Dilution						
Land Water - cfs.	4,912	4,914	13	5,000	81	59
" " mgd.	3,175	3,176	8	3,232	52	38
Sea Water cfs.	5,800	23,700	1790	33,400	253	41
" " mgd.	3,750	15,320	1157	21,590	164	27
Land & Sea water - cfs.	10,712	28,614	1803	38,400	334	100
" " " " mgd.	6,925	18,496	1165	24,822	216	65
1930 Conditions						
Equiv. Contributing Pop.	*1,378,995	*2,311,712	3,228,083	*7,930,165	529,699	404,507
" Untreated Sew.mgd	* 223.33	* 407.17	465.12	*1,173.30	60.82	51.79
Dilution Ratio for sewage						
land water only	14.2/1	7.8/1	---	2.75/1	0.85/1	0.73/1
land & sea water	31/1	45/1	2.5/1	21/1	3.5/1	1.25/1
Dilution per 1,000 Pop.						
land water only	3.6 cfs.	2.1 cfs.	---	0.6 cfs.	0.15 cfs.	0.15 cfs
land & sea water	7.8 "	12.4 "	0.6 cfs.	4.8 "	0.6 "	0.25 "
* Includes Total Hudson R. Watershed						
Omitting Hudson River Watershed above N.Y.-N.J. Line:-						
Contributing Population	718,767	1,651,484		7,269,937		
Equiv. Untreated Sew. Mgd.	109.71	293.55		1,059.68		
Dilution Ratio for Sewage						
land water only	29/1	10.8/1		3.0/1		
land & sea water	63/1	63/1		23/1		
Dilution per 1,000 Pop.						
land water only	6.8 cfs.	3.0 cfs.		0.7 cfs.		
land & sea water	14.9 "	17.3 "		5.3 "		

1970 Conditions - New York City Disposal "Plan A" in effect.

	Hudson R. off Battery	East River - South End	Upper Bay - Narrows
(Omitting Hudson R. Watershed above N.Y.-N.J. Line)			
Water Available for Dilution			
Land Water - cfs.	4,914	13	5,000
Sea " cfs.	23,700	1790	33,400
Land & Sea Water - cfs.	28,614	1803	38,400
Equiv. Contributing Population	1,259,100	885,800	4,721,900
Dilution per 1,000 Pop.			
Land water only	3.9 cfs.	---	1.1 cfs.
Land & sea water	22.8 "	2.0 cfs.	8.1 "

TABLE 8.

MINIMUM OBSERVED DISSOLVED OXYGEN SATURATIONS

AT SELECTED STATIONS

NEW YORK HARBOR

1909 and 1931

Station	Minimum Percentage Saturation 1909	1931
East River		
Throggs Neck	88	48
42nd St.	57	0
23rd St.	52	4
Pier 10	43	1
Hudson River		
Mt. St. Vincent	60	43
Spuyten Duyvil	55	26
155th St.	69	28
42nd St.	65	18
Pier A	57	12
Harlem River		
Morris Heights	46	1
Willis Ave.	32	0
106th St.	21	1
Upper Bay		
Bell Buoy 2 G	60	15
Robbins Reef	62	11
The Narrows	62	22
Kill Van Kull		
Shooters Island	78	24
Arthur Kill		
Opp. Fresh Kills	71	11
Tottenville Ferry	100	43
Jamaica Bay		
Barren Island	78	69
Beach Channel & L.I. R.R.	80	79
Bergen Beach or Carnarsie	67	46

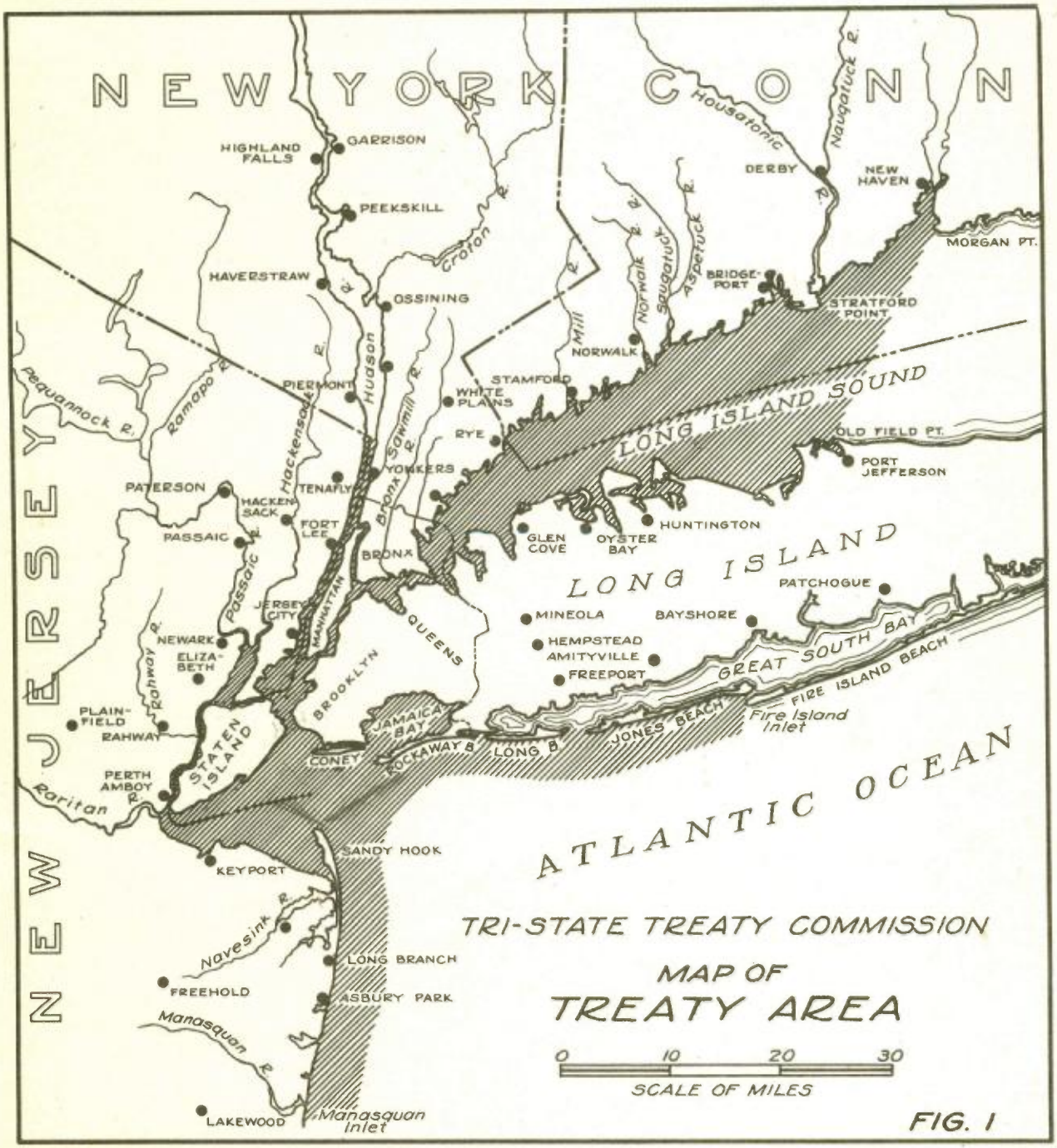
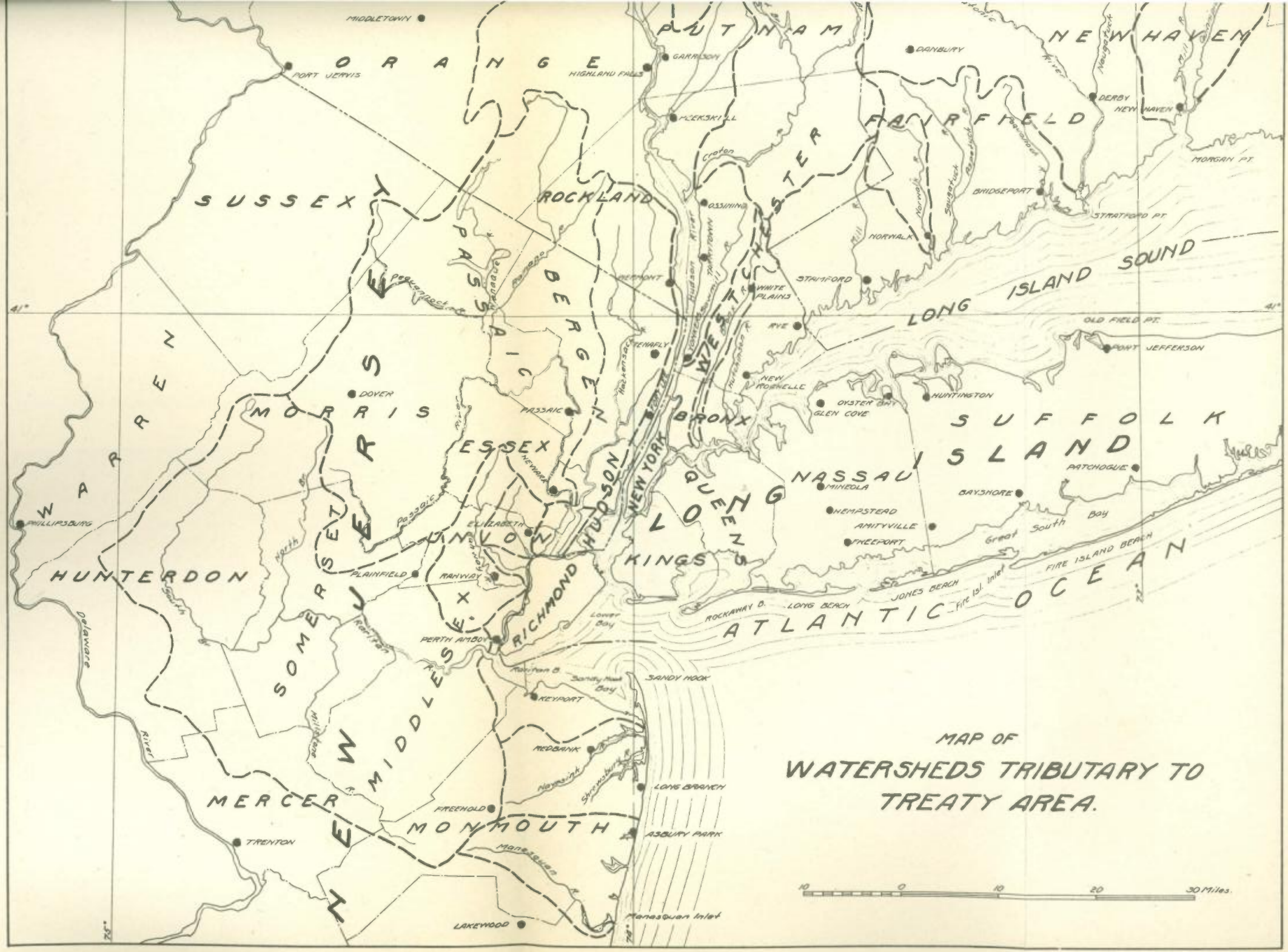

NEW YORK
CONN
NEW JERSEY
HIGHLAND FALLS
GARRISON
PEEKSKILL
HAVERSTRAW
OSSINING
PIERMONT
WHITE PLAINS
STAMFORD
NORWALK
RYE
YONKERS
TENAFLY
PATERSON
HACKENSACK
FORT LEE
PASSAIC
BRONX
JERSEY CITY
NEWARK
ELIZABETH
PLAINFIELD
RAHWAY
PERTH AMBOY
KEYPORT
SANDY HOOK
FREEHOLD
LONG BRANCH
ASBURY PARK
LAKEWOOD
Manasquan Inlet
Raritan R.
Navesink R.
Manasquan R.
Passaic R.
Hackensack R.
Hudson R.
Bronx R.
Sawmill R.
Croton R.
Mill R.
Norwalk R.
Saugatuck R.
Aspetuck R.
Housatonic R.
Naugatuck R.
Pequannock R.
Ramapo R.
Rahway R.
MANHATTAN
BROOKLYN
QUEENS
STATEN ISLAND
JAMAICA BAY
CONEY
ROCKAWAY B.
LONG B.
JONES BEACH
Fire Island Inlet
FIRE ISLAND BEACH
GREAT SOUTH BAY
LONG ISLAND SOUND
LONG ISLAND
ATLANTIC OCEAN
DERBY
NEW HAVEN
MORGAN PT.
BRIDGEPORT
STRATFORD POINT
OLD FIELD PT.
PORT JEFFERSON
GLEN COVE
OYSTER BAY
HUNTINGTON
PATCHOGUE
MINEOLA
BAYSHORE
HEMPSTEAD
AMITYVILLE
FREEPORT
TRI-STATE TREATY COMMISSION
MAP OF
TREATY AREA
0 10 20 30
SCALE OF MILES

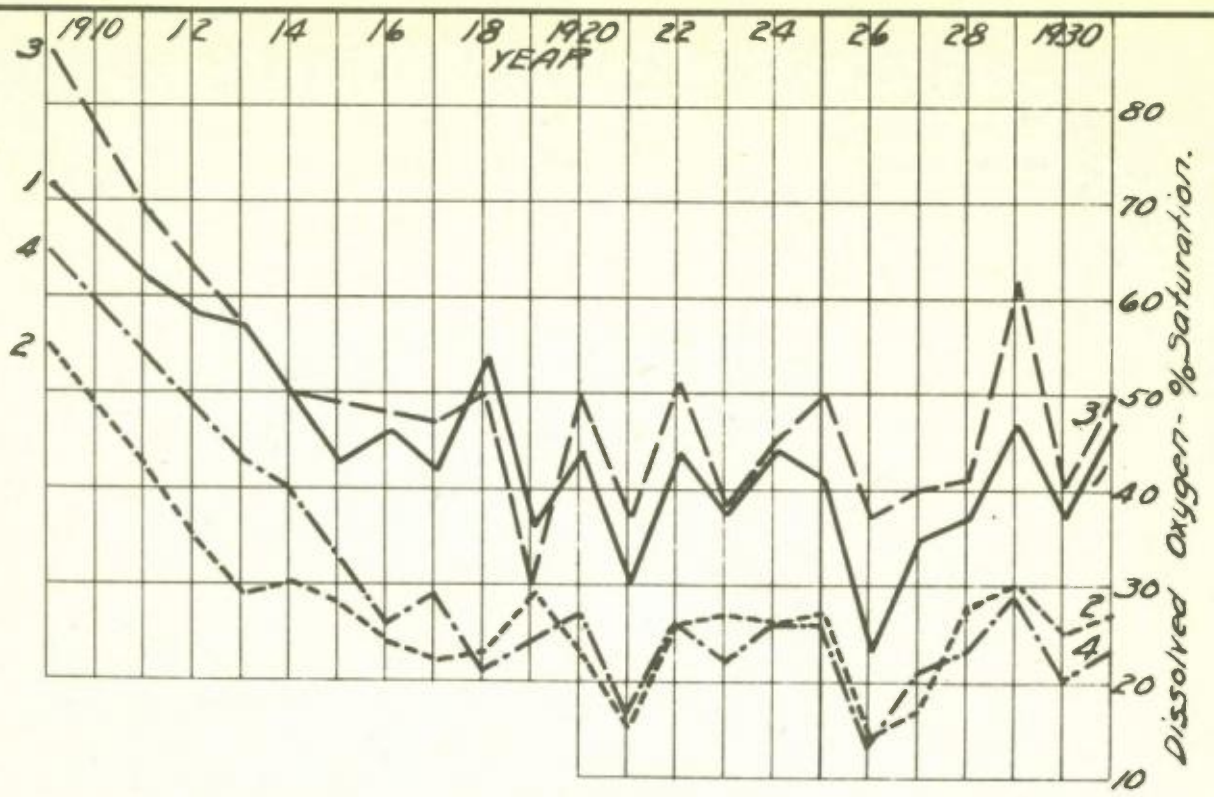
FIG. 1

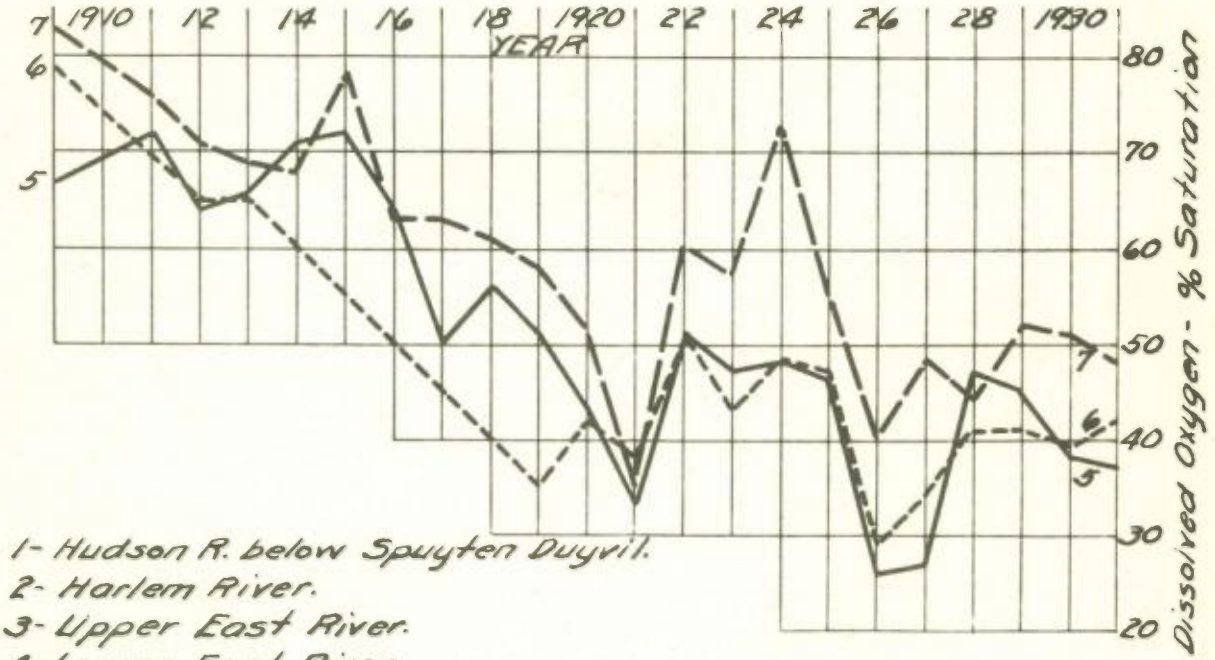


MAP OF

WATERSHEDS TRIBUTARY TO TREATY AREA.

FIG. 2.





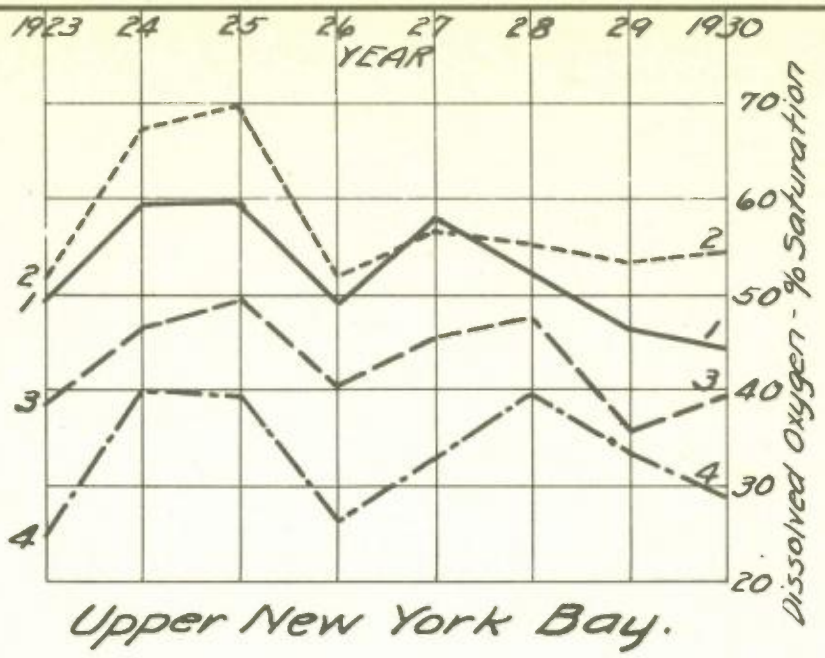
Curve 1- Hudson R. below Spuyten Duyvil.
2- Harlem River.
3- Upper East River.
4- Lower East River.
5- Upper Bay.
6- Kill van Kull.
7- Narrows.

Averages of Samples Analyzed between June 1 and Sept. 30 for Each of the Main Branches of the Harbor.

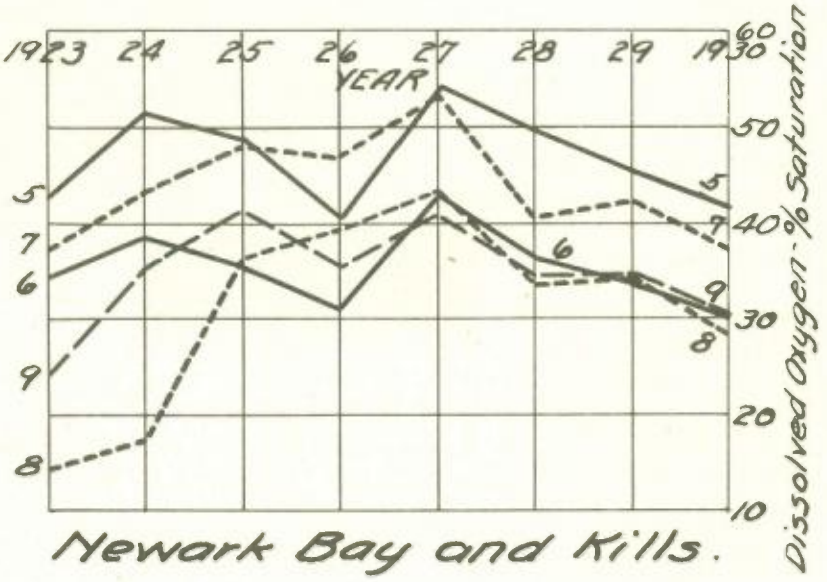
DISSOLVED OXYGEN TESTS. NEW YORK HARBOR.

REPORTS OF CHIEF ENGINEER, BOARD OF ESTIMATE.

FIG. 3.



Upper New York Bay.



Newark Bay and Kills.

Curve 1 - Passaic Valley Sewer - Robbin's Reef.
2 - Narrows
3 - Hudson R. - Pier A.
4 - East R. below Brooklyn Br.
5 - Kill van Kull (Avg.)
6 - Arthur Kill - Elizabethport.
7 - Newark Bay (Avg.)
8 - Mouth of Passaic R.
9. Mouth of Hackensack R.

DISSOLVED OXYGEN TESTS.

PASSAIC VALLEY SEWAGE COMM.

Averages for June 1 - Sept. 30.

FIG. 4.