The Water Supply of the City of New York

The Merchants' Association of New York

AN INQUIRY INTO THE CONDITIONS
RELATING TO

THE WATER-SUPPLY

OF

THE CITY OF NEW YORK

BY

THE MERCHANTS' ASSOCIATION
OF NEW YORK.

AUGUST, 1900.

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AUTHORIZATION OF THE COMMITTEE ON WATER SUPPLY.

NEW YORK, Dec. 4, 1899.

To the Members of the Committee on Water Supply:

GENTLEMEN:

I have appointed a Committee on Water Supply specifically to inquire into and report upon all the material conditions relating to the present and future water supply of this City, including the advisability of a certain proposed contract between the Ramapo Water Company and the City of New York, whereby the City agrees to purchase water from the Ramapo Company to the value of $5,000,000 annually during a period of forty years; and also as to the effect of existing statutes relating to water supply, with a view to possible amendments. The subject matter is covered by the following general heads:

1. Is an increased water supply an immediate necessity?
2. What is the best available source?
3. Will the City's present financial condition permit municipal construction?
4. Is a private contract expedient, and is the proposed contract for the public interest?
5. Are amendments to existing statutes regulating the water supply of municipalities, and especially of the City of New York, desirable?

The occasion for this inquiry is set forth in our printed report of November 16, entitled "The Ramapo Water Contract."

By the following preambles and resolution adopted November 22 by the Board of Public Improvements, the assistance of that department is assured:

"*WHEREAS,*

The Merchants' Association of New York proposes, at its own expense, to undertake a thorough and expert examination of all questions involved in the improvement and enlargement of the water supply of the City of New York, whether by municipal ownership or by contract with private corporations, and for the purpose of properly undertaking such examination has requested that all action by the Board of Public Improvements in regard to a proposed contract with the Ramapo Water Company be suspended for a period of three months; and

"*WHEREAS,*

The scope of said examination, as set forth in a printed pamphlet issued by the Merchants' Association, includes (1) the necessity for an additional supply; (2) the localities from which such additional supplies can be best obtained, both on Long Island and the region northwards and northwesterly from the City line; (3) the cost of obtaining such additional supply from private companies and by municipal ownership, and (4) the City's financial ability to provide for such municipal ownership.

"*RESOLVED,*

That this Board approve of the scope of such inquiry and defer all action upon the said proposed contract with the Ramapo Water Company for three months, and that it give to said Merchants' Association all reasonable and proper assistance, and that the Commissioner of Water Supply be and is hereby requested to give similar assistance, in order that the actual necessities of this city as to water supply may be fully shown to the satisfaction of taxpayers and the public."

The Comptroller has also offered the hearty assistance of his department.

The conditions make it necessary that a report covering the essential facts of the present water supply and probable future needs be ready for publication by February 1, 1900.

The staff of this office will be at your disposal for the purposes of the inquiry, with such additional assistance as may be needed.

You will, doubtless, require the expert services of engineers, and those selected by your committee will be retained by the Association. The entire staff of the Association will be at your service for general purposes. All reasonable facilities will be supplied upon your request to Mr. Mead, and his assistants will carry out your wishes in all work of detail.

Yours very truly,
WM. F. KING,
President,

THE MERCHANTS' ASSOCIATION
OF NEW YORK.

S. C. MEAD, *Assistant Secretary.*

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To Report on Water Supply from the Adirondack Mountains,

GEO. W. RAFTER.

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FOSTER CROWELL.

To Report on Pumping Stations and Water Distribution.

LEBBEUS B. WARD.

SECTION I.

PREFATORY: I.

BRIEF STATEMENT OF THE CAUSES OF AN INQUIRY INTO THE WATER-SUPPLY QUESTION.

BRIEF STATEMENT OF THE CAUSES OF AN INQUIRY INTO THE WATER-SUPPLY QUESTION.

To the Members of the Merchants' Association of New York:

GENTLEMEN:

Extraordinary circumstances relating to the water supply of this City led to the inquiry whose results are set forth in the following pages. In order that the need of inquiry and its usefulness may be duly considered, I state those circumstances concisely.

On August 16, 1899, Mr. William Dalton, Commissioner of Water Supply, presented to the Board of Public Improvements for approval a certain proposed contract between the City of New York and the Ramapo Water Company. With it he submitted a long report wherein he recommended that the contract be approved, and cited the reasons for his recommendation in great detail. A copy of the proposed contract and a summary of the Commissioner's report are printed in the Appendix to this Report. In effect, Commissioner Dalton proposed that the City of New York should abandon its present policy of municipal ownership of water supply, and obtain water for its future needs by contract with a private company. He asserted that the City was in urgent need of an increased water supply; that it was in such financial straits that it could not itself construct the necessary works, and that a contract was therefore desirable. The contract recommended by him bound the City to pay $70 per million gallons for water during a period of forty years, and to buy what water it might hereafter require from the Ramapo Water Company, to the amount of 200,000,000 gallons per day.

Commissioner Dalton asserted that he is duly empowered by law to contract for a water supply, subject only to the approval of the Board of Public Improvements. The contract itself cites the sections of the law by virtue of which it is created, namely, Sections 415, 457 and 471 of the City Charter. The contract was approved as valid by the Corporation Counsel. It was then affirmed, and has since been reaffirmed both by Commissioner Dalton and the President of the Board of Public Improvements, that a decision of the Appellate Court of Kings County in the case of Gleason vs. Dalton affirmed the validity of a contract for water made by the Commissioner with the approval of the Board of Public Improvements only, under Section 471.

A majority of the Board of Public Improvements present at the meeting of August 16 informally stated that they were in favor of the proposed contract. Comptroller Coler opposed it strongly. Having made such inquiry as practicable upon a single week's notice, he challenged the accuracy of the statements made by Commissioner Dalton as warrant for a contract, and also the lawful right of the Commissioner and the Board to make the contract. The Comptroller moved that the matter be postponed four weeks to permit investigation by his department. The motion was lost by a tie vote. A motion for three weeks' delay was then voted down. Finally the Board voted to defer further consideration of the proposed contract for two weeks. August 30 Comptroller Coler, in a communication to the Board of Public Improvements, submitted reports made to him by several engineers, which impugned Commisioner Dalton's statements as to the present water supply, the future demands and the sufficiency of the proposed sources. Mr. Coler also contended that the financial resources of the City were ample to construct any required new waterworks.

Writs of injunction issued in several taxpayers' suits were served on that day, and estopped immediate action by the Board of Public Improvements.

Early in October members of this Association requested that inquiry be made into the authenticity of certain petitions alluded to by Commissioner Dalton in his report, and said to be before the Board of Public Improvements, in support of the proposed contract. A copy of the memorial in question being obtained, it was found to comprise an argument strongly advocating a contract with the Ramapo Water Company as a necessary measure to properly protect the City against fire. To this were appended a number of petitions very numerously signed by business men, and praying for a proper water supply. In some of these the incidental statement was made that such a water supply could be obtained by contract without direct outlay by the City. In others no reference was made to any source. These petitions seemingly related to and supported the argument to which they were appended, and thereby upwards of a thousand signers, comprising many firms and citizens of the highest repute, appeared to favor a contract for water supply.

It was learned that nearly all the petitions so used in a memorial bearing date of 1898 were prepared from three years to fifteen years before, not in support of a contract, but in support of a sufficient water supply. Most of them were dated 1895. Dates were omitted from three. These three were prepared and signed in 1883.

Of those who several years ago signed the petitions in question, 323 formally repudiated the present use of their names in support of a contract with the Ramapo Water Company, and authorized this Association to withdraw them. The present address of 271 other signers could not be found.

A member of the office staff was directed to make further inquiry as to the expediency of the proposed Ramapo contract. A report thereon was made to me under date of November, 1899. I quote its conclusions and recommendations as follows:

"The expediency of the proposed contract between the Ramapo Water Company and the City of New York involves a very wide range of questions of fact, public policy and law. Practically all of these questions are in dispute. The parties to the issue are two coördinate branches of the city government, one of which has *prima facie* legal power to complete the proposed contract, and the other legal power to impede the completion of its intent. Moreover, it is the statutory duty of the Comptroller to resist the payment of the public moneys which may hereafter become due under the contract, so long as there is reasonable question of its validity. If the contract be signed before these disputed questions of fact are in the main disposed of, and if the contract be entered into by executive officers whose legal powers in the premises are in dispute, it is a certainty that the contract will contain the seeds of protracted litigation. That fact alone would render such a contract inexpedient, no matter how desirable it might otherwise be, if it were possible to reach the desired ends without such liability to litigation.

"The warrant for this contract is found in the alleged public needs set forth by a report of Water Commissioner Dalton, under date of August 9, addressed to the Board of Public Improvements. The essential allegations of fact contained therein, which appear to make evident the public necessity and to show that the method proposed is the only practicable method for securing the desired relief, cannot be regarded as established, inasmuch as they are opposed by contrary allegations of fact advanced by the coördinate department of the Comptroller, and made the basis of legal proceedings for preventing the consummation of the contract at present and impeding its operation by litigation in the future. The validity of the assumed powers of the Water Commissioner and the Board of Public Improvements as to the execution of this contract are also matters of dispute in the courts, with the probability of several years' delay before a final construction can be obtained. The powers of the Ramapo Water Company are likewise attacked by the Attorney-General of the State.

"If the assumed powers of the Board of Public Improvements are exercised under the existing circumstances, the question of their ultimate effect upon the welfare of this city is a vital one; and those powers manifestly should not be used in a way to entail possible serious harm, unless their exercise is shown to be absolutely necessary through absence of any reasonable alternative.

"No cursory investigation of the question of fact at issue can have any value nor be convincing as to the real merits of the case. A proper examination would require to be of a technical and scientific nature and of necessity would need a considerable time for its proper performance. Many collateral questions would also require examination. Above all, the questions of public policy and of construction of the law are so grave and the consequences of a present error of judgment so far-reaching and persistent, that they should be examined, and passed upon only after most mature deliberation, by men of large experience in affairs and the highest legal attainments. It is evident that examination by me into the merits of the case under these circumstances is superfluous, and I have therefore confined myself to showing, as a reason why a radical examination should be had, that all the essential facts are in controversy, that the construction of the law is unsettled, that these conditions made prolonged litigation certain, and that while such litigation continues the city cannot obtain more water.

"It is, however, proper to point out here what has not yet been set forth, namely, that the effect of the proposed contract concerns not only the quantity of water to be delivered to this city and its price, but also the future power of this city to obtain an increased supply from any source whatsoever.

"It has appeared to me that, for the reasons stated, practical results, if any, must be sought in the line of bringing about an adequate examination into all the questions of fact and of law involved, with the friendly concurrence of the coördinate departments concerned. Such an examination would settle most of the physical facts, namely, whether the city needs more water, where it can be got, the approximate and relative cost of getting it, etc. All these are demonstrable. If demonstrated they simplify the question of policy by removing most of the causes of difference. The present disputes as to policy turn entirely upon the question of urgency. If the established facts do not show the urgency a private contract becomes a matter of deliberate choice, instead of compulsion. If urgency disappears, unsound provisions of law need not be resorted to to expedite a contract, and the city will be relieved from the danger of prolonged litigation.

"The matter has, therefore, been properly represented to the President of the Board of Public Improvements in a personal conference on November 1, at which were present Maurice F. Holahan, Esq., President Board of Public Improvements, and on behalf of this Association Messrs. S. C. Mead, William R. Corwine and myself. As the result of a lengthy conversation, in which Mr. Holahan set forth with considerable particularity his convictions and his position as to an increased water supply, and in which it was also made clear to him that the purposes of this Association were not obstructive, but would be helpful if the purpose were found worthy, Mr. Holahan assented to the suggestion of an examination by this Association and a postponement of action by the Board of Public Improvements for a time sufficient for that purpose."

In view of the conditions shown by the preliminary inquiry and set forth in the report cited, it was determined to make a thorough investigation of all the facts bearing upon the City's water supply. Formal request was made that the Board of Public Improvements suspend action upon the contract for three months pending the result of the inquiry purposed by this Association. The request was duly acceded to by resolution November 22, the time being subsequently extended to April 30.

To conduct the inquiry I appointed a special Committee on Water Supply, carefully selected with a view to adequate examination of the important engineering, legal and financial problems involved.

How well the members of that committee have done their arduous task is best shown by an examination of their report, which follows. I deem it my duty to say that, in my opinion, they have placed every taxpayer and business interest of this community under heavy obligation. They have made a comprehensive analysis of the water finances since 1832, showing thereby what water has cost taxpayers hitherto, what it should cost them hereafter by municipal ownership, and that to resort to private contract will more than double the cost. They have shown that private contract is unnecessary by demonstrating that the City's immediate needs can be otherwise met by a very moderate outlay, and have indicated the legal steps and the financial methods which will enable the City to build the works needed for the future. They have shown the available sources whence the City can obtain a water supply ample for all future time, and the cost in detail of each of several possible projects. They have shown the legal obstacles and the objections of expediency which disqualify some otherwise desirable sources. Finally, they have shown the legal harmfulness, the financial wastefulness and the impolicy of the proposed Ramapo contract.

The subject has never before been examined as a whole. Most of the essential facts have been unknown. Assertions hitherto made concerning them have been mere vague guesses. The labor of the Committee on Water Supply has banished guesswork and substituted certainty.

The practical result has been to establish a state of facts and obtain present legislation which gives present protection to the taxpayers of this City against a contract involving an ultimate cash and property loss to the City of nearly $200,000,000. The proposed contract was prepared and promoted by City officials claiming lawful authority to consummate it; the courts had refused to enjoin them from so doing, and affirmed their right to exercise the powers claimed; and refused the relief asked by taxpayers, on the ground that the contract was not shown to be wasteful.

The waste was not proved in the several taxpayers' suits, because at that time it could not be. No one knew the facts. They are now abundantly shown by the work of the Committee on Water Supply. In a court of equity they are an ample bar to a wasteful contract.

The inquiry was begun nearly eight months ago, and the entire time of part of the permanent office staff has been given to it. For more than seven months the Committee on Water Supply has labored with great earnestness and persistence. The sub-committees have met from two to five times per week; some of the members have given constant daily supervision to the subjects in their charge; others have given much time to special investigations; and the committee, as a whole, has labored assiduously for the public good. The members of the committee who have given so large a part of their valuable time, without compensation and at considerable personal sacrifice, are, for the most part, non-members of this Association. Their public spirit in consenting to assist in the large task undertaken by the Association is most commendable.

The committee has employed continuously a paid working staff of from 25 to 33 persons, comprising six principal engineers, each in charge of a special division of the work, with the necessary assistant engineers, draftsmen, stenographers, etc. In addition to this staff, the Chief Bookkeeper of the Department of Finance, Mr. Joseph Haag, assisted by Mr. John R. Sparrow, C. P. A., and Mr. Warren R. Bostwick, worked daily after office hours for many weeks in preparing the valuable tables exhibiting the water finances during more than 60 years.

This community is deeply indebted in this connection to Comptroller Coler, Deputy Comptroller Levey and Governor Roosevelt.

Mr. Coler's determined opposition to the proposed contract and the partial investigation directed by him made possible the final defeat of a plan entailing great waste upon the people of this City. Public sentiment became strong in support of his position, but safety required a change in the laws. The work was undertaken by this Association, and has been greatly assisted at all stages by the coöperation of Messrs. Coler and Levey.

No less cordial was the support given by Governor Roosevelt, without whose assistance it would have been much more difficult, perhaps impossible, to have awakened the Legislature to the gravity of the situation.

I present on the following pages a letter from Governor Roosevelt to the Association, which shows the practical results of its work and what yet remains to be done.

Irrespective of the merits or demerits of the proposed contract with the Ramapo Water Company, it became obvious very soon after the appointment of the Committee on Water-Supply that existing laws did not properly guard the interests of the

City, and that amendments were desirable. Section 471 of the City Charter apparently gave the Commissioner of Water-Supply extraordinary powers of contract, subject only to approval by the Board of Public Improvements. Both the Commissioner and the Board maintained that their right to exercise these powers had been affirmed by the Appellate Court in the case of Gleason v. Dalton; both had sought to exercise them, and only a temporary injunction in a taxpayers' suit intervened.

Section 472 of the City Charter so restricts the City's powers of condemnation as to make it possible for private companies to prevent the City's obtaining the water-rights necessary to an increased supply from new sources. An examination of County Records in the State showed that the Ramapo Water Company had already acquired preliminary rights in nearly all the sources of supply available to the City. When expedient these might readily be made operative to exclude the City from sources sought by it.

It was therefore deemed wise to promote legislation for these purposes:

1. To restrict the powers of the Water Commissioner and the Board of Public Improvements as to contracts for water-supply.

2. To restore to the City of New York the power of condemnation of water-rights as against all private companies, but not as against other municipalities.

3. To annul excessive and dangerous special powers granted the Ramapo Water Company by special acts; without in anywise attacking the rightful powers of that company.

The first of these was covered by the Fallows Bill. It annulled the special powers of the Water Commissioner and the Board of Public Improvements as to water contracts, and subjected the latter to special restrictions.

The second was covered by the Morgan Bill, drawn by the Committee on Legislation of the Merchants' Association.

The third was covered by the Demarest Bill, for the repeal of the special statute of 1895, under which the Ramapo Water Company was granted extraordinary powers.

It was soon evident that there was powerful covert opposition to these bills. Repeated efforts to advance them in Committee failed. The Committee hearings were postponed repeatedly, and when granted were so brief as to make a clear presentment of the argument impossible. No real arguments were presented against the bills, yet it was alleged by members of the Committee that there were strong reasons why they should not be reported.

After several delegations of the Merchants' Association of New York had made arguments before both the Assembly and the Senate Cities' Committees without result, it was decided to appeal directly to the constituents in all the Senatorial and Assembly Districts in the State, on the ground that it was a breach of privilege for Committees to refuse to permit discussion and a vote by the Legislature.

Printed statements were therefore prepared and mailed to 35,000 merchants and taxpayers in selected counties. Four series of these were sent and formal protests in great numbers against further suppression of the bills were made by the constituents of the majority of the members of the Legislature. It was also announced that unless some of the bills were brought out and fairly discussed, the Merchants' Association would persistently agitate the subject throughout the State and make it an issue at the ensuing election.

A statement of fact and law showing the necessity of legislation for the protection of the City was submitted to Governor Roosevelt at his request. This caused the immediate reporting of the Fallows Bill, and intimations that the Morgan Bill would be accepted by the majority party if restricted in its scope to specific counties. It was therefore so amended and reintroduced near the end of the session.

There was reason to believe, however, that an attempt would be made by the opponents of any water legislation to substitute the Morgan Bill for the Fallows Bill, with the probable effect of defeating both. The Morgan Bill was therefore instantly withdrawn, and the Fallows Bill became law. The Demarest Bill was defeated early in the session on the ground of unconstitutionality.

The Fallows Act gives the City present protection against a summary water contract. It does not relieve the City from the possible necessity of resorting to contract hereafter as the only means for obtaining more water; nor does it restrict the special powers of the Ramapo Water Company, which might entangle the City in an unjust contract. These omissions require other legislation at the next session of the Legislature. Its nature and reasons are set forth in the Report of the Committee on Legislation.

It is further essential that the validity of Chapter 985, Laws of 1895, entitled "An Act to Limit and Define the Powers of the Ramapo Water Company," be judicially tested, as recommended by Governor Roosevelt.

While the present work of the Committee on Water Supply has been directed mainly to inquiring into the City's needs and the best manner of meeting them, it has become evident that a careful examination into the management of the Water Department and into the Water Revenues is desirable.

In order to complete these things, the Committee on Water Supply will be continued.

William F. King,
President.

PREFATORY: II.

REQUEST OF GOVERNOR ROOSEVELT THAT THE WORK OF THE COMMITTEE ON WATER SUPPLY BE CONTINUED.

REQUEST OF GOVERNOR ROOSEVELT THAT THE WORK OF THE COMMITTEE ON WATER SUPPLY BE CONTINUED.

STATE OF NEW YORK,
EXECUTIVE CHAMBER, ALBANY, April 6, 1900.

The Merchants' Association of New York, N. Y.:

GENTLEMEN:

I thank you for your letter of the 29th ultimo.

The veto by the Mayor of the Fallows bill, and the passage over his veto of the bill, against the practically solid opposition of his party representatives, by the Legislature, has emphasized the wisdom of following out just the course we followed this year.

The work already done by the Merchants' Association has brought about two most valuable results: first, the Fallows bill, the principle of which was suggested by you in November last, and the passage of which your agitation made practicable; and, second, the exposure of the true character of the Ramapo scheme, whereby you have checked its present consummation and made future remedial legislation certain. You have thus achieved present protection for the City, so that the immediate urgency is past.

I very earnestly hope that you will continue your work, and will coöperate, through your Committee on Water Supply, with the Charter Revision Commission, so that it may profit by your wide and exhaustive study of the question of the water supply of the City of New York—a study wider and more exhaustive than has ever before been made, and wholly free from any official bias or prejudice. You can supply the Charter Commission with data of the utmost value, and I hope that your special committee will continue its work with this end in view, for you would thus render an additional and important service.

Your work should be continued, for at the next session of the Legislature laws must be passed which will afford, not a temporary, but a permanent, remedy. I also hope that your committee will push for a judicial decision, both as to the precise powers under the extraordinary grants to the Ramapo Company and as to the exact effect of the phraseology in the Charter which brought about the belief in the necessity for the Morgan bill. Personally, I trust that next year we can have legislation taking away the unhealthy and excessive powers granted to the Ramapo Company, especially under the act of 1895. Even if it be necessary to award compensation for whatever has actually been done under these grants, I hope that the grants can themselves be withdrawn.

As it turned out, it was wise not to endeavor to push through the Morgan bill, especially in view of the differences between your advisors and those of the Comptroller—differences which were more seeming than real, but which rendered it utterly impracticable to get the measure through at this time.

Let me point out to you also that there were very real objections to the Morgan bill in its original form. In your letter you show the grossest and most culpable misconduct on the part of the City officials. Their acts, as described by you, verge on actual criminality. You show that they attempted to bring about an artificial water panic, and that the aid of the State had to be invoked to prevent them from turning waters from polluted ponds into the conduits, and that they were barely prevented by an explosion of popular indignation from entering into a most grossly improper contract with the Ramapo Company. You show that the City authorities of New York have themselves prepared the laws which disqualify the City from obtaining water through municipal ownership. Such being the case, it was but natural that the country members should object to seeing these same officials against whom so heavy an indictment is framed made supreme over the water systems of the country counties.

You have shown that the only hope lies, not in the action of the City authorities, but in the action of the State Legislature and the Executive; and finally, that the danger is not only to the City of New York, but to all of the counties in the eastern part of the State. When it is necessary thus to invoke the aid of the State, and when the legislation asked for is to benefit a city by means of works carried into various country counties, then it is well worth considering whether or not the legislation should be of such a character as will permit these counties a voice in the matter. If Manhattan and Brooklyn are to draw their water supplies from Dutchess or Rockland, or Suffolk or Essex, then the question of home rule is quite as important to these country counties as it is to the two great metropolitan boroughs. The water can be obtained only through special powers conferred by the State, and the State has a right to impose such conditions as it deems wise in granting these powers. It might be well while studying the general question to examine into the methods by which in Massachusetts the City of Boston obtains its water supply.

Let me congratulate you on the masterly manner in which you have exposed the facts in connection with the effort to produce a fictitious water famine, hoping that the panic thereby produced would result in securing a contract for the Ramapo Company. The Comptroller believes that the waste of water in New York is so excessive that proper economy will guarantee the City against any possible water famine in the immediate future. You have clearly shown that the immediate danger is, not of a water famine, but of an attempt on the part of the City authorities to create a panic by reason of an artificial water famine in order to force a contract with this Ramapo Company. In view of this exposure, any such effort would now be discounted from the outset.

New York will in the lifetime of men now living be the largest city on the globe, and we should build a water system, not for one summer, but for half a century to come—a system that shall once for all meet the needs of the future city and be capable of almost automatic expansion as these needs increase.

Yours very truly,

(Signed) THEODORE ROOSEVELT.

II. CONCURRENCE BY THE BOARD OF DIRECTORS OF THE MERCHANTS' ASSOCIATION IN GOV. ROOSEVELT'S SUGGESTION.

The foregoing letter from Governor Roosevelt, commending the work of the Merchants' Association and requesting that it be continued, was duly considered by the Board of Directors at its meeting April 11. The following resolutions were unanimously adopted:

" *WHEREAS,*

The efforts of this Association to secure the passage of laws designed to protect the City of New York from private water contracts and to enable the City to obtain a necessary future supply of water have at all stages had the concurrence and the active support of Governor Theodore Roosevelt; and,

" *WHEREAS,*

A letter has been addressed to The Merchants' Association of New York by Governor Roosevelt, under date of April 6, wherein the Governor is pleased to place a high value upon the work of this Association, and to request that such work be continued;

" *RESOLVED,*

That this Board tenders to Governor Roosevelt, on behalf of The Merchants' Association of New York, this expression of appreciation of his sincere, earnest and consistent endeavor to secure legislation necessary for the protection of this City against great waste of its revenues by means of private water contracts, and designed to enable it to obtain by municipal ownership a necessary additional supply;

"RESOLVED,

That this Board concurs in the belief of Governor Roosevelt that further legislation is necessary, and approves his expressed purpose to seek to bring about such legislation.

"RESOLVED, FURTHER,

That this Board accepts the recommendation made by Governor Roosevelt that the work be continued in order that its results may be placed at the service of, and that it may co-operate with, the Charter Revision Commission, to be appointed by him, as a basis for the future revision of the laws governing this City's water-supply."

SECTION II.

REPORT OF THE COMMITTEE ON WATER SUPPLY.

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To the Merchants' Association of New York:

GENTLEMEN:

The Committee on Water Supply presents herewith its report.

The proposal of the Board of Public Improvements in August, 1899, to enter into a long-term contract with the Ramapo Water Company to furnish the city with water, called the earnest attention of the public to two important subjects:

First: The City's needs, immediate and future, for an additional supply of water.

Second: The best method of meeting these needs, both as to the sources of the supply and the manner in which it should be procured; that is, whether by private contract or municipal construction.

The Merchants' Association requested the Board of Public Improvements to suspend action upon the proposed contract with the Ramapo Water Company, pending the result of an investigation to be made by a committee appointed by the Association. The request was acceded to and this committee was accordingly appointed by your president to investigate whether the need of the City for an additional supply was urgent; what was the best available source for an additional supply; whether the City's financial condition permitted municipal construction; whether the Ramapo contract, or any contract with a private company, was advisable; and, finally, whether there were legal or constitutional difficulties in the way of the City's acquiring and owning an additional water supply adequate to its needs, and, if any such difficulties were found, how they should be removed.

The creation of Greater New York projected a new element into the problem of supplying water to the inhabitants within the enlarged City. Manhattan and the Bronx had been supplied from the Croton, Bronx and Byram watersheds; Brooklyn from ponds and wells on Long Island; Queens and Richmond partly from private, partly from public, local sources. But, if additional water was needed, the uniting of these communities into a single municipality, with common aims and interests, demanded a large plan and a long look ahead both as to the sources of the additional supply and as to the manner in which it should be obtained. To secure a bountiful supply of pure and wholesome water, sufficient for immediate needs and ample for future needs, seems not only to be the concern of the whole City, but to present a problem which can best be solved by treating it in the largest way, both from an engineering and a financial point of view, and by planning for many years to come. In this spirit the committee has studied the questions involved in this investigation.

We wish to extend to the Merchants' Association our hearty thanks for the prompt and generous manner in which it has aided us in making the investigation.

The work of the committee, which has extended over a period of more than seven months, has been divided among four sub-committees:

1. The Engineering Committee has considered the present supply and the available sources of future supply, with their cost; also the use of salt water for fire protection and sanitary purposes;
2. The Committee on Municipal Finance and Public Policy has investigated the financial history of the water supply of the City, and has considered whether it is in the public interest that the City's needs for water should be met by private contract or by a municipally-owned plant;
3. The Committee on Fire Protection and Insurance has considered the question of an additional water supply from the viewpoint of insurance and protection for the business parts of the City;

4. The Committee on Legislation has considered the various legal and constitutional questions arising in the course of the investigation.

The reports published herewith, notably from the Engineering and the Municipal Finance Committees, contain much valuable information which has never before been published.

PART I.

RELATIVE FINANCIAL RESULTS OF MUNICIPAL AND PRIVATE OWNERSHIP.

The Committee on Municipal Finance, with the cordial cooperation of the Comptroller, has made an exhaustive examination of the records of the Water Supply Department so far as the Comptroller's office contains them. Statutes and resolutions authorizing the issue of bonds or outlays for water supply have made it necessary to keep many separate accounts on the Comptroller's books, with the result that it has been an exceedingly laborious matter to ascertain fully the City's investment in its water-supply; but the work done has laid a foundation for a more scientific and accurate system of bookkeeping. The official reports of the Department of Water Supply are very incomplete and lack most important data necessary to any real knowledge of the management and finance of that important department.

The data collected and analyzed under the direction of this committee demonstrate that the water works of the former City of New York have been and are a source of profit and not a financial burden.

We may divide the history of New York's water supply into three periods: the first commences in 1832, when the municipality initiated measures to use the Croton watershed for the supply of the City, and ends in 1884, when a new supply was found necessary. During this period the Croton Aqueduct was built, which is still available for a supply of 90,000,000 gallons daily. About 20,000,000 gallons daily additional were secured in the latter part of the period from the Bronx and Byram rivers.

The second period, 1885-1889, is marked by the building of the New Aqueduct, water from which was supplied to the city in

1890; the maximum capacity of the New Aqueduct is 290,000,000 gallons per day.

The third period begins in 1890, when water was first delivered through the New Aqueduct, and terminates, so far as our report goes, at the end of 1898, which is the latest date for which statistics are available. During this period the Cornell and Jerome Park Reservoirs have been under construction. All the work has not yet been completed; and probably will not be before 1903.

During the first period the total expense for construction was $37,382,521.25. The profit on operation, that is, the difference between the revenue and the total expense for maintenance, interest, etc., was $3,060,938.34, which reduced the cost of construction at the end of the first period to $34,321,582.91. This sum includes the cost of the Forty-second street reservoir now in process of demolition; the City has donated this property, worth from $4,000,000 to $4,500,000, to the public library.

In the second period, 1885-1889, the total expense for construction was $24,571,264.63. The profit on operation was $4,510,543.64, reducing the construction cost for this period to $20,060,720.99.

In the third period, 1890-1898, the total expense for construction was $24,405,776.21. A similar profit of $13,901,602.36 was shown, reducing the construction cost for this period to $10,504,173.85.

It will be noticed that the net profit has been increasing, being in the last period about 57 per cent. of the total amount expended for construction.

In other words, during the term of sixty-seven years, from January 1, 1832, to December 31, 1898, the City of New York made a capital investment of $86,359,562.09 for the construction of water works. It expended during that period for interest charges, maintenance and operation $66,544,245.38; the aggregate earnings were $88,017,329.72; the total net profits were $21,473,084.34.

The committee reaches the following conclusions from the data analyzed:

1. The maximum cost of water per million gallons by the

Croton System (obtained by dividing the total annual charge by the quantity delivered) was $54.20 in 1849.

2. The average cost per million gallons from 1866 to 1898, both inclusive, was $35.06. The data of consumption during some of the preceding years are lacking and the average cost cannot be accurately computed prior to 1866.

3. The approximate average cost per million gallons in the year 1898 was $29.07, and in the period 1898 to 1910 (the latest date when the present system and the works now being constructed will be able to supply the City with sufficient water even if recourse be had to meters and other means of reducing waste), it will be under $25 and probably in the neighborhood of $20, owing to the great relative decrease of outlay and increase of consumption during the next few years.

4. The annual cost of distributing water to consumers is not less than $10 per million gallons at present, and this expense should be added to the cost of delivering water at the city limits.

The relative cost, therefore, to the City per million gallons by the proposed Ramapo contract, which fixes the price of water delivered at the northern limits of the city at $70, and by municipal ownership is approximately:

Contract Cost	$80.00		
Average City Cost, 1866-1898	35.06	Excess Cost by Contract	$44.94
Average City Cost, 1898–1910	25.00	Excess Cost by Contract	55 00
City Cost, 1898	29.07	Excess Cost by Contract	50.93

5. The City has received an average revenue of $52.87 per million gallons for all water supplied by the Croton system since 1865.

6. The Croton system had yielded up to the end of 1898 a net profit of $21,473,084. In the year 1898 it paid a net profit of $1,881,843. The ratio of profit is increasing rapidly and the annual net profit will probably exceed $4,000,000 by 1910.

7. The relative profit by municipal ownership and loss by the proposed Ramapo contract is:

City System.

	1866-1898.	1898.
Average Revenue per Million Gallons......	$52.87	$50.29
Average Cost per Million Gallons..........	35.06	29.07
Average Profit........................	$17.81	$21.22

Contract System.

	1866-1898.	1898.
Average Cost per Million Gallons..........	$80.00	$80.00
Average Revenue per Million Gallons.......	52.87	50.29
Average Loss...........................	$27.13	$29.71

Comparison on Basis of 1898.

Profit by City System..........................	$1,881,843
Loss by Proposed Ramapo Contract..............	2,635,127
Total Loss..................................	$4,516,971

Comparison for Period of Forty Years, 1906-1945.

Poughkeepsie System and Ramapo Contract.

Net Profit by City System....................	$48,338,259.55
Deficit under Ramapo Contract..............	60,241,811.32
Cash Loss..........................	$108,580,070.87
Plus Value of Poughkeepsie System, all Bonds having been paid.......................	$36,880,000.00
Cash and Property Loss to City............	$145,460,070.87
Estimated Cash and Property Loss on Second System, Constructed by 1920, Capable of Supplying 250 Million Gallons Daily Additional..................................	$50,000,000.00
Final Loss by the Acceptance of Ramapo Contract..................................	$195,460,070.87

For the purpose of comparison of the relative financial advantage of municipal ownership and the proposed Ramapo contract we have made calculations of the cost under both systems, as shown in the table above; we have taken as a basis for the municipal supply the Poughkeepsie system as recommended by the engineers, the ultimate cost of which is $36,880,000 for a supply of 250,000,000 gallons daily. We have assumed that a plant, capable of delivering 100,000,000 gallons daily, would be completed in 1906 at a total cost of $29,691,000; we have further assumed that in each of the years 1911, 1914 and 1917 a further supply of 50,000,000 gallons daily would be needed and have calculated the cost thereof, making the total cost in 1917 $36,880,000. We have allowed for interest at 3 per cent., for a sinking fund of 4 per cent., for depreciation and the cost of operation. We find that in 1937 the bonds issued for construction would have been paid.

In calculating the cost under the contract system with the Ramapo Company, we have assumed a payment by the City to that Company for the same amount of water as delivered under the municipal system.

Both estimates are based upon an increase of population at a rate justified by the increase in the last few years and a consumption relative to such increase; we have also estimated that the total annual City receipts would be, as at present, $50.29 per million gallons.

The results of these calculations are as follows:

First: By 1937 the City would own its plant under the municipal system free from all debt, and would own nothing under the Ramapo system.

Second: Between 1906 and 1917 the City, under municipal ownership, would have an annual deficit beginning with about $1,800,000 in 1906 and ending with about $104,000 in 1917, but that thereafter, beginning in 1918, the City would commence to make a profit which in that year would be about $133,000 and would constantly increase year by year until 1945 (a date chosen because it is the termination of the proposed Ramapo contract), in which year it would be about $3,100,000. The excess of this profit over the deficit in the forty years of operation from 1906 to 1945 would be about $48,000,000, a sum which represents the cash profit to the City during that period under municipal ownership.

Third: Under the proposed contract the payment to the Ramapo Company of $70 per million gallons, less the revenue from consumers at $50.29 per million gallons, would result in a deficit to the City of over $60,000,000.

Fourth: If, therefore, the City should fail to build and operate its own water-supply and should make a contract with the Ramapo Company it would suffer a loss of $108,000,000 in the forty years of operation.

Fifth: But that amount of $108,000,000 does not represent the total loss to the City, for it would own no plant under the Ramapo system, while, under the municipal ownership plan, it would have paid for its plant by 1937 and own it free of indebtedness thereafter. The total cash and property loss, therefore, would be $145,000,000 on a system supplying only 250 million gallons daily.

Sixth: Furthermore, by 1920, another system to meet the increasing needs of the City and to supply an additional 250 million gallons daily, must be constructed. During the twenty-five years of the operation of this new system a further loss of at least $50,000,000 to the City would result, compared with a contract with the Ramapo Company, for such additional supply at the proposed price. This makes the total loss to the City during forty years over $195,000,000.

Seventh: The operation of increasing the supply from the Hudson every fifteen or twenty years by an additional supply of 250,000,000 gallons daily, is a perfectly feasible plan, not only from an engineering, but most of all from a financial standpoint. The supplying of water to its citizens becomes an increasingly profitable enterprise, while on the other hand contracting with the Ramapo Company would probably result in giving that company the monopoly of all future additional supplies for the City of New York.

PART II.

THE PRESENT SUPPLY.

The Boroughs of Manhattan and the Bronx are at present supplied from the Croton, Bronx and Byram watersheds. All of the supply of Manhattan is furnished by the City, and also all of the Bronx, except about one million gallons daily, which is furnished by a private company.

The Borough of Brooklyn is supplied from ponds and driven wells on Long Island, excluding Suffolk County whose waters a special act forbids that borough to use as a source of supply. All but about seven per cent. of Brooklyn's supply is furnished by the City.

Queens is likewise supplied by wells, about thirty per cent. owned by the City and seventy per cent. by private corporations.

Richmond is supplied by wells on Staten Island, and has practically no municipal supply.

Forty-five per cent. of the City's supply is pumped, and fifty-five per cent. is delivered by gravity; that is, from reservoirs at a sufficient elevation to deliver under pressure. The average daily consumption of all the boroughs in the City of New York was, in 1899, 371,778,000 gallons, an estimated average daily consumption per capita of 103 gallons, distributed as follows:

In Manhattan	230,000,000
In Bronx	21,000,000
In Brooklyn	102,663,000
In Queens	12,925,000
In Richmond	5,190,000
Total	371,778,000

The greatest safe permanent yield of the Croton Watershed, upon the completion of the Cornell Dam now building, is estimated at from 275,000,000 to 280,000,000 gallons per day. The additional yield from the Bronx and Byram watershed cannot be safely estimated at more than 15,000,000 to 17,000,000 gallons per day, making about 290,000,000 gallons per day, directly available for the Boroughs of Manhattan and the Bronx, although these amounts have been exceeded in some years.

In Brooklyn and Queens the City's consumption is already about equal to the average yield of the sources of supply—116,000,000 gallons per day; the present supply will be increased and improved by building a 48-inch conduit from Millburn to Spring Creek to utilize the water now available, for which bonds will probably soon be authorized. This, together with other improvements, will tide these boroughs over until a new municipal supply can be made available.

In the Borough of Richmond, the daily supply of about 5,000,000 gallons can be somewhat increased, but the conformation of Staten Island is such that any large increase of population would compel that borough to go outside its limits for any considerable additional supply.

The investigation by the Engineering Committee shows that in Brooklyn, Queens and Richmond the present consumption nearly equals the present supply; that in Manhattan and the Bronx the consumption in 1903 will nearly equal the supply at that time available under present methods. It is therefore necessary for the citizens of New York to take immediate steps to prevent such a scarcity of water as was experienced before the New Aqueduct was completed.

The year fixed above, 1903, as the date when the consumption will equal the supply, may be postponed if some of the waste can be lessened. This measure of precaution must be taken in order to save the boroughs from a water famine until a new and larger source of water supply can be obtained. The lessening of waste is, however, not merely a temporary expedient, but it will be a means of economy and security for the future. Modern hydraulic engineers and managers of water works are agreed that it is quite within the resources of engineering and administration to prevent a very considerable part of the waste. It is estimated by the engineers employed by the committee that the total daily waste is from 120,000,000 to 150,000,000 gallons daily, part of which is in houses, but the larger part of which is underground. A complete cure for the latter can be found by putting all water mains in subways, where they will be accessible for the detection and repair of leaks; and the leakage can be materially lessened by other methods, all of which, however, are costly and slow of development.

A well-administered meter service has been found efficacious in other cities in discovering leaks in the mains, as well as inside of buildings, and has led to the repair of both mains and the plumbing in houses, resulting in a marked diminution in the daily waste. The engineers estimate that a substantial saving (ten per cent.) can be effected by the prevention of waste and the present supply thus made to last until the year 1910.

Attention is also called to that portion of the Engineering Committee's report relative to a possible use of salt water for street cleaning and other purposes; some saving of the supply might thus be effected.

We are thus brought to the conclusion that an additional supply for all the boroughs of the City is imperative, and that measures should be taken to furnish the additional supply at the earliest practicable moment. The Engineering Committee estimates that from six to seven and one-half years will be necessary from the inception of the work to the delivery of additional water. Your committee most strenuously urges that immediate steps be taken to furnish an adequate supply of water, to be available, at the latest, in 1910.

No words are necessary to convince the people of the City that one of the greatest calamities is an insufficient or impure supply of water.

PART III.

AVAILABLE SOURCES FOR ADDITIONAL SUPPLY.

Fortunately for the City of New York, abundant supplies of water can be obtained without any great engineering difficulties, and at a much less cost than the proposed Ramapo contract involves.

There are four great sources of supply which the committee has investigated: (1) On the east side of the Hudson River, the

Housatonic and Ten-Mile River watershed; on the west side (2) the Wallkill River watershed; (3) the watershed of the Catskills, viz.: The Esopus, Catskill and Schoharie creeks; (4) the Hudson River itself.

The first two named, the Ten-Mile and Housatonic rivers, and the Wallkill River, are interstate rivers and have been eliminated from consideration by reason of certain legal difficulties set forth in the report of the Committee on Legislation.

The Esopus and Catskill creeks, the sources from which the Ramapo Company proposes to supply the City under its contract, will yield about 260 million gallons daily, and the entire Catskill watershed, which includes Schoharie Creek, will yield about 460 million gallons per day. This is probably the limit of the Catskill system. The Hudson River system, however, is capable of extension to 1,500 million gallons per day at relatively small cost.

For a discussion of other possible sources of supply, reference should be made to the accompanying reports from the Engineering Committee.

PART IV.

HUDSON RIVER SUPPLY.

All the additional water that the City of New York is likely to need for many years to come, until its population shall increase to 18,000,000, can be obtained from the Hudson River above Poughkeepsie. It is proposed to build pumping stations and filter beds on the east side of the river, an aqueduct from Poughkeepsie to the northern limits of this City, and a reservoir near the northern limits. The plant thus constructed would be capable of supplying 250,000,000 gallons daily, although it is not proposed to build a plant capable of delivering at first more than 100,000,000 gallons daily. The 250 million gallons a day, combined with the present supply, will meet the needs of the City for fifteen or twenty years to come. Thereafter increased pumping facilities at the same point, with additional aqueducts, will furnish an additional supply in any amount up to 1,500 million gallons daily. It is proposed to filter this water, the experience of other cites having shown that filtration is a perfect method of purifying water, being, indeed, only a scientific reproduction of a process of nature. That filtration is effective in removing impurities and germs of disease is amply proved by the experience of Albany, Poughkeepsie, London (England), Hamburg (Germany) and other cities. It has already been recommended by the Health Board of the City for the Croton water.

The watershed from which this supply may be drawn comprises all the streams flowing into the Hudson above Poughkeepsie, including the Adirondack region. The area of the watershed is approximately 11,800 square miles.

In order to prevent the water above Poughkeepsie becoming brackish, by reason of taking so large an amount of water from the river at that point, it is proposed to build in the Adirondacks compensating reservoirs, in which may be stored the freshet waters during the months of excessive rain. These waters are to be delivered into the river during the dry season, so that the flow of water may be kept even throughout the year.

Incidental benefits would be the improvement of the navigation of the upper waters of the Hudson, the prevention of floods and the provision of a uniform flow for the mill owners along the various streams.

That the project is entirely feasible, the report of the Engineering Committee leaves no doubt. It has already had examinations made for reservoirs at various points in the Adirondacks, and has shown that it is entirely practicable to obtain the necessary storage without excessive cost.

As an alternative proposition to the pumping of water from the Hudson at Poughkeepsie, the Engineering Committee suggests the taking of water from the Hudson at the junction of the Sacandagua about eighty miles above Albany, whence it may flow by gravity through longer aqueducts to the City limits. Both projects require the construction of storage reservoirs to equalize the seasonal flow.

The Poughkeepsie project is more advantageous in that the streams below Glens Falls furnish an additional supply.

To furnish 250,000,000 gallons daily from Poughkeepsie, the cost of construction would be $36,880,000; the yearly cost after construction, including interest at three per cent., operation and maintenance, $2,585,000; cost per million gallons, $28.33. This estimate includes the delivery of the additional supply at a level of about 132 feet above tide-water, the level of the Jerome Park Reservoir. To furnish from the same source 500,000,000 gallons daily, the construction cost would be $72,374,000; the annual cost after construction, including interest, operation and maintenance, $5,546,000; cost per million gallons, $30.39.

The alternative proposition of taking the water from the Adirondacks would be as follows: Construction cost, 250,000,000 gallons, $71,727,000; yearly cost after construction, including interest, operation and maintenance, $2,727,000; cost per million gallons, $30. To furnish 500,000,000 gallons, the construction cost would be $140,155,000; the yearly cost after construction, $5,338,000; cost per million gallons, $29.25.

It should be noted that the above figures and those that follow do not include a charge for the sinking fund.

The advantages of the Poughkeepsie plan over the Catskill and the Adirondack are as follows:

First: *Ultimate Cost.*—On the basis of 250,000,000 gallons per day, and at a labor cost of $1.35 per day, the estimate for the Catskill system is $53,000,000; for the Adirondack system, $72,000,000; for the Poughkeepsie system, $37,000,000. With a labor cost of $2 per day, the estimates are: Catskill system, $76,000,000; Adirondack, $103,000,000; Poughkeepsie, $50,000,000.

Second: *Deferred Cost.*—By the Poughkeepsie plan it is possible to postpone a considerable part of the ultimate cost, by constructing the plant for only the additional supply which the increase of population demands, enlarging it as needed until the whole available supply is utilized.

Third: *Time Necessary for Construction.*—Water from the Hudson above Poughkeepsie could be delivered in six years; from the Adirondacks in seven and one-half years; from the Catskill watershed in seven years.

Fourth: *The Possible Supply.*—The Adirondacks and the Hudson would furnish about the same amount, 1,500,000,000 gallons per day; the Catskill watershed, now controlled by the

Ramapo Water Company, 260,000,000 gallons per day; including Schoharie Creek, not more than 460,000,000.

Fifth: *Length of Aqueduct.*—The comparison of length and cost of the necessary aqueducts is as follows: The cost given in the second column is based on labor at $1.35 per day; in the third, at $2 per day.

Poughkeepsie high level, 60 miles...	$14,693,000	$20,732,000
Poughkeepsie low level, 64 miles...	17,221,000	25,831,000
Adirondack, 203 miles............	62,340,000	92,399,000
Catskill, 100 miles...............	38,652,000	55,216,000

The lesser length of the Poughkeepsie aqueduct is an important element in the time of construction; but it is quite as important in maintenance and protection.

Sixth: *Constitutional Debt Limit.*—We show later in this report, that although there is no limit to the power of the City to incur indebtedness for a water supply, yet such indebtedness must be included in calculating the limit of indebtedness for other purposes, such as parks, schools, etc. The lesser cost of the Poughkeepsie plan, distributed over a period of years, would make it possible for the City to furnish an increased supply from this source with less likelihood of exceeding its debt limit.

PART V.

The Ramapo Contract and the Experience of Other Cities.

The Ramapo Water Company was organized in September, 1887, under an act which, with its amendments, permitted companies organized under it to supply with water any municipality in the State of New York. In 1890 the act was repealed and a general law enacted which surrounded with new safeguards contracts made with companies organized under it. These safeguards did not apply to the already organized Ramapo Company; and a few years later the Legislature extended to that company privileges greater than those possessed by any other water company in the State, far greater than the privileges of the City of New York. This was done under the guise of an act (Chapter 985, Laws of 1895) which purported to "limit and define the powers of the Ramapo Water Company." This act gives the Ramapo Company full power to contract to supply water not only to any municipality, but to any corporation, public or private, with no requirement such as other companies must meet, for filing an amended certificate, or obtaining the consent of the local authorities. The power to supply water for municipal purposes, and, in addition, to supply water for commercial use, given by this special act, is a power which no corporation can obtain except by special legislation, and is a power possessed only by the Ramapo Water Company. The company is also given broad powers of condemnation and may, without fear of opposition, select such route as it chooses; it is practically impossible for any one objecting to the route selected, within the time limited by the act, to comply with its provisions for making opposition to the condemnation proceedings, and, as an additional safeguard to the company, the expense of such opposition is made prohibitive. This is the method which the Legislature used to "limit and define the powers of the Ramapo Water Company."

While the Legislature has thus increased the powers of the Ramapo Company, it has very greatly restricted the power of the City to acquire its needful additional supplies of water.

The first important restriction was the act of 1896, known as the Suffolk County Act, which prevented Brooklyn from using the waters of Suffolk County, whence an abundant supply could have been obtained for that borough for many years to come. This act was expressly continued in force by the Greater New York Charter, which went into force January 1, 1898. Moreover, in 1898, the Legislature made more expensive the supply already in use for that borough. Chapter 469 of the Laws of 1898 requires the municipality, in certain instances, to deepen tide-waters to a depth of at least three feet in cases where fresh waters flowing into such tide-waters have been diverted for the water supply of the municipality. Already large claims have been filed under this act, which, if declared valid by the courts, will have to be paid by the Greater City.

Not content with the statutes enlarging the powers of the Ramapo Company and lessening the powers of the City, the

Legislature put into the Greater New York Charter itself a most ingenious clause which prevents the City from taking water from a supply devoted in whole or in part to the supply of any other municipality. Such a restriction was entirely new; it had never before appeared as a part of the general law, nor in the Consolidation Act which was the charter of the old City of New York. Its effect was to give the greatest city of the State the least power in respect of its water supply.

As to the contract which the Ramapo Company proposes to make with the City, the substantial features of it are that the Ramapo Company agrees at its own expense to build and maintain a system of water works by which it shall be able to furnish the City of New York 200,000,000 gallons of water daily. This water is to be delivered to the City at its northern boundary at the point of intersection with the present Croton Aqueduct, at a "pressure due to an elevation of 300 feet above the mean tide level," and for this water the City of New York agrees to pay $70 per million gallons, and is to be put to no other or further expense in connection with the supply, excepting the additional expense for distribution.

The delivery of water is to begin in 1902, and is to continue for forty years. It is not within the range of engineering possibilities for the Ramapo Company to deliver water in 1902, a date which gave that company three years and a half in which to construct its dams, reservoirs and aqueducts. The report of the Engineering Committee fixes seven years as the shortest probable time within which a system can be constructed to supply water from the Catskill watershed, which the Ramapo Company proposes to use.

It is certainly true that the City can construct its system quite as rapidly as a private company. The difficulties which Commissioner Dalton urged against the City's constructing its own plant and as an argument in favor of the Ramapo contract are nearly all difficulties of administration; that is, obstacles which City officials desirous of a private contract might create, but which City officials zealous for the City's interest would surmount.

The contract requires a bond of only $100,000 for the faithful performance by the Ramapo Company of its contract, a sum ridiculously inadequate to protect the City's interest.

A serious question is whether the contract gives the City an option to take as much of the 200,000,000 gallons of water as it needs, or whether it is an absolute agreement on the part of the City to take this water.

Upon such important points as the amount to be delivered, the obligation of the City to take and the pressure at which the water is to be delivered, the contract is ambiguous, and for this reason alone, if for no other, it should not have been approved. The contract gives the City no right to acquire the property at its expiration, and at the end of the period the City would be just where it began, needing water and being obliged to get its supply by private contract.

The specific objections to the Ramapo contract are as follows:

First: The price is exorbitant.

Second: The contract is ambiguous as to the pressure at which the water is to be delivered at the City limits;

Third: The contract is ambiguous as to the respective duties and privileges of both contracting parties;

Fourth: The City will not own the plant at the termination of the contract;

Fifth: The effect of the contract will be to force the City hereafter always to purchase water from that company;

Sixth: It will deprive the City of large profits from a water supply owned by the City, or force it to raise the price of water, which would be injurious to its industrial interests.

Moreover, the experience of other municipalities in the United States, as well as in other countries, shows an almost continuous tendency to substitute publicly owned water systems for private, a tendency so persistent and so universal, and of such constantly increasing force, that the wisdom, in the public interest, of the policy of municipal ownership and control of water supply, would seem established by abundant experience.

In 1800 there were sixteen plants in operation in the United States, of which fifteen were private and one public. Since that time fourteen of the fifteen have become public.

At the close of 1896 there were in the United States 3,196 water works; of these 1,690 were under public control, 1,489 under private control, twelve were under joint control and of five the ownership was unknown; in other words, in 1800, 6.3 per cent. were public, 93.7 per cent. were private; in 1896 53.2 per cent. were public, 46.8 per cent. private. Similar conditions prevail abroad, notably in Great Britain. In London a strong movement is on foot to replace with a public service the inadequate and unsatisfactory supply of the private companies which have become enormously wealthy from their monopolies in the various parts of the municipality.

The cost of the private plants throughout the United States and Canada (excluding the Pacific Coast, where special circumstances render the comparison unfair) is slightly less, some three and one-half per cent., than the public. This slight increased cost of public over private may be due to the care taken by municipal authorities to keep the sources unpolluted; in other words, to the cost of lands bordering on streams and ponds, as in the case of our Croton system. But, on the other hand, the cost to the consumer is almost always less under public than under private ownership. The average cost per family throughout the United States is, for public, $21.55; for private, $30.82; that is, privately supplied water costs about forty per cent. more than that supplied by the municipalities.

PART VI.

Legislative and Constitutional Obstacles to the City's Acquiring the Needed Additional Supply.

The principal argument urged in favor of entering into the proposed Ramapo contract is the City's lack of power, through legal difficulties, to supply its necessities. It is urged that the City has not the power to condemn and so to acquire the properties it needs. Our answer is that the Legislature should give the City of New York this power. It is almost the only city in the State which does not already have that power. Why Brooklyn should be prevented from using the waters of Suffolk County, and why the present Charter of the City should so markedly have limited the City's power, while the Legislature has increased the powers of the Ramapo Water Company, we do not care to inquire, but that these limitations should be removed, no citizen of New York not interested in a water company will dispute.

It is urged, also, that there are constitutional difficulties in the way. To this we answer that these difficulties are exaggerated, and so far as they exist they will be quickly removed when the people who make constitutions realize the character of the difficulties and their unreasonableness. When our cities were incurring a burden of debt beyond their ability to meet, there was put in our Constitution a restriction upon their debt-incurring capacity. No city was permitted to incur debt beyond ten per cent. of its real estate assessed for taxation. Later, on account of the absolute need that our cities should have an abundant supply of pure water, and in order to prevent their falling into the power of private water companies, the Constitution was amended so that, even though cities had reached their debt limit for other purposes, they were allowed to go beyond it to obtain a supply of water. This was due to the general recognition of the wisdom of the policy of municipal ownership and control of the supply of water. If, however, the City's debt, including its debt for water supply, exceeds the ten per cent. limit, no debts for other purposes than water-supply can be incurred until the assessed valuation shall permit.

It is upon this provision of the Constitution that reliance is placed to compel the City of New York to supply by private contract its great need for water.

The demonstrated wisdom of the policy of municipal ownership of water-supply, irrespective of the question of mere profit; the demonstrated great profit of that municipal policy in New York City, irrespective of any other question— these two factors, gaining in force every year in forming public opinion, are bound in a short time to compel the removal of the present constitutional bar.

We therefore believe that without waiting for any further constitutional amendment the City should at once take the necessary steps to provide for itself a supply of pure water ample for future needs.

We believe that the facts, briefly alluded to in this short report, and set forth more in detail in the divisional reports upon which this is based, need only be brought fairly and fully to the attention of the public, to bring about a very prompt amendment of the Charter and the Constitution.

The legislative obstacle to the acquisition of the additional supply is Section 472 of the Charter of the consolidated City, which forbids the use by the municipality of any waters which are wholly, or in part, devoted to the supply of any other municipality; hence it is necessary that Section 472 be amended.

The Merchants' Association recommended to the Legislature the passage of a bill intended to free the City from the difficulties created by that section, and to give it power to obtain water from certain sources named. The bill, which was an amendment to Section 472, failed of passage. Such a measure must be passed; there must be no doubt of the City's power.

The constitutional limit of indebtedness, so far as water supply is concerned, should be removed. It is absurd that the indebtedness created by a self-supporting, profit-making enterprise, yielding at present a net profit of nearly $2,000,000 annually, should prevent needed improvements in other directions.

Recommendations.

The committee therefore recommends as follows:

I. No contract whatever should be entered into with the Ramapo Water Company.

II. The policy of supplying New York City with water by contract should be opposed by all lawful means.

III. The Legislature should clothe New York City with power to acquire by condemnation any water rights needed for its public water supply, excepting water rights actually used by, or necessary for, the supply of any other city, town or village.

IV. The constitutional requirement that the bonds issued by New York City for a water supply shall be included in ascertaining whether the City can become indebted for other municipal purposes should be removed.

V. The Comptroller's quarterly and annual reports should contain a clear and business-like statement of the financial status of the City's investment in its water works.

VI. A carefully devised system of detailed, accurate and easily understood public records and reports should be adopted by the Department of Water Supply.

VII. The financing by the City of any addition to its water supply should include the application of the surplus of the revenues over expenditures to the redemption of bonds issued to establish the plant.

VIII. Immediate steps should be taken by the City of New York to acquire an additional supply of 250 million gallons of water daily from the Adirondack Mountain watershed by either of the systems proposed in this report.

IX. Immediate steps should be taken by the City officials to prevent the waste of water.

Committee on Water Supply,

M. E. Bannin,
Chairman;

S. C. Mead,
Secretary.

New York, August 3, 1900.

SECTION III.

REPORTS AND TRANSACTIONS OF THE ENGINEERING COMMITTEE.

REPORTS AND TRANSACTIONS OF THE ENGINEERING COMMITTEE.

PART I.

Introductory Review of the Work of the Engineering Committee.

PART II.

Present Water Supply.

PART III.

Additional Water Supply.

PART IV.

Salt-Water Supply for Fire Extinguishing and Other Purposes.

PART V.

Appendices: Special Reports to the Engineering Committee.

INTRODUCTORY: REVIEW OF THE WORK OF THE ENGINEERING COMMITTEE.

INTRODUCTORY: CONTENTS.

INTRODUCTORY: REVIEW OF THE WORK OF THE ENGINEERING COMMITTEE.

We present below, as briefly as possible, a summary of the work of the Engineering Committee, the problems presented and investigated, the scope of its inquiry, and the methods by which it arrived at the conclusions and recommendations therein contained.

Inception of the Work.

The four sub-committees, of which this committee is one, owe their organization to the disinterested action of The Merchants' Association of New York, which proposed, at the expense of its membership and for the welfare of New York, to investigate the entire subject of the City's present and future water supply, particularly as to the necessity of an additional supply, the sources of such supply, and the best methods of obtaining it.

In carrying out this purpose it was very soon apparent that much original investigation and study were necessary before results of value could be presented to the public; and the Association then invited the assistance of a number of gentlemen of this City, representing varied interests and fitted by training or professional experience, to pass judgment upon the problems presenting themselves. As a result of the efforts of the Association, on December 4, 1899, a Committee on Water Supply was organized, and divided into Sub-Committees on Engineering, Municipal Finance and Public Policy, Legislation, Fire Protection and Insurance. The members of this Water Committee served without other compensation than contributing to the general good of the citizens of New York. They were to act mainly in a judicial capacity, making such suggestions and recommendations as the facts presented should warrant. As intelligent conclusions could be based only upon reliable and late data, collected and collated as they saw fit to direct, The Merchants' Association retained and paid such engineers, statistical experts and other assistants as the Water Committee deemed necessary for the purposes of a complete investigation, and as were recommended by the several committees.

Organization of the Engineering Sub-Committee.

The Engineering Sub-Committee, as organized on December 4, 1899, was made up as follows:

Thomas C. Clarke, Past President American Society of Civil Engineers, Chairman; Rudolph Hering, Vice-President American Society of Civil Engineers, Vice-Chairman; and Messrs. Edward P. North, D. Le Roy Dresser, H. S. Haines, D. McN. Stauffer, Henry G. Prout, E. E. Olcott and R. R. Bowker, members. To this sub-committee was later added Mr. Henry R. Towne, Past President of the American Society of Mechanical Engineers.

To this sub-committee were submitted for investigation and report the following three broad problems:

1: The present water supply of Greater New York, including its history and the consumption of water.

2: The need of more water, and the extent of that need at present and in the future.

3: The sources from whence an additional supply of water can be derived.

After deciding upon the best division of labor in the time available and the proper fields for immediate original investigation, the sub-committee, under the authority granted by The Merchants' Association, recommended the retention of the following engineers: Messrs. J. J. R. Croes, Foster Crowell, James H. Fuertes, George W. Rafter, L. B. Ward and Wm. B. Fuller, all engineers of professional experience. The Merchants' Association provided these gentlemen with such engineering and clerical staff as they deemed requisite; and to the several engineers in charge the Engineering Sub-Committee assigned certain carefully specified lines of investigation, which were pursued under its constant direction.

Instructions to Engineers.

The methods followed for obtaining data for the study submitted to the Engineering Sub-Committee are broadly outlined in the written and verbal instructions under which the engineers retained by the Association conducted their inquiry in the City and in the field. Mr. Croes was directed to study and report upon the present and past actual consumption of water in Greater New York; to carefully examine and discuss the present distribution systems, including the pumping plants, and to prepare and present such topographical maps, diagrams and tabular matter as would be required for an intelligent exhibit of past and existing conditions. He was also instructed to investigate and report upon the questions of regulating the consumption of water by the restriction of waste, the introduction of water meters, etc.; and he was to provide the necessary data upon which to base a decision as to the needs of a greater supply of water at the present time and in the future. He was, finally, to briefly describe the works at present in operation in all the boroughs of Greater New York, in such detail as to give a clear statement of their capacity, and, as far as possible, their efficiency, durability and economy. In this work Mr. Croes was associated with Mr. Ward, who was specially entrusted with the examination of the pumping plants and water distribution.

Mr. Crowell was requested to make an independent report upon the use and waste of water.

Mr. Fuertes was instructed to examine and report upon the following possible sources of additional supply:

1: The sources on the eastern side of the lower Hudson River.

2: The best aqueduct lines from the upper Hudson River.

3: The Hudson River above Poughkeepsie, free from salt water pollution.

4: The Esopus, Catskill and other neighboring creeks.

5: The Wallkill and neighboring creeks.

6: The Long Island sources.

7: The Staten Island sources.

The committee did not investigate the upper Delaware River, on account of the probable use of such water by cities in New Jersey and Pennsylvania, of the greater cost than other available sources, and of serious legal questions involved.

Nor did the Committee require further information regarding a supply from the Housatonic River and its tributary, the Ten Mile River, nor of the Ramapo River, because these had been carefully examined and reported on by Mr. W. E. Worthen for the City of Brooklyn in 1896, and were being again and more fully examined by Mr. John R. Freeman for the City Controller, Mr. Bird S. Coler. Nor was it necessary to do more than collect existing information regarding the Long Island and Staten Island sources, as this information was deemed sufficient for present purposes.

It was proposed by the Committee that this investigation should indicate the best sources for an additional water supply of both 250,000,000 and 500,000,000 gallons per day, properly apportioned to the needs of the several boroughs, and the quality of the water recommended was to be at least equal to that of the present water supply of New York in its best condition; and in case water was to be taken from the Hudson above Poughkeepsie, or other sources exposed to pollution, such water to be so filtered as to equal in purity the best water anywhere provided for municipal use.

The height at which water was to be delivered at the city should be that found most practicable in the case of a high-level supply from the respective territories, or found most advisable in case the water must be pumped.

With the result of these studies, combined with the examination of such other matter as should in the course of his surveys be found proper for investigation, Mr. Fuertes was to submit approximate estimates covering the required investment and the probable cost of annual operation, maintenance, interest, etc.

For the State of New York and for the U. S. Geological Survey, Mr. George W. Rafter, M. Am. Soc. C. E., had made a series of investigations and reports bearing upon the watershed of the upper Hudson, or the Adirondack region. To avail itself of the knowledge and experience of Mr. Rafter, the Engineering Sub-Committee recommended that The Merchants' Association obtain from him a report covering the subject of an additional water supply for New York from that section of the State. In accordance with this recommendation, Mr. Rafter made a report covering the following main heads: A supply of 500,000,000 gallons per day from a single large reservoir on Schroon River; the supply of an equal volume from Lake George and Schroon River combined, and projects for storage and compensating reservoirs; the latter to be used for restoring to the Hudson River any water abstracted for the supply of Greater New York.

In addition to these special examinations and reports, this Committee has availed itself of all useful published reports, maps, etc., bearing upon the subjects investigated. As part of the information thus utilized should be mentioned, the reports presented in 1896 by Mr. I. M. de Varona upon the several projects for increasing the water supply of Brooklyn, from the Ramapo and Wallkill Rivers, in Rockland and Orange Counties, N. Y., from the Ten Mile and Housatonic Rivers in New York and Connecticut, and from the streams and underground sources in Suffolk County, Long Island.

Mr. Crowell was directed to take up the subject of an auxiliary supply of salt water within the limits of New York. This investigation was to cover the needs of fire-protection, street washing and flushing to reduce the street temperature on very hot days, sewer-cleaning, the possible application of salt-water to water-closet and urinal service in large office buildings, and any other purpose for which salt-water could be economically used. He was to investigate and include in his report an account of results accomplished in establishing a separate salt-water fire-service in Boston, and the results of a separate fire-service in Buffalo, Cleveland, Detroit and Milwaukee, together with any recorded results available setting forth the experience of European cities operating a similar service. Mr. Crowell's report was, further, to state the probable extent of the reduction of fresh water consumption per capita, by reason of such auxiliary supply, and the estimated total amount of such reduction. Special subjects of investigation were included under the following heads: The relative injurious and beneficial effects arising from the use of salt-water; possible injury to the plant and consequent increase in the cost of maintenance; the sanitary effects of the use of salt-water in cooling streets, flushing sewers, etc.; the possible harm to stocks of merchandise in case of fire, and the effect of salt-water upon asphalt pavements.

With this investigation Mr. Crowell was to submit approximate estimates giving the cost and the data upon which estimates were made for supplementing the present system of piping, in specified districts of the city, with a salt-water system; these estimates to include pumping plant and the probable cost of operation, maintenance, interest, etc.

For the use of the Sub-Committee Mr. Alfred T. White, late Commissioner of Public Works of the City of Brooklyn, presented a statement of water conditions in that borough based upon his own experience and the investigations made while he was in office.

A valuable report has been recently prepared by Mr. John R. Freeman, M. Am. Soc. C. E., for the Controller of New York City, discussing questions very similar and partly identical with those submitted to the Engineering Sub-Committee. Most of this report has been available to the Sub-Committee, in manuscript, and the information contained in it has greatly aided in the work of the Sub-Committee. Its revision of the recorded yield of the Croton watershed is of great importance: and its full discussion of a supply obtained from the Housatonic watershed, and of many other allied questions, has enabled the Sub-Committee to employ the brief time at its disposal in other directions, and has made it possible for the Sub-Committee to draw its conclusions from data gathered from a larger area.

Much information was furnished to this committee by the Engineers of the Department of Water Supply, for which we have to make acknowledgment.

We have to thank the Engineers above named, who have made the reports hereto annexed, for the care and fidelity with which they have carried out their instructions. This has resulted in bringing together much valuable information never before published.

Finally, our thanks are due to President W. F. King and the other officers of the Merchants' Association for the liberal and thorough manner in which they have met all our requests, and furnished all the assistance that we asked for.

PRESENT WATER SUPPLY.

PRESENT WATER SUPPLY: CONTENTS.

PRESENT WATER SUPPLY.

The Engineering Committee presents the following summary of its conclusions and recommendations regarding the present use of water by this City:

I. That the average daily consumption of water in all the boroughs of New York City in 1899 was 371,778,000 gallons, or an average daily consumption per capita of 103 gallons, which approximates to the lowest rate of consumption in any large American city.

II. That while the amount of waste is considerable, we do not see any present prospect that it will be materially reduced.

III. That an increased water supply will become a necessity within ten years or less, and examinations and surveys should be commenced immediately.

IV. That a reduction of waste by the extension of the meter system can and should be effected.

V. That more exact means should be provided for measuring and recording the actual consumption of water in all the boroughs.

VI. That the flow through the new Croton aqueduct should be increased by giving it a thorough cleaning.

VII. That a better distribution should immediately be effected in the Bronx.

VIII. That the present supply from the Croton should be increased, by urging the completion of Cornell reservoir, by the use of flash boards on the dams whereby a large additional amount of water may be secured, and also by the construction of new reservoirs, if found economical.

IX. That the present supply of Brooklyn should be increased and improved by building a 48-inch conduit from Millburn to Spring Creek to utilize the water now available; by the erection of additional pumps at Millburn; by filtering the water at Jameco and Springfield; by remodeling the high service at Mt. Prospect; and by making some of the other extensions and repairs now planned by the Water Department.

X. That the pollution of the surface waters of the Croton, Bronx and Long Island supplies is such as to warrant a purification of these waters by filtration as soon as this can reasonably be accomplished, this opinion having also been expressed by the Board of Health.

XI. That additional pumping machinery should be provided for the high service in Manhattan, and where required in other boroughs.

XII. That if 10 per cent. of the waste within buildings in all the boroughs can be saved by metering (this saving amounting to about ten gallons daily per capita of the population of 3,608,000), this saving, together with the available increase of supply referred to above, would probably enable the City to tide over a period not exceeding ten years, which would barely suffice to make new sources of water supply available.

The Present Water Supply of the City of New York.

The population of the City of New York, as estimated by the Health Department for July, 1899, was 3,607,900.

The total area of the city is 187,944 acres; of this area 48,275 acres, or 25.7 per cent., is served with water.

Of the total daily supply of 371,778,000 gallons, the city furnishes 348,379,000 gallons, or 93.7 per cent., and private companies furnish the balance, 23,399,000 gallons. Of the water supplied by the City, 248,500,000 gallons were delivered into the City reservoirs by gravity and 44,000,000 gallons of this were pumped to greater elevations. All of the water furnished by companies, including 1,500,000 gallons sold by the City to the New York & Westchester Company, is pumped.

A short history of the water works of Greater New York and Brooklyn is found in the special reports made to this committee by Mr. J. James R. Croes and Mr. Lebbeus B. Ward, whose reports are attached. There will also be found an account of the capacity and management of these works, also of the amount of water distributed by gravity, the amount pumped, the amount of ground water and surface water and the amount furnished by private companies. Mr. Ward's report on the pumping stations is especially valuable because of its intelligent analysis and clear statements of facts not heretofore collated.

The old aqueduct, which has a carrying capacity of 90,000,000 gallons a day, was put in service in June, 1842, and the new aqueduct, which was completed in 1890, has a carrying capacity of 290,000,000 gallons. In 1891 the Aqueduct Commission was reorganized, and it is now building additional storage reservoirs. The official existence of this commission will end when these reservoirs are finished, which should be not later than in 1903.

The reservoirs of the Croton water works, already built and building, will have an aggregate storage capacity of 73,736,000,000 gallons. The safe yield of the Croton watershed is estimated by Mr. Croes at 280,000,000 gallons a day, and by Mr. J. R. Freeman (in his report to the Comptroller) at 275,000,000 gallons a day. This yield is based on the completion of the Cornell dam, now building, and is estimated to be the greatest safe permanent yield then available. The Bronx and Byram watersheds will yield in addition from 15,000,000 to 17,000,000 gallons a day. The safe yield of all these watersheds will be therefore about 290,000,000 gallons a day directly available for the Boroughs of Manhattan and the Bronx. This water is all brought in by gravity and delivered at Central Park Reservoir, about 120 feet above tide level.

The present safe yield of the Croton watershed, pending the completion and filling of the new storage reservoir, is estimated by Mr. Freeman at 232,000,000 gallons a day, allowing for the most severe drought of the last thirty-two years. By the temporary use of flashboards on all the dams, this can be increased to 250,000,000 gallons.

The quality of the water furnished to the several boroughs varies with the source, and in the case of surface water, also with the rainfall and the season.

The Croton supply is surface water, and coming mostly from an eozoic rock country, is soft. Most of the territory is used for farming, and has a considerable population living upon it. Although many restrictions exist against the pollution of the streams, it is impossible to prevent the surface washing from heavy rains from causing the water to become turbid and from introducing some polluting elements. In the autumn vegetable matter frequently gives the water a slightly unpleasant taste.

The surface water supply of Brooklyn is derived from deposits of sand and gravel, and the surface water is nearly as soft as the Croton water. A large part of the watershed is cultivated, causing at times a slight turbidity, and the surface washings are likely to cause some pollution and sometimes a slight taste. The remaining supplies are from wells and are ground or spring water. Both in Long Island and Staten Island, the quality of this water may be very good, although, of course, harder than the surface waters. If derived from a territory, the surface of which is not spotted with cesspools or crossed by sewers, the water is entirely unpolluted, clear, limpid, and has an excellent taste. Where deep wells were sunk, the water occasionally is not good. If the wells are lowered beyond a certain level, brackish water appears.

The Borough of Brooklyn is supplied from various ponds, streams and wells on Long Island extending as far east as Massapequa, and the reliable yield is stated to be about 108,000,000 gallons a day. This water must all be pumped. The boroughs of Queens and Richmond are supplied by pumping from wells, and have no large storage reservoirs.

The reports of present daily consumption as made by different observers vary somewhat. We use the term "consumption" in its accepted sense as meaning all the water delivered into the service mains. It includes the water wasted as well as the water used.

Mr. Ward estimates the present consumption for the boroughs of Manhattan and Bronx at 230,000,000 gallons a day from the Croton watershed, 16,000,000 from the Bronx and Byram, 1,000,000 from the ground water, or 247,000,000 gallons in all. Mr. Croes' figures are 245,700,000. Mr. Freeman makes the daily consumption of Croton water 226,000,000 gallons, and that of water from the Bronx and Byram 16,000,000 gallons. We may safely say that the present daily consumption in the boroughs of Manhattan and the Bronx is from 242,000,000 to 247,000,000 gallons a day, and that the average daily rate is increasing about 15,000,000 gallons each year. At this rate the consumption in 1901 will be about 260,000,000 gallons a day; in 1902, 275,000,000, and in 1903, 290,000,000.

The safe yield of the Croton watershed, plus the Bronx and Byram watersheds, using flashboards on all dams, will now be 265,000,000 gallons a day, and will be 290,000,000 after the Cornell dam is completed.

If we use Mr. Freeman's figures for consumption of Croton water, namely, 226,000,000 gallons, and Mr. Ward's figures for consumption of Bronx and Byram water, we have for the present a daily consumption of 242,000,000 gallons; in 1901, 257,000,000 gallons; in 1902, 272,000,000 gallons, and in 1903, 287,000,000.

With average rainfalls, and with no reduction in the per capita rate, we may, therefore, expect to pass 1903 with sufficient water for the needs of the city, but the margin is close. After 1903 the daily consumption will have passed the daily supply, and the shortage will increase each year.

On several occasions within recent years New York and Brooklyn have had narrow escapes from water famines. On the 5th of February, 1900, the rainfall on the watersheds supplying the city of New York had been below the normal for 255 days; more water had been steadily drawn from the Croton reservoirs than had run in, and the boroughs of Manhattan and the Bronx were within a few days of a water famine. Brooklyn was in fully as bad condition, for water could not be pumped fast enough to supply the needs, and its reservoirs were nearly exhausted. About the same time Brooklyn had a still narrower escape. That borough came within one day of exhausting its water supply. In the Boroughs of Manhattan and the Bronx a similar situation was developed in 1891, but the public did not know of it. The storage reservoirs were exhausted; the only reserve left was a little water in the Central Park reservoirs. Rain came on each of these occasions just in time. When the people of the City of New York understand the peril that they have escaped and the danger in which they still live, and when they know the means of averting the peril, they will naturally expect their officers to proceed promptly to forestall the catastrophe of a failure of its water supply.

Few persons stop to think what a calamity a water famine would be to a great city. It does not mean actual thirst; before the water was exhausted in the service reservoirs the responsible officers might cut the flow in the mains from, in the case of New York, say, 250,000,0000 gallons a day down to 50,000,000 gallons, and the people could still procure water for washing, cooking and drinking. But the interruption of business, using water for power, would cause serious financial loss, and actual suffering would be felt among the poor; and worst of all, would be the danger of a large conflagration.

This is no mere sensational statement of an imaginary situation. In each of the cases mentioned above the cities escaped just this situation by the fortunate occurrence of rains. After a protracted drought, suddenly on the night of February 5, 1900, a very heavy rain began and continued for twenty-four hours. The reservoirs were filled and 4,000,000,000 gallons of water ran to waste over the Croton dam. But even this timely rainfall would have been too late to avert loss and suffering but for the foresight of the chief officers of the Water Department in previous years in causing the water for manufacturing and other large uses to be metered. Thus they had already stopped considerable waste, and the margin thus saved during a long drought was a full supply for several weeks. This is an object lesson of what may be accomplished by a judicious use of meters.

Improvement of Present Supplies.

In this section of our report we are dealing only with the present supply and consumption, by which we mean the supply in sight and which may be developed on the watersheds now available, and the consumption which will be reached in a very few years and which may be provided for by the present supply. The future requirements and supply will be dealt with in another section of the report, where we shall consider conditions that reach far into the future.

We desire to state here that even with reasonable skill and vigilance and without droughts of exceptional severity and duration, the present water supply at the present rate of consumption will reach its limit within a few years, leaving barely sufficient time to carefully arrange for the future.

The Croton supply for Manhattan and Bronx may suffice, we believe, for some five to ten years to come.

There is a large area of the Bronx which is already in great need of more water, over two thousand buildings being quite insufficiently supplied. The borough of Brooklyn has also reached its limit of supply, as already stated.

To furnish reasonable security for the next few years, certain measures of precaution are therefore called for. These measures are of two kinds: first, temporarily to increase the available supply; secondly, to diminish the waste.

The completion of the Cornell dam will add 32,000 million gallons, and the use of flash-boards on the other dams may possibly add from 3,000 to 5,000 million gallons to the Croton storage. The cost of the latter will be a trifle as compared with the value of the insurance against a shortage.

To furnish the Bronx borough, now insufficiently supplied, with more water, a new main has been proposed to deliver water to it from the new aqueduct. An appropriation has recently been made for the purpose.

To relieve the present conditions of Brooklyn urgent requests have repeatedly been made by the engineers in charge of the Brooklyn Water Supply for the immediate construction of the following works:

1. A 48-inch pipe from Millburn to Spring Creek.

2. Additional pumps at Millburn.

3. Filters for the water from Jameco and Springfield now polluted, and recommended as the quickest means to safely increase the supply.

4. Remodeling the High Service at Mt. Prospect, so as to stop waste of water and increase the supply.

An appropriation has quite recently been made to lay the required 48-inch pipe and to repair the Millburn reservoir, hitherto useless.

In addition to the above, an appropriation for additional pumping machinery at Millburn has been demanded. To insure a supply in case of a serious accident to the present pumps or conduit a new distributing reservoir at Forest Park is required, as the Ridgewood basins scarcely hold a three days' supply.

A number of other extensions and repairs have also been urgently called for to insure parts of the borough against a possible water famine, and to render the present works more effective and economical, and to protect exposed water from contamination. These additions are all urgent and will be required, whatever the future source of supply may be.

As the borough is growing rapidly, we cannot too strongly recommend the early construction of the above-needed works.

There is no general scarcity of water in the Boroughs of Queens and Richmond, now generally supplied by private water companies. When, however, a scarcity seems imminent it is best to extend the present sources until a new supply from the mainland is available.

Reduction of Waste of Water.

The second measure of precaution which may be taken to save the boroughs from a water famine until a new and larger source of supply can be developed is to diminish the waste. Fortunately, this measure may begin to produce some effect almost at once. Fortunately, too, it is not merely a temporary expedient, but will be a means of economy and security for the future. Modern hydraulic engineers and waterworks managers are agreed that it is quite within the resources of engineering and administration, at least in some cities, to save a considerable part of this waste. The most serious difficulties in the way are a mistaken public opinion and a fear of the political effect of an attempt to control the domestic use of water.

There has been a great deal said in this city and in other cities about the waste of water, curable and incurable. Mr. Freeman, in his recent report to the Comptroller, devotes a lengthy discussion to the subject; and Mr. Croes and Mr. Crowell have gathered information on the same subject for us.

To obtain reliable data as to the actual consumption of water in private houses and buildings of other types, the Committee has been instrumental in having placed in such buildings a considerable number of water-meters, which were read at short intervals and the readings carefully studied in connection with the conditions under which the meters were used. To supplement this record the Sub-Committee obtained from Mr. J. H. Bellis a record of meter-readings for 600 buildings and covering a period of three years. These meter-readings were collated and deductions were made from them by Mr. Croes and Mr. Crowell.

In reviewing the whole subject we are inclined to share the view taken by Mr. Freeman to the extent that in this city great practical results in reducing the waste are not promising, and that "it is dangerous to the public interests to be too hopeful about preventing waste when estimating the date when the new supply must be available, or in estimating its necessary magnitude, for with these hopes unfulfilled and the reservoirs emptied, the disaster would then be beyond remedy."

The reports of Messrs. J. James R. Croes and Foster Crowell contain valuable information on the subject of waste. They do not agree upon definite conclusions as to the amount of preventable waste of water in the City of New York, except in the assumption that it is very large.

Mr. Crowell considers that the "theoretically preventable waste" amounts to 120,000,000 gallons daily. Mr. Croes estimates the total waste at 150,000,000 gallons daily, of which 30,000,000, he thinks, is wasted inside of houses and 120,000,000 under ground. The latter he considers could be reduced to 70,000,000 gallons daily by the year 1950.

We believe that a complete cure for leakage below ground could only be found by putting the mains in subways, accessible to detect and repair leaks. The leakage can, however, be materially diminished by certain other recognized methods of detection; but all of these methods are costly and slow of development. No great saving could be hoped for inside of twenty years.

The amount of water wasted inside of houses is considerable, but it cannot even approximately be separated from the leakage below ground. There is no question regarding the possibility of quickly saving part of this waste by metering the water in all large houses.

We should, however, not be oblivious of the fact that in houses having careful consumers the expense of a meter service might be greater than the actual cost of the water usually wasted. While a proper discrimination should, therefore, be made, it is an entirely safe plan in all cases to give the municipal government the right to place a meter in any house where it may deem it desirable and, on the other hand, to give any user the right to demand a supply by meter measurement, if he desires it.

We cannot, therefore, share Mr. Croes' final conclusion that *pari passu* with the increased use of water the waste can be gradually reduced to such an extent that the present supply from the Croton river will be sufficient for Manhattan and Bronx for the next fifty years. While such a result would be highly desirable, we do not think it sufficiently probable of attainment to advise any postponement in the construction of works for an additional supply.

It seems to us that reasoning based on waste suppression in other cities is not conclusive, and we cannot compare European cities in this respect with our own cities. The habits of people as regards the use of water are not only different in the two countries, but they are so well fixed that they cannot be suddenly changed.

It is a well known fact, ascertained by meters, that in the houses of the wealthier classes there is a very much greater per capita consumption than in the houses of the poorer class, ranging from several hundred in the former to but a few gallons per day per individual in the latter class. Districts inhabited by the former, therefore, require much more water than districts inhabited by the latter. The same difference extends to entire cities. Those like Fall River and Woonsocket, quoted so often as having a small per capita water consumption, are cities having a preponderance of the operative class whose average wealth and opportunities for luxuries are small. Boston, New York, Philadelphia, Washington, Chicago and other large cities of wealth, have and will always have a large per capita domestic consumption, irrespective of the water used for power and manufacturing purposes. Another reason for the difference is the existence of greater facilities for exercising control in a smaller than in a larger city.

It is certainly true that much water is now wasted, partly through carelessness, partly through leaks in service pipes and mains, indicating that a decrease is possible. But it is also true that there is an undoubted and a perfectly legitimate increase in the amount of water actually used in those cities where the standard of living is raised and where water is more and more employed for power and producing purposes.

The conditions in New York, therefore, seem to us to point towards a legitimate and desirable increase of supply per capita. With this prospect in view, it becomes imperative not merely to reduce the waste as far as practicable, but also to look forward to a bountiful legitimate supply for the future, if the same can be economically obtained.

General Statistics.

Table No. I presents some general statistics of the present works brought together for convenient reference. It will be noticed that there is a large area, about 74 per cent. of the whole, still unsupplied with water from a common source. But the population residing upon this area is probably small. The average supply per capita, as given in the last column, and obtained by dividing the supply for the whole population, is, therefore, less than the real consumption per head of actual users. From the information before us we are not able to obtain the correct amount.

The supply given per tap in 1899 is free from this objection by having no reference to the whole population. In comparing the amounts for the several boroughs we must, however, remember that in New York 30 per cent. of all taps are metered, serving the many large apartment houses and steam-producing establishments. In Brooklyn only about 2½ per cent. of all taps are metered, and are confined almost entirely to those serving the largest consumers. Therefore, although in this borough the per capita consumption is less than in New York, the consumption per meter is much greater.

The table further shows that the present consumption in New York is about 103 gallons per capita. Making some allowance for the discrepancy in the per capita rate, it is smaller than in most of our large cities, a rather gratifying fact.

The reports of Mr. Croes, Mr. Ward and Mr. Freeman together furnish the best general account of the condition of the waterworks of New York, from which we may learn how far they need improvement, and we must refer to them for the detailed facts.

Filtration of Water.

As we shall more fully discuss the subject of quality when speaking of an additional supply, it need here only be said that we consider the time to have arrived when the surface waters of the Croton, Bronx and Long Island watersheds should be filtered. It is not so much the occasional turbidity and unpleasant taste of these waters which demand this improvement, but the frequent high percentage of bacteria contained in them, due to a pollution by the population residing upon the watersheds, either brought about by the surface washing of rains or in some other way, unquestionably propagating water-borne disease germs.

The evidence on hand connecting certain diseases with water supplies exposed to occasional pollution, as are the Croton, Bronx and populated parts of the Long Island watersheds, is now so strong that it is no longer questioned. Although this pollution is at present not great, it is sufficiently great, in our opinion, to warrant a purification of these waters as soon as it can be brought about. We share this opinion with the Board of Health, which last year recommended a filtration of the Croton and Bronx supplies.

The reports of Messrs. J. James R. Croes, L. B. Ward and Foster Crowell follow as appendices "A," "B," and "C," respectively.

General Statistics for Present Supply.

TABLE I.

Borough.	(1) Population, 1899.	Municipal or Private Supply.	Source of Water.	Daily Consumption of Water. (2) Gallons. Gravity.	Pumped.	Total.	Reservoir or Direct Pressure.	Elevation Above Sea Level. Feet.
Manhattan.	2,149,090	Municipal.	Croton.	186,000,000	44,000,000	230,000,000	Reserv'rs	115
Bronx.		Municipal.	Bronx and Byram.	18,500,000		21,000,000	Reservoir	190
		Private.	Surface and Ground Water.		1,500,000 (4) 1,000,000		Stand Pipe.	
Brooklyn.	1,256,178	Municipal.	Surface Water.		63,938,000	102,663,000	Reservoir	170
			Ground Water.		31,969,000		Reservoir Tower.	198 278
		Private.	Ground Water.		6,756,000		Reservoir St'd Pipe.	150
Queens.	133,366	Municipal.	Ground Water.		3,892,000	12,925,000	Stand Pipe.	
		Private.	Ground Water.		9,033,000		Reservoir St'd Pipe.	125
Richmond.	69,266	Municipal.	Ground Water.		80,000	5,190,000	Stand Pipe.	
		Private.	Ground Water.		5,110,000		Reservoir Reservoir St'd Pipe.	215 251
Totals.	3,607,900			204,500,000	167,278,000	371,778,000		

(1) From Reports of Board of Health.
(2) From Report of Mr. L. B. Ward.
(4) This is Bronx water sold to the New York and Westchester Water Co.

General Statistics for Present Supply.

TABLE I.—(Continued).

Borough.	Acres (2) supplied.	Acres (2) unsupplied	Total (2) area. Acres.	Highest land supplied. Feet above sea level.	Number of Taps.	Average daily supply per tap. Gallons.	Average daily supply per capita Gallons.
Manhattan.	11,369	2,118	13,487	258			
Bronx.	4,870 1,764	14,854	21,488	260	*122,519	2,028	117
Brooklyn.	13,368 4,866	21,476	39,710	165	110.740	927	82
Queens.	2,770 5,875	68,014	76,659	200	15,493	836	97
Richmond.	202 3,281	33,117	36,600	300†	7,263	714	75
Totals.	48,365	139,579	187,944	——	——	——	(average) 103

(2) From Report of Mr. L. B. Ward.
* Computed by Mr. Croes.

ADDITIONAL WATER SUPPLY.

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Engineering Committee: Part III.

Additional Water Supply.

ADDITIONAL WATER SUPPLY.

The Engineering Committee presents the following summary of its conclusions and recommendations regarding the future water supply of this City:

I. That the Borough of Brooklyn and a portion of the Borough of Bronx are in urgent need of provision for increasing their supply at the earliest possible day, and the other boroughs require an increase within not many years, leaving at present but a short time to prepare for and construct the new works.

II. That the quality of the water should be of as high a degree of purity as practicable, such as is furnished by spring water, filtered water or surface water from almost uninhabited and uncultivated mountain regions.

III. That the source of supply should be capable of yielding at least 400,000,000 gallons daily, and of economically furnishing at least one-half of this quantity at the outset.

IV. That of the available sources of supply for the City, yielding large quantities of water of the requisite purity, the most economical are:

1. Ten Mile and Housatonic Rivers, a gravity supply; a part of the water to be filtered.
2. The Wallkill River, in Orange County; the water to be filtered and delivered by gravity.
3. The Hudson River above salt water influence (i. e., above Poughkeepsie); the water to be pumped, then filtered and delivered by gravity.
4. Several streams in the Catskill Mountains; the water to be filtered and delivered by gravity.

5. The North Hudson filtered and Schroon Lake in the Adirondacks, in its natural condition; to be delivered by gravity.

V. That the ground water of Long Island is not sufficient in amount to supply the entire metropolis, nor can the available quantity be supplied at as low a cost as the same quantity from other sources. But the pressing needs of the Borough of Brooklyn can most speedily and most economically be satisfied by a farther extension of the present ground water supply, until a more economical source on the mainland becomes available.

1. That the entire City of New York can be supplied from the Ten Mile and Housatonic Rivers, which can deliver 750 million gallons daily. But this source being chiefly in the State of Connecticut, is surrounded with legal difficulties, the nature of which, we are informed by the Legal Committee, render it impracticable.

2. That second in order of economy is a supply from Wallkill River, from which 460 million gallons daily may possibly be procured. The quality of this water is impaired by the presence of limestone and by muck beds too deep to be removed. One-fifth of the area of the reservoir is located in the State of New Jersey, where, we are advised by the Legal Committee, the right of condemnation cannot be exercised.

3. That we have a supply in the Hudson River at a point above salt water contamination, whence daily more than 1,500 million gallons could be pumped, but of which a supply of only 500 million gallons daily has been investigated by us.

4. That there is available a daily supply of possibly 460 million gallons from the Esopus, Catskill and Schoharie creeks, in the Catskill Mountains. Doubts exist as to the foundations for some of the dams and as to the possible leakage of the reservoirs, which can only be solved by further investigations.

5. That the Adirondack Mountains can yield a daily supply of over 1,000 million gallons, a project to furnish one-half of which we have investigated at Schroon Lake, and at Hadley, on the North Hudson, 29 miles below.

VI. That all of the above sources can be developed and economically utilized within a few years to furnish 250 million gallons daily until more is wanted.

VII. Our final conclusion is: That the water of the Adirondack mountain region can supply purer water and more of it, than by any other project examined by us. This source lies entirely in the State of New York and has no complications of inter-State ownership.

There are two methods by which this water can be obtained—one is by pumping the water of the Hudson River at Poughkeepsie into filtering basins on the adjacent high lands, and letting it flow thence by gravity to New York. The other plan is to take the water from the North Hudson near Hadley, and let it flow to New York through longer aqueducts by gravity alone.

Both projects require the construction of storage reservoirs in the Adirondacks to equalize the seasonal flow.

This source is by far the largest investigated by us and can supply from 1,000 to 1,500 million gallons daily, which is enough with the present Croton system to supply the wants of a population of from thirteen to eighteen millions of persons.

In comparing the two methods, we find that the final supply taken at Poughkeepsie would be the greater by the amount coming from streams below Glenns Falls.

The water taken from the upper Hudson would be purer than that taken at Poughkeepsie, which is below the drainage of many cities. The Poughkeepsie water would have to be filtered at once, and the North Hudson water (with the exception of Schroon

Lake), would have to be filtered eventually to remove discoloration and taste from swamps and the refuse of mills, unless its purity could be maintained by turning the whole water-shed into a State Park where pollution could possibly be prevented.

The Poughkeepsie water would be pumped into a reservoir at such an elevation that it could flow by gravity, reaching New York at an elevation of 260 feet above sea level. The water taken from the North Hudson at Hadley would flow by gravity to an elevation of 310 feet.

Both projects would improve the navigation of the Hudson below Troy, and increase the horse power of the river above, by equalizing the seasonal flow. The Poughkeepsie project would be the more efficacious in improving navigation, as no water would be taken out of the river above Poughkeepsie.

To furnish 250 million gallons daily from Poughkeepsie, the first cost would be $36,880,000; the yearly cost would be $2,585,000; cost per million gallons, $28.33. To furnish 500,000,000 gallons, the first cost would be $72,374,000; yearly cost, $5,546,000; cost per million gallons, $30.39.

To furnish 250 million gallons from the Adirondacks, the first cost would be $71,727,000; the yearly cost, $2,727,000; cost per million gallons, $30.00. To furnish 500 million gallons, the first cost would be $140,155,000; the yearly cost, $5,338,000; cost per million gallons, $29.25.

We estimate that the shortest probable time between letting contracts for the work and the first use of the new aqueduct, would be for the Poughkeepsie project six years, and for the Adirondack project seven and a half years. The surveys and preparations for letting the work could and should be made coincidentally with the legislative and legal preparations.

The Engineering Sub-Committee presents these two projects to the Merchants' Association as the result of its labors.

Our reasons for these conclusions are set forth below, and a summary of the main features and cost of the several projects is given in Tables I. and II.

Our investigations for future supplies were necessarily limited to a careful reconnaissance of the ground and to broad views of the subject, so as to bring out the essential features of the various problems in their relatively true proportions, rather than to consider details which had no important bearings either upon the practicability or cost of the projects.

All of the estimates of cost for an additional supply assume the water to be delivered at the northern city line. They are, therefore, directly comparable. Both to reduce the first cost and to insure safety in case of accident, and also for better maintenance and cleaning, we have assumed that one aqueduct should not be larger than sufficient to carry 250,000,000 gallons daily. We have, therefore, at a greater cost, assumed two aqueducts to furnish 500,000,000 gallons per day.

No allowance is made in the estimates of cost for a sinking fund to retire the bonds issued for the construction. We omitted this because a comparison between the projects requiring a large investment with small cost of operation and those requiring a smaller investment with large cost of operation would manifestly become unfair. We have, however, added a sufficient sum for maintenance and renewals to provide for keeping the works permanently in proper repair and good order.

TABLE I.

DATA CONCERNING AVAILABLE SOURCES FOR ADDITIONAL SUPPLY.

Installation for 350 Million Gallons Daily from the Ten Mile and Housatonic Rivers, and for 250 Million Gallons Daily from the other sources.

Name of Source.	Character of Water.	How Delivered.	Elevation of Delivery at CityLine Feet above Sea Level.	Length of Aqueduct to City Line. Miles.	Area of Watershed. Square Miles.	Capacity in Million Gallons Daily.
Ten Mile and Housatonic Rivers.	150 Million Gals. Filtered Daily	Gravity.	300	36	1020	350
Wallkill River.	Filtered.	Gravity.	310	48	465	250
Hudson Riv. above Poughkeepsie.	Filtered.	Pumped.	260	60	11,800	250
Esopus and Catskill Creeks.	Filtered.	Gravity.	310	100	437.5	250
Adirondack. Schroon Lake.	Natural.	Gravity.	310	203	518	250

NOTE.—If the Ten Mile and Housatonic rivers system should be constructed, with a daily capacity of 350,000,000, but should temporarily be used only to the extent of a daily delivery of 250,000,000, the resulting cost per million gallons delivered would be $21, which would be reduced to the above figure of $15 when the rate of delivery is increased to 350,000,000 gallons per day. But, when the other systems supply 350,000,000 gallons per day, the resulting costs per million gallons delivered would be respectively about $20, $30, $35 and $40.

TABLE I—(Continued).

DATA CONCERNING AVAILABLE SOURCES FOR ADDITIONAL SUPPLY.

Installation for 350 Million Gallons Daily from the Ten Mile and Housatonic Rivers, and for 250 Million Gallons Daily from the other sources.

Name of Source.	Cost of Construction.	Annual Cost of Operation, Interest and Maintenance.	Cost per Million Gallons delivered at City Line.	Notes.
Ten Mile and Housatonic Rivers.	$46,600,000	$1,917,000	$15.00	Estimates of cost made by Mr. John R. Freeman, but modified by this Committee. Aqueduct has capacity to deliver, in addition, 50,000,000 gallons from Croton Basin. Ten Mile River water is filtered.
Wallkill River.	36,827,000	1,652,000	18.10	Reservoir stripped in few places Water all filtered. One aqueduct
Hudson Riv. above Poughkeepsie.	36,880,000	2,585,000	28.33	One aqueduct. Annual cost could be largely reduced by rent of water power in Adirondacks.
Esopus and Catskill Creeks.	59,653,000	2,498,000	27.35	One aqueduct.
Adirondack. Schroon Lake.	71,727,000	2,727,000	30.00	One aqueduct.

TABLE II.

DATA CONCERNING AVAILABLE SOURCES FOR ADDITIONAL SUPPLY.

Installations Ranging from 460 to 750 Million Gallons Daily.

Name of Source.	Character of Water.	How Delivered.	Elevation of Delivery at City Line. Feet above Sea Level.	Length of Aqueducts to City Line. Miles.	Area of Watershed. Square Miles.	Capacity in Million Gallons Daily.
Ten Mile and Housatonic Rivers.	150 Million Gallons Filtered Daily. / All Filtered	Gravity.	300	36	1020	750
Wallkill River.	Filtered.	Gravity.	310	48	512	460
Hudson River, above Poughkeepsie.	Filtered.	Pumped.	Half at 131.5; and half at 260.	64 60	11,800	500
Esopus, Catskill and Schoharie Creeks.	Filtered.	Gravity.	310	100	742.9	460
Adirondack. Schroon.	Natural.	Gravity.	310	203	518	500
Hadley.	Filtered.	Gravity.	310	174	4500	500

TABLE II—(Continued).

DATA CONCERNING AVAILABLE SOURCES FOR ADDITIONAL SUPPLY.

Installations Ranging from 460 to 750 Million Gallons Daily.

Name of Source.	Cost of Construction.	Annual Cost of Operation, Interest and Maintenance.	Cost per Million Gallons delivered at City Line.	Notes.
Ten Mile and Housatonic Rivers.	$52,000,000	$2,125,000	$8.00	Estimates of cost made by Mr. John R. Freeman, but modified by this Committee. Aqueduct delivers 800,000,000 gallons daily.
	67,000,000	3,245,000	11.86	
Wallkill River.	62,534,000	2,778,000	16.54	Two aqueducts.
Hudson River, above Poughkeepsie.	72,374,000	5,546,000	30.39	Two aqueducts. A large credit available for water power. Supply may be increased to over 1,500 million gallons daily.
Esopus, Catskill and Schoharie Creeks.	118,881,000	4,838,900	28.82	Two aqueducts.
Adirondack. Schroon.	140,155,000	5,337,900	29.25	Two aqueducts. Capable of increasing supply to over 1,000 million gallons daily from over 4,000 square miles.
Hadley.	140,155,000	5,885,400	32.25	do. do.

We have had the estimates of cost made on a basis of wages, both of $1.35 and of $2.00 a day for common labor. As the entire work will be located outside of the city and would most probably be done by contract, and for a better comparison with the estimates of cost made by Mr. Freeman for the Housatonic project, we have in our summaries and conclusions used the cost obtained from the lower rate.

An important part of the investigation necessarily referred to the question of cost. There was naturally insufficient time available to make such surveys and examinations that would be required prior to actual construction. But for purposes of comparison there is enough information at hand to obtain a safe approximation. Recent experience in Massachusetts, and the cost of the new Croton aqueduct, as well as the similar studies recently made in the City of Philadelphia, offered guides with which to proceed. Points of serious doubt were cleared by personal instructions to the engineers.

Our conclusions are based upon the data collected by our engineers; but we do not endorse, in all cases, the opinions which they have expressed or the conclusions which they have drawn.

Quality of the Water to be Provided.

During the last fifty years, the close relation between the quality of the water used for domestic supply and the sick and death rates from zymotic diseases, notably typhoid and diarrhœal, has received increasing recognition, imposing more serious responsibility upon engineers charged with the duty of selecting potable water. In both Europe and America, this question has received the most careful attention and much discussion. On one side is the sanitary demand for the purest water, on the other side is the expense required to satisfy this demand. Progress in the knowledge of water purification has of late reduced the relative cost, and the public demand for a pure water supply has been increased sometimes regardless of expense.

We assume that the people of this city will not be satisfied with any new source of water supply that is not equal to the highest standard now set in any other city. We therefore have considered only the three best kinds of water to be acceptable. These are: First, spring or ground water not subject to pollution; second, mountain water from almost uninhabited and uncultivated territory, and third, filtered water.

There will be no hesitancy in accepting spring and mountain waters, provided they are not polluted. A few words should, however, be said regarding filtration, as the art of properly filtering water is of recent origin.

At present there is no longer a mystery regarding this process of purification. The conditions which allow water to free itself not only of turbidity but of microscopic bacteria and pathogenic germs suspended therein, are now fairly well known. Artificial filtration is in fact but an imitation of nature's process, operating under the most favorable conditions of converting surface water into spring water.

Highly polluted water can, by this method, be rendered free from the dangerous poisons and organisms. The reduction of typhoid fever and diarrhoeal diseases with the introduction of filtered water has consequently occurred in a large number of cities of Europe and America, and the necessary conditions are now so well known that the result can in most cases be safely foretold.

The oldest filtration plant in this neighborhood is located at Poughkeepsie, and since the works have been properly operated the sanitary effect has been satisfactory. The latest and the largest filter plant in the United States is at Albany. Since its recent introduction the typhoid fever death rate has been lowered very materially. The cities of Philadelphia, Pittsburgh, Cincinnati and Louisville are now engaged in preparing for works to filter their water supply.

The expense of filtration, including interest on the cost of the necessary works, ranges in the projects here presented from $4.23 to $6.91 per million gallons. The great sanitary benefit is therefore not expensively secured.

Quantity of Water to be Provided.

We have already discussed the question of quantity, so far as it relates to the water heretofore consumed, including the question of waste. Whether or not it will be practicable to reduce this waste as much as it should be reduced concerns us at this place only so far as it will prolong the period at the end of which an increased supply must be available.

The indications are strong that an additional supply will be needed quite as soon as it can be provided, even if preliminaries are begun at once. We believe, therefore, and earnestly recommend that no time should be lost in starting them.

We did not fix a per capita rate of water consumption nor a time limit to be used as a basis for investigating an additional supply, because it is uncertain to what extent an average per capita rate of reduction of waste can be effected, and therefore how long a given supply will last; and it is otherwise unnecessary for our purpose to consider these items.

We have taken the broad view that whatever new source is selected, it should more than double the present supply and we, therefore, decided to investigate a daily addition of 400,000,000 to 500,000,000 gallons.

To decide upon a smaller quantity, irrespective of the fact as to whether or not it could be readily increased thereafter, would be, within a few years, to open anew the question of a future supply, with possibly increased legal difficulties and possibly demanding the acquisition of water rights and the purchase of property for aqueducts at greatly advanced rates.

It is, however, in no case necessary at once to provide works to supply the entire quantity. It is practicable in all of the projects to provide first for about 250,000,000 gallons and later to provide for the remaining quantity. The filter plants for the entire estimated quantities also do not require immediate installation, but can be gradually extended as the consumption increases. Nor is it necessary to make a distinction at this time between the amounts of water later required in each of the several boroughs. The distributing pipes are laid as the new districts develop and their location and sizes can then be adjusted to the timely needs.

Pressure to be Provided.

In addition to the qualifications given above regarding the water to be furnished, we have further to determine the elevation at which it should be delivered. This elevation depends partly upon the service in the city and partly upon the source.

Plate I shows the areas that can be supplied from the present reservoirs and the areas requiring pumping. In the several projects considered those which bring the water into the city by gravity can, as well as not, deliver it for all the territory at a high elevation, which we have fixed at 310 feet above tide.

The project requiring pumping from the Hudson River should deliver the water at no greater height than necessary, and it was decided to deliver a portion of the Hudson River supply at 131.5 feet and another at 260 feet above tide. A small portion will require a further lift into the highest districts of a limited area, to nearly the same extent as required at present.

We are of the opinion that it would be unwise to materially increase the present pressure in the lower part of Manhattan, where the high buildings are increasing in number. It is impracticable to deliver water to the highest floors of these by gravity. Therefor some of it must in any event be pumped.

A material increase of pressure would not only require a remodeling of much of the plumbing, but would cause a large increase in the unavoidable waste of water and a correspondingly large increase in its consumption. After the new aqueduct was brought into service with a better pressure the consumption at once increased about 30.8 per cent., which increase was almost wholly due to the greater pressure.

On the other hand, the only advantage from an increased pressure is the better fire service. Yet, our examinations point to the fact that a still greater advantage can be obtained at less cost by a separate salt water fire service in the important districts.

We have, therefore, assumed that of the water brought in by gravity at an elevation of 310 feet, as much of it as may be required by the low service would flow into the present reservoirs, and that the high-service districts would be supplied as far as practicable directly from the aqueducts.

AVAILABLE SOURCES FOR AN ADDITIONAL WATER SUPPLY.

Ground and Filtered Water from Parts of Nassau and Suffolk Counties.

As has before been implied, we are of the opinion that on Long Island the surface waters should be filtered or the supply confined to ground-water. From Mr. Ward's tables we gather that the yield of ground-water per square mile last year was 369,581 gallons per day, and that the total yield, including surface-water, was 745,983 gallons per square mile per day.

Including both the ground-water and filtered surface-water, the watersheds of Long Island available for a future supply are probably insufficient to yield more than about 100,000,000 gallons per day. This source could, therefore, only be considered as a partial supply for the City of New York and confined to the boroughs of Brooklyn and Queens, which it might serve for a long time.

The question then presents itself as to the relative economy of the Long Island source and a source from the main land. The decision depends on the particular one selected. If either the Housatonic or Wallkill were obtained, such water would be less expensive than the Long Island water. But, if the water is pumped from the Hudson River above Poughkeepsie, and also filtered, it would be cheaper to pump the near sources of Long Island ground-water. In the latter case, legal difficulties stand in the way, which prevent the use of Suffolk county water. And without this, the quantity available in Nassau county will not be sufficient very long.

For the present and until a much larger supply is required by the Borough of Brooklyn, this can be supplied with greater economy by extending the present system. In making the extensions, so far as they pertain to surface-waters, although they are apparently not greatly polluted, filter plants for purification should, in our opinion, be made an integral part thereof.

In extending the ground-water supplies, it would be well to gather it along a line further from the shore than it is gathered now. Under present conditions its removal is noticeable to agricultural interests. When ground-water is removed from a plane more than 10 or 12 feet below the surface of the ground, these interests could not be seriously affected thereby. If it is not obtained too near the surface, where it may receive surface pollution, nor is taken from too great a depth where it may have a mineral pollution, or be affected by the percolating ocean water, the ground-water on Long Island, filtering naturally as it does through deep beds of sand and gravel, and being thus transformed into spring-water, has a high degree of purity and should be preferred whenever it is economical.

In view of the uncertainties existing as to the source to be selected for a new general supply and as to the time when the Borough of Brooklyn will be served by it, all of which governs the proper special treatment of the provisional extensions of the local supply, we have not made any further detailed examinations nor estimates of cost than what was necessary for recommendations to satisfy immediate needs.

Mr. De Varona, engineer of the water supply, who kindly furnished most of the information regarding the Brooklyn works, made an elaborate report in 1896 for increasing the supply 100,000,000 gallons per day. His estimate of cost for extending the ground-water supplies is $30 to $35 per million gallons delivered in the reservoirs, excluding payments to sinking fund.

Ten Mile and Housatonic Rivers.

Immediately after entering upon our duties, and knowing that the Housatonic watershed had been heretofore considered as the probable source from which New York would be supplied, after the Croton watershed had become exhausted, we inquired of our Legal Committee regarding the availability of this watershed, as it was located chiefly in the State of Connecticut, and as all of the water finally passed into that State.

The report of that Committee (q. v.) advised against its availability. We therefore devoted no further time to an investigation of this project, and a further study would, in any event, have been unnecessary, as Mr. Freeman in his recent report to the City Comptroller recommends it for adoption and describes it in detail.

From an engineering point of view, and in the matter of cost, it is certainly a very attractive source. We will, therefore, at this place, record at least its salient features and its cost substantially as it was given to us by Mr. Freeman, for the purpose of comparison with the other projects.

A dam built across the Housatonic River about a mile below Merwinsville, Conn., would control the flow from a watershed of about 1,000 square miles. The reservoir thus formed would have a water surface of about 33 square miles and would store sufficient water to sustain a daily supply to the city of 750,000,000 gallons, or about three times the present Croton supply.

A part of the drainage area and chiefly that of Ten Mile River, lies within the State of New York, and immediately north of the Croton watershed.

The water from the large reservoir would be brought to New York by diverting the flow into the East Branch Reservoir of the Croton watershed through the bed of an ancient stream which evidently once discharged the waters of the Ten Mile River basin naturally into the Croton basin. The outlet dam and sluices would be located at Pawling.

It is proposed to take the water from the reservoirs to Rye Lake, northeast of Kensico, through a single masonry aqueduct and thence to a new reservoir 305 feet above sea level and about half a mile north of the city line.

The aqueduct proposed by Mr. Freeman is to be large enough to carry not only the 750,000,000 gallons available from the new watershed, but also 50,000,000 gallons daily available in the present Croton watershed (East Branch) which can be brought to the City at the higher level, instead of letting it descend into the present aqueducts.

Mr. Freeman does not deem it necessary to filter the water from this source. It is undoubtedly true that, although the watershed contains a number of towns and is largely improved, the proposed large lake gives an excellent opportunity for a natural purification. Nevertheless, there is at present no guarantee in sight that such water would reach the standard which is now with good reason set for the best municipal water supplies. The City of Liverpool filters the waters of Lake Vyrnwy, in the Welsh Mountains. The City of Zurich and other Swiss cities filter the waters taken from the large lakes, which to the ordinary observer are of pristine purity.

In Mr. Freeman's estimates of cost we have, therefore, added in our comparative statement the cost of filtering this water.

On the other hand, it was necessary for a proper comparison to deduct from Mr. Freeman's estimates his allowance for a sinking fund, for the reasons mentioned on page 65.

Our estimate of cost for this project thus modified is given herewith in Table III.

INQUIRY INTO NEW YORK'S WATER SUPPLY.

TABLE III.

TEN MILE AND HOUSATONIC RIVERS.

Estimates of cost of construction, operation and maintenance, made by John R. Freeman, C. E., modified by the addition of the cost of constructing and operating filters and by the omission of sinking fund charges.

The water to be delivered at the city line at an elevation of 300 feet above sea level.

Cost of Construction.

	Delivering* 350 million gallons daily. 150 million gallons filtered daily.	Delivering* 750 million gallons daily. All filtered.
Rights, collection, storage and conveyance of water to East Branch Reservoir....	$24,439,000	$24,439,000
Structures for storage and conveyance to City Line..........................	17,143,000	22,594,000
Filter Plant............................	5,018,000	19,967,000
	46,600,000	67,000,000

Annual Cost of Operation and Maintenance.

	Delivering 350 million gallons daily. 150 million gallons filtered daily.	Cost per million gallons.	Delivering 750 million gallons daily. All filtered.	Cost per million gallons.
Collection and storage:				
Interest..................	$708,000	$5.54	$708,000	$2.59
Taxes and special assessments..................	94,000	0.73	94,000	0.34
Operating exp. and repairs.	80,000	0.63	80,000	0.29
No extraordinary repairs and depreciation........		0.00		0.00
	882,000	6.90	882,000	3.22
Filtering:				
Interest..................	150,540	1.18	600,000	2.20
Cost of filtering water.....	163,710	1.28	821,250	3.00
Depreciation	15,000	.12	30,000	.11
	329,250	2.58	1,451,250	5.31
Conveyance:				
Interest..................	542,000	4.24	705,000	2.57
Taxes and special assessments..................	36,000	0.28	47,000	0.17
Operating exp. and repairs.	72,000	0.56	84,000	0.31
Extraordinary repairs and depreciation	56,000	0.44	76,000	0.28
	706,000	5.52	912,000	3.33
Total annual charges......	1,917,250		3,245,250	
Total cost of water, per million gals, at city line		$15.00		$11.86

*Aqueducts have capacity to deliver 50,000,000 gallons daily of Croton water, in addition to the 350,000,000 and 750,000,000 gallons from the Housatonic and Ten Mile Rivers.

Wallkill River.

By constructing a dam across Wallkill River near Phillipsburg, N. Y., about 60 feet above the river and about 1,200 to 1,500 feet long, the extensive flat lands lying to the south, and locally called the "drowned land," may be flooded, forming a storage reservoir or lake with a water surface of over 50 square miles.

The area of the watershed above Phillipsburg is about 465 square miles, about 275 square miles being in the State of New York and 190 square miles in the State of New Jersey. The river flows in a northeasterly direction, rising in New Jersey and emptying into the Hudson River at Kingston.

To the west and nearly parallel with the Wallkill River is Shawangunk creek, one of its tributaries, and emptying into it near Gardiner. By building a tunnel from near Bloomingburg on the Shawangunk to near Mechanicstown, on another tributary of the Wallkill, about 47 square miles of the Shawangunk watershed may contribute to the Wallkill Reservoir, thereby making the total watershed available above Phillipsburg about 512 square miles.

The dam at Phillipsburg, with the water surface at elevation 410 feet above sea level, would have an available storage capacity of about 53,000,000,000 gallons. This would insure, with the watershed of 465 square miles, a yield of 254,000,000 gallons daily, if the water of the reservoir were drawn down only five feet.

If the water surface were raised to the elevation of 422 feet the reservoir would make about 219,000,000,000 gallons available, which with the combined watersheds of the Wallkill and Shawangunk, as above described, might yield possibly 460,000,000 gallons daily in the dry years.

The valley which is flooded by building this dam is uncommonly well adapted for a reservoir. Its bottom lands are flat between the hills, with very slight variations from a level plain, for a distance of over 20 miles along the river, and vary from one to five miles in width. The hills then rise from the plain quite abruptly all around.

The valley is clearly the bed of an ancient lake, which the proposed dam would in some respect reëstablish.

On the west and north sides the rock is principally of slate and limestone. On the east side the rock is for the most part granite and limestone. The valley is underlaid to some extent with limestone, which crops out at places, notably in some of the so-called islands.

The geological conditions of the watershed, therefore, point to a probability that the water would be harder than the Croton water.

Mr. George C. Whipple, Director Mt. Prospect Laboratory of the Brooklyn Water Department, states that while the waters of the Brooklyn supply, of the Croton supply and of the Hudson River above Poughkeepsie all vary considerably in hardness at different times, they are not very different as compared with one another, ranging in hardness from 25 to 56 parts per million, the higher figure being the upper limit for the Croton water. Whether the Wallkill water would be hard enough to affect it for steam producing and other purposes sufficiently to become a serious question we are at present not able to say.

The Wallkill River shows a rather small flow for its drainage area. This fact and the existence of calciferous sandstone underlying a large part of the reservoir, and of lime stone formation on other parts of the area, seem to indicate the probability of some loss of water. We are, therefore, of the opinion that the estimates of yield may be too liberal.

The large areas of muck and vegetal earth, sometimes of considerable depth and spread out over most of the bottom of this reservoir, unless removed, would have the tendency to discolor the water with a slight brownish hue which filtration does not always wholly remove.

The total rural population on the watershed is about 16,400, or 32 per square mile, according to the census of 1890, which is less than was given for 1880. The total population of the villages on the watershed, excluding Goshen and Middletown, whose sewage would be diverted below the dam by outfall sewers, and the villages around the edge of the reservoir, whose sewage would be purified, is about 5,000.

Several railroads would require relocating around the proposed reservoir.

The construction of the reservoir will reduce the flow of the river below the dam, and consequently, also, the water powers.

The most important developed power is at Walden, where about 500 H. P. is available at low water flow. In the estimates of cost liberal figures have been used to compensate for the destruction of this and the other water powers on the river. No water powers are affected in the State of New Jersey.

The filters would be located below the dam, and the water would flow from the reservoir to the filters. After passing through these it would flow to New York in an aqueduct leading to a new covered reservoir to be built near the City line. The description given of the filter plants of the Poughkeepsie project will serve in general also for the Wallkill filters.

The aqueduct line crosses the Hudson River just above the State line, between New York and New Jersey. It is largely in tunnel.

Although several railroads would require relocating, their business would not be interfered with in New Jersey, as the construction of roads across the reservoir is provided for. The communication from one side to the other would be as convenient as it is now, and the railroads could readily be rebuilt on the new location before the reservoir is filled.

The construction of this work would offer no serious difficulties, and barring legal difficulties, should not require more than five years' time.

As a portion of the land that would be submerged by the reservoir lies in the State of New Jersey, much difficulty may be experienced and much time expended in securing the necessary property, indicating a serious complication connected with this project.

In view of these facts, we have deemed it necessary to increase the contingent expenses above the amount which Mr. Fuertes assumes in his report, by $5,000,000, but lacking the power of condemnation, it may not be possible to acquire all of the New Jersey lands, and a part would be of no use.

To furnish 250,000,000 gallons daily, therefore, requires an investment of $36,827,000, and an annual expense for operation, maintenance and interest of $1,652,000. To furnish the entire yield of the watershed, assuming it to be 460,000,000 gallons, would require an investment of $62,534,000, and an annual expenditure of $2,778,000. The cost per million gallons, delivered, would be $18.10 and $16.54 respectively.

Hudson River Above Salt Water Influence.

The Hudson River may be used for obtaining an additional supply of water for New York City, if the water is taken from the river above the effects of salt water, which is above Poughkeepsie, and if it is filtered before being delivered into the city reservoirs.

The minimum flow of the river at Poughkeepsie is about 1,500,000,000 gallons daily. In the years from 1879 to 1884, when the rainfall was much below the normal and the flow of the river at times was near the minimum above mentioned, the water at Poughkeepsie was somewhat brackish; and on another occasion this condition is said to have existed at Kingston. It is clear that if 500,000,000 gallons of water are taken daily from the river near Poughkeepsie, the tendency of the salt water to flow up the river is still further increased. During such years of low flow the Poughkeepsie water supply, which is now derived from the river, would be objectionable for use, as well as the water proposed to be furnished for the City of New York.

In 1871 the U. S. Coast and Geodetic Survey made observations between New York and Poughkeepsie regarding the under run of the salt water. Through the kindness of the Superintendent, Mr. Henry S. Pritchett, we have received the following information from Mr. H. L. Marindin, who conducted the tests.

"The influx of sea water by the flood stream was studied by parties in my charge in 1871, by observing the changes in the density of the water at surface and near the bottom, at the times of slacks (turning of current from ebb to flood and flood to ebb); 12 stations were thus occupied, about 5 miles apart.

"From knowledge gained while making the observations, and an analysis of the results shown in the . . . table, I am of the opinion that traces of diluted sea water can be found, near the bottom of channel, as far as Carthage, 70 miles above Sandy Hook, but that the surface water is practically fresh above Teller's Point."

The results are exhibited in the subjoined tabular statement:

Specific Gravities of Water in the Hudson River At and Below the Surface, Reduced to a Temperature of 60 Degrees Fahrenheit, September, 1871.

Distance from Sandy Hook.	Station.	End of Flood Current.			End of Ebb Current.		
		Surface.	Below		Surface.	Below	
		Specific Gravity.	Depth.	Specific Gravity.	Specific Gravity.	Depth.	Specific Gravity
Nautical Miles.			Feet.			Feet.	
17⅛	Off Twentieth St........	1.0198	57	1.0206	1.0141*	53	1.0181
34¼	Off Dobb's Ferry........	1.0024	30	1.0114	1.0013	30	1.0022
38¼	Off Tarrytown	1.0021	30	1.0089	1.0016	30	1.0076
42½	Off Teller's Point........	1.0011	30	1.0087	1.0013	30	1.0087
49½	Off Verplanck's Point...	1.0012	30	1.0034	1.0014	30	1.0014
53¼	Off Iona Island..........	1.0017	30	1.0037	1.0012	30	1.0012
56¾	Off Denning's Landing..	1.0016	—	1.0028	1.0012	—	1.0021
61	Off Cold Spring..........	1.0015	30	1.0026	1.0010	—	——
65	Off New Windsor........	——	—	——	1.0006	—	——
70¼	Off Carthage	1.0003	48	1.0016	1.0006	48	1.0012
75	Off Barnegat	1.0006	60	1.0006	1.0006	60	1.0006
79¼	Off Poughkeepsie	1.0007	48	1.0007	1.0006	48	1.0005

* 1872.

To ascertain the relation of this under run to the discharge of the river, we requested Mr. Fuertes, from data furnished by Mr. Rafter, to compute the probable flow of the river at the time of Mr. Marindin's observations. This flow he finds to be about 2,900,000,000 gallons per day. It is not until the minimum flow becomes less than 2,000,000,000 gallons that brackish water may reach Poughkeepsie. The lowest known flow, as above stated, is 1,500,000,000 gallons. Therefore, an artificial increase of this lowest flow to the extent of at least 500,000,000 gallons daily, plus the quantity withdrawn from the river for the City's use, should prevent brackish water from reaching Poughkeepsie.

This can be done by building a system of reservoirs on the tributary streams in the Adirondack Mountains sufficient in capacity to store the flood waters from heavy rains. These waters can afterwards be turned into the river when dry weather approaches.

Mr. George W. Rafter, in his report to us, shows that it is quite feasible to increase the present minimum flow at Poughkeepsie, by the addition of 3,200,000,000 gallons daily from such storage reservoirs, to about 4,700,000,000 gallons per day, and no great difficulties stand in the way of a still larger increase.

This would have the practical effect of forcing the brackish water much further down stream than it is now, should even 1,500,000,000 gallons be withdrawn daily from the river at that point.

The addition of this large quantity of water would in dry weather slightly raise the river level from Troy to below Poughkeepsie and thus be an advantage to navigation. On the upper Hudson River it would greatly increase the present water power. The principal water powers are below Hadley, from which point to tidewater there is a fall of 575 feet. With the increased flow from storage reservoirs above Hadley the available power could be increased by 150,000 horse-power above that which is now available at low water. This increased power would furnish opportunity for large investments of capital for manufacturing purposes, and would add to the population of this State.

The project for securing the additional water from the Hudson River comprises, therefore: 1st, a large increase of the flow of the river in dry weather, between Hadley and the intake; 2nd, an intake for the water as far above Poughkeepsie as will absolutely prevent the pumping of brackish water; 3rd, a pumping plant to lift it to filter beds on sufficiently high lands on the east side of the river, and 4th, aqueducts to carry it to covered reservoirs near the city line, from where it is discharged into the distribution system of the city.

Estimates of cost have been made for a duplicate system; one delivering the water at an elevation of 260 feet above sea level, and the other at 131.5 feet above sea level, or sufficient to discharge into the present reservoirs.

The Hudson River water offers no difficulty in the way of purification. By passing it through properly constructed filter beds, such as have been used extensively in Europe for the same purpose, and now used in Poughkeepsie for its own supply derived from the Hudson, the water can be made clear and healthful. The City of Albany has quite recently put such a plant in service, and its installation resulted in immediately and very materially reducing the typhoid fever death rate of that city.

In September, 1899, a board of water experts, of the City of Philadelphia, after an extended and thorough examination, recommended that city to filter the water of the Schuylkill and Delaware Rivers, instead of seeking a new supply of water from the Blue Ridge. The Schuylkill water is much more polluted than the Hudson water. The waters of the Allegheny and Ohio Rivers, likewise inferior to that of the Hudson, are to be filtered for the cities of Pittsburgh, Cincinnati and Louisville. The water of the Elbe, in Germany, supplying Hamburg and Altona; of the Thames, in England, supplying London, and the waters supplied to numerous other large cities in different parts of the world, are all more or less polluted by the discharge of sewage. In each of these cases, where the water is now being properly filtered, the death rate from water-borne diseases is very low, and a marked decrease immediately followed the introduction of filters.

The cost of construction, operation and maintenance of the plant are given in the following table:

For a supply of 250,000,000 gallons daily, filtered, delivered 260 feet above sea level at the city line:

Cost of construction..............................	$39,725,000.00
Annual cost of interest, operation and maintenance	3,088,000.00
Cost of water, per million gallons, delivered at city line	33.88

For a supply of 250,000,000 gallons daily, filtered, delivered 131.5 feet above sea level at the city line:

Cost of construction..............................	$36,880,000.00
Annual cost of interest, operation and maintenance	2,585,000.00
Cost of water, per million gallons, delivered at city line	28.33

For a supply of 500,000,000 gallons daily, filtered, to be delivered at the city line, half at elevation 260 feet and half at elevation 131.5 feet above sea level:

Cost of construction..............................	$72,374,000.00
Annual cost of interest, operation and maintenance	5,546,000.00
Cost of water, per million gallons, delivered at city line	30.39

Since it would not be necessary, at the outset, to build the filters and pumping plant for the full capacity, but rather for much smaller quantities, to be extended as necessity demanded, the above estimates of cost of construction and operation indicate an expense greater than would actually be required, by reason of deferred payments for a part of the works.

As this project should also be credited with largely increasing the water power of the upper Hudson River, to the extent of perhaps 150,000 horse-power, which at $10 would represent a revenue of $1,500,000 per annum, we might reduce the cost given above for furnishing the water at the city line by about one-quarter of the amount.

Inasmuch as the addition of so large a quantity of water during the dry season will increase the depth of the channel for some distance below Troy, the navigation interests will also be benefited by the project.

It might still be added that if the enlargement of the Erie Canal was so arranged that the canal could be fed throughout from Lake Erie, a still further increased flow in the Hudson River could be obtained.

The chief advantages of this Hudson River project are that it furnishes:

1st. The largest available supply of water short of the Great Lakes.

2nd. A water, practically as soft as the Croton supply, and the purity of which can be controlled by filtration.

3rd. A supply, capable of being gradually increased with the growth of the city to the extent of over 1,500,000,000 gallons daily.

4th. The incidental creation of a large water power in the upper Hudson River valley.

Streams in the Catskill Mountains.

Mountain streams are to many persons the most attractive source for a city's water supply. The Catskills, with their limpid brooks and a possibility of bringing their water into the houses of New York City, have, therefore, been frequently mentioned as the best future source.

To make a study of this source we have availed ourselves of existing maps, have had special surveys made of doubtful features and a careful examination of all the essential points. On Esopus Creek and its tributaries eight sites have been chosen by Mr. Fuertes for storage reservoirs. The necessary dams would be from 60 to 95 feet in height and from 500 to 1,670 feet in length. The available capacities of the reservoirs formed by the construction of the dams would be about 27,210,000,000 gallons. The available daily yield from all the reservoirs in dry years he computes at about 150,000,000 gallons.

On Schoharie Creek, also, eight reservoir sites have been examined. These have an aggregate water surface of 5.75 square miles, and may impound, for use in equalizing stream flow, 39,530,000,000 gallons of water. The dams range from 50 to 110 feet in height and from 710 to 1,840 feet in length. The yield from all the reservoirs might be about 200,000,000 gallons daily in dry years.

Catskill Creek Mr. Fuertes depends upon to furnish about 110,000,000 gallons of water per day, by constructing five reservoirs in the main creek valley. The dams would range from 60 to 100 feet in height and from 620 to 1,600 feet in length. The reservoirs would have a combined area of water surface of 3.08 square miles, when full, and would afford about 18,550,000,000 gallons of available storage.

The watershed of Catskill Creek, above the first dam, is 192 square miles. The Esopus watershed, above Olive, is about 245.5 square miles, and the Schoharie watershed, above Gilboa, is 305.4 square miles.

The building of the reservoirs would require the removal, in part or in whole, of several small villages and the reconstruction of several miles of railroads. The sewage from the villages near the reservoirs or tributary streams would require purification or some satisfactory disposal, to prevent the pollution of the water; this has been provided for in the estimates of cost.

A serious element of danger in the use of the natural waters from the streams in the Catskill Mountains lies in the possibility of pollution from isolated houses and hotels, in which probably over a hundred thousand tourists and summer boarders reside during the summer months. Many of these are present on account of their suffering from disease. The only effective protection of the proposed water supply that can be secured against such pollution is a filtration of the water before it supplies the city, and we have allowed for it.

These watersheds have not, as a rule, a very large amount of timbered land, as often supposed. Much of the land has been cleared for cultivation and is used for farming purposes. The principal villages in the watersheds are all in the main valleys of the larger streams.

On Catskill and Esopus creeks there are several water-powers that would be destroyed by the diversion of the waters, and in the estimates of cost a liberal allowance has been made for them. On the Schoharie Creek the abstraction of the water would not only destroy the powers on that stream, but would reduce the power now available on the Mohawk River. The powers on the Schoharie would have to be purchased, but the damages along the Mohawk could be adjusted by a money compensation.

It is proposed to conduct the water to New York in an aqueduct located on the east side of Hudson River to a short distance above Peekskill, where it crosses under the river in a tunnel and then runs along the high ridge parallel with the river, to Kingston, crossing Rondout and Esopus creeks in pipes to a point in the hills about three miles northwest of Kingston; here the aqueduct divides, one branch going to the Olive reservoir on Esopus Creek, and the other to the reservoir near East Durham, on Catskill Creek. The waters of Schoharie Creek would have to be diverted into the valley of Esopus Creek, through a tunnel ending near Shandaken.

The estimates of cost for three dams are based on masonry construction, and for eighteen dams on earth or rock fill with core walls; fifteen dams are over 80 feet high. As the geological formation of several of the valleys indicates a considerable depth of drift, it may not be practicable in the suggested reservoirs to retain so large a quantity of water as Mr. Fuertes has assumed. A larger number of dams of less height might possibly be required. Even then it seems questionable whether as much as 260,000,000 gallons could daily be secured from the Esopus and Catskill creeks.

Regarding the Catskill project, we, therefore, conclude that the estimates are probably too liberal as regards the quantity of water to be obtained. They are as follows:

For Daily Supply of 250,000,000 Gallons, Filtered.

Cost of construction	$59,653,000.00
Annual cost of interest, operation and maintenance	2,498,000.00
Cost of water, per million gallons, delivered	27.35

For a Daily Supply of 460,000,000 Gallons, Filtered.

Cost of construction	$118,881.000.00
Annual cost of interest, operation and maintenance	4,838,900.00
Cost of water, per million gallons, delivered	28.82

The Adirondack Mountains.

The Adirondack Mountains have been mentioned even oftener than the Catskills as a favorite locality towards which the New Yorker has turned his hopes and expectations for a future water supply. The small population, the almost complete absence of farming with attendant manuring of fields and muddy water in the streams, has made this territory exceedingly attractive.

In order, in the short time at our disposal, to present some tangible facts, sufficient to judge of the practical merits of this source, we asked Mr. George W. Rafter, M. Am. Soc. C. E., who had previously investigated the hydraulic aspects of the Adirondacks, to make us a special report on the subject.

We have examined into the cost of bringing only 500,000,000 gallons daily to the city, but a further development of the watershed would readily yield over 1,000,000,000 gallons per day.

The least summer flow of the Hudson River, above the Mohawk, is insufficient to supply New York. It would be necessary therefore to equalize the seasonal flows by the construction of storage reservoirs to retain the water of the wet months and of floods, with which to increase the flow during droughts.

We have examined two available projects, one taking the water at a dam at the lower end of Schroon Lake; the other taking the water at Hadley, 29 miles below.

The Schroon watershed has an area of 518 square miles. It has a population only of about 14 per square mile, has but a small area of swampy ground and only about 15 to 18 per cent. of the area is cleared of timber. Granite rocks prevail, with large areas of fine sand. The topography is rugged and contains the highest mountains of the State.

The water in its natural condition is, therefore, of a high order of purity and softness, and excellently suited for a municipal water supply.

Mr. Rafter presents tables which assume that if this reservoir had been in existence since 1888 it would have yielded water to the extent of 18 inches of rainfall per annum upon the watershed—a rather high figure. In a former report for other reservoirs of the same region, he mentions a run off of only 13.5 inches. Assuming a yield of only 13.5 inches of rainfall, the reservoir would supply only 421,000,000 gallons per day. A further increase of supply could, however, when demanded, be supplied, from neighboring regions, without meeting physical difficulties.

The dam for the reservoir is located at Tumblehead Falls, 14 miles above the mouth of Schroon River and about 29 miles above Hadley, on the Hudson. The reservoir itself would be an enlargement of Schroon Lake, and, assuming a supply of 500,000,000 gallons per day, would have to cover 16,900 acres or over 26 square miles, and contain 162,248,000,000 gallons of water.

Below the dam the village of Warrensburg is situated, and several water powers have been developed on the river. The water surface at Tumblehead Falls is 780 feet and at the mouth of Schroon River it is 620 feet above tide, giving a fall of 160 feet, of which only 39 feet are developed.

Mr. Rafter suggests preserving these powers and not taking the water until at a point one mile above the mouth of Schroon River. We have thought it well, however, in our estimate of cost, to extend the aqueduct to Tumblehead Falls, because the mills utilizing so large a water power and being located on the stream, might endanger the water's purity.

In estimating the cost we have included an allowance for cleaning, stripping and giving the reservoir all necessary sanitary protection, where the water is to be used for potable purposes. Experience has shown that an accumulation of vegetable matter at the bottom of a reservoir not only tends to discolor but also to give an unpleasant odor and taste to the water. The large reservoirs for the new Metropolitan supply of Boston have thus been treated.

In valuing the water powers on the Hudson River we are confronted by two methods of procedure. One, the European method, which supplies the mills throughout the year, uniformly, with an amount of water which they can and ordinarily do utilize for power purposes. This may be estimated at about 1/3 of the annual flow of the stream. The other, a method frequently applied in the United States, is to purchase the entire power outright at a fair valuation. Our Legal Committee thinks the latter is the method to be adopted in this State. Mr. Rafter has considered both, and in his estimate of cost finds that to furnish compensating power, i. e.: to compensate in kind instead of in money, would cost about $1,000,000, while the capitalized 5 per cent. value of the net horse-power actually developed in 1899, namely, 14,695 horse-power, becomes $4,761,180.

An outright purchase of all the power would leave the city in possession of what is above the amount needed for the city's purpose. A re-sale or rent based upon the new conditions could, therefore, return a large part of the purchase money.

Adjacent to the location suggested for the aqueduct from the Adirondacks to New York City, are a number of large towns, which might be supplied with water on the way. Nearly all of the towns and cities now have municipal supplies, which they might not wish to abandon; but admitting that they would all take a supply from the aqueduct, it could serve on its way to New York about 400,000 people.

Allowing an average per capita consumption in these cities and towns of 100 gallons per day, the entire amount required would be about 40,000,000 gallons a day.

While a number of cities, including Albany, would probably not wish to change their present supply, yet it might be a benefit to many others to be supplied from the aqueduct with mountain water.

The aqueduct line bringing the water from Schroon Lake to New York is a long one, measuring 203 miles, and is approximately located on Plate I.

In this case as in others, for 500,000,000 gallons, we have proposed two aqueducts, each delivering 250,000,000 gallons daily. The estimated cost is as follows:

For a Supply of 250,000,000 Gallons Daily, Delivered at an Elevation of 310 Feet Above Sea Level at the City Line.

Cost of construction	$71,727,000.00
Annual cost of interest, operation and maintenance	2,727,000.00
Cost of water, per million gallons, delivered at City Line	30.00

For a Supply of 500,000,000 Gallons Daily, Delivered at an Elevation of 310 Feet Above Sea Level at the City Line.

Cost of construction	$140,155,000.00
Annual cost of interest, operation and maintenance	5,337,900.00
Cost of water, per million gallons, delivered at City Line	29.25

The above described project has the merit of delivering a pure water not requiring to be filtered, by gravity in New York at an elevation of 310 feet above sea level. But its greatest yield will probably not exceed 500,000,000 gallons daily, and the first cost seems very large for a supply limited to that amount.

Hadley.

Fortunately this supply can be increased to 1,000,000,000 gallons daily or even more, by taking in the whole flowage of the Hudson and Sacondaga Rivers above a diversion dam near Hadley, 29 miles below the outlet of Schroon Lake.

As all the projects proposed would allow a gradual development, the Schroon Lake system should first be put in operation, and the Hadley dam be built later when required.

The site at Hadley makes available the whole drainage basin of the upper Hudson, including Schroon—an area of 4,500 square miles.

Its elevation, just below the mouth of the Sacondaga River, is 550 feet above sea level, enabling the water to be delivered by gravity in New York at an elevation of 310, with a fall of one foot per mile in the aqueduct 174 miles long.

Mr. Rafter's Table I. (p. 333) gives the maximum mean monthly discharge of Hudson at Mechanicsville during period of 11 years as 23,822 c. f. s. and the minimum mean monthly 1,393 c. f. s.

It would be impossible to take out 500,000,000 gallons daily = 775 c. f. s. without regulating the river.

Mr. Rafter states (p. 330) that a reservoir system with an available storage in the Adirondack Lakes of 50,720,000,000 cubic feet may be easily developed capable of maintaining a flow at Mechanicsville of 4,500 c. f. s. = 2,904,000,000 gallons.

It would seem feasible to take out at least 1,000,000,000 gallons daily from the river, and leave in it nearly double as much.

Both the water power of the upper river and the navigation of the lower river would be greatly improved thereby.

We consider that this water, but not that of Schroon Lake, would need to be filtered to remove the color and taste coming from swamps, and from sawdust and pulp mills.

It may be observed that for a supply as large as 1,000,000,000 gallons daily, it would probably cost less than filtering the water to buy that part of the watershed not now owned by the State and make it into a park whereby the purity of the supply could be maintained.

The cost of the two Adirondack projects will differ very little from each other, as the length of aqueducts saved by the Hadley project over that of Schroon Lake will counter-balance the cost of filtering plant.

We therefore assume the same figures for both, as given on page 90. But any supply from Hadley would have to be filtered at an extra cost of $3 per million gallons.

To Col. J. T. Fanning, M. Am. Soc. C. E., is due the credit of being the first to make detailed surveys and estimates for a project to supply New York with water from the Adirondack watershed. His first idea was to use Lake George as a storage reservoir, but finding that enough storage could be obtained from the smaller Adirondack lakes, he abandoned the Lake George plan in a second report. (November, 1884.)

Col. Fanning proposed to take the water from the North Hudson, by a diversion dam above Glens Falls, and carry it in an open conduit to New York, delivering it into the Croton reservoir. The elevation is sufficient, however, to deliver the water at a much higher level.

This open conduit was designed to be from 60 to 80 feet wide and from 15 to 18 feet deep, and was intended to pass nearly 1,400 million gallons daily. The sectional area provided for from 24 to 30 inches thickness of ice in winter, and this enlarged area took care of evaporation in summer.

The marked feature of this project was its great economy of first cost as compared with a closed aqueduct. The cost per million gallons of water delivered for 1,000 million gallons supply, might not exceed $20, which is less than that of any supply legally attainable. This project would of course require the filtering beds to be placed at the lower end near New York.

The objection to such a plan lies in its involving an open hillside canal for most of its length of nearly 200 miles, thus exposing the water to pollution, to injurious vegetable growth and to the liability of sudden interruption of service by washouts or other accidents, for all of which reasons the committee has not given detailed consideration to this plan.

Other Streams.

We have examined more or less in detail all of the available sources, beginning on Long Island, and extending east of the Hudson River as far north as Lake Champlain and then returning west of the Hudson River down to New Jersey. On the preceding pages we have described all of the most economical sources for supplying New York City with water of a suitable quality.

We shall now briefly mention the remaining sources and state the chief reasons for discarding them.

On the east side of the Hudson River between the Croton River and the Adirondack region, the streams are not available for our purpose, because they are either already appropriated, or have an insufficient supply, or do not offer satisfactory sites for storage reservoirs, or are too low to deliver water by gravity into city reservoirs, or are too expensive in development.

In brief, from all the small watersheds on the east side of the Hudson, excepting those involving the diversion of water flowing into other States, the available daily yield might not be over 150,000,000 gallons, and would require an aqueduct 150 miles long.

On the west side of the Hudson, between New Jersey and the Adirondack region, there are, besides the Wallkill and the Catskill streams, still fewer which offer any favorable features.

The only sources that are worth mentioning are: Lake George, Lake Champlain and the Great Lakes.

Lake George.

Lake George has been frequently proposed in connection with New York's water supply. The quality of its water, the apparently large quantity and its elevation have been its chief attractions. Yet even a hurried examination will dispel the two latter supposed advantages.

The quantity of water holds a direct relation to the rainfall and the area of the watershed. Mr. Rafter has made the necessary calculation for us, which indicates that this source cannot yield over 227,000,000 gallons per day, and probably much less.

The elevation of the lake is 323 feet above sea level, which is insufficient to deliver the water in New York at the required elevation, without pumping. The length of the aqueduct would be about 180 miles. Lake George water, therefore, cannot be brought to New York as cheaply as the Schroon or Hudson River water. To use Lake George as a storage reservoir, would require heavy payments for most of the property around it, because it would be entirely destroyed as a location for summer resorts.

The water level of the lake would rise and fall perhaps 20 feet, to equalize the flow into the aqueduct, and in the dry months of summer and autumn leave large areas of bottom lands exposed along the shores.

The great expense, the destruction of one of the most beautiful resorts in the country, the insufficient supply, and the possibility of getting more water equally good and at a less cost from a number of other sources, permanently rules out this source from serious consideration.

Lake Champlain.

Lake Champlain has also been urged as a source of supply for New York. But here there are still more serious objections in the way.

The water surface is only 101 feet above sea level; therefore 222 feet lower than Lake George. The water would require a lift of 400 feet to be delivered by gravity 300 feet above sea level in New York. Most serious of all, the diversion of a material quantity of water would be immediately felt in the outlet river from the lake, which passes into Canada to the St. Lawrence River, and is available for power purposes on the way. The diversion of Lake Champlain water is, therefore, impracticable.

The Great Lakes.

A supply from Lake Ontario, which is about 247 feet above sea level, would require an aqueduct over 300 miles long and require the water to be pumped nearly 400 feet if delivered at 300 feet above sea level in New York.

A supply of water from Lake Erie, which is about 580 feet above sea level could be obtained advantageously if the proposed Erie Canal enlargement were so located that the canal could be fed throughout from Lake Erie. Yet the canal as proposed could not deliver more than 230,000,000 gallons per day and this practically at tide level when reaching Troy.

The reports of Messrs. James H. Fuertes and George W. Rafter follow as appendices "D" and "E," respectively.

SALT-WATER SUPPLY FOR FIRE EXTINGUISHING AND OTHER PURPOSES.

SALT WATER SUPPLY: CONTENTS.

SALT WATER SUPPLY FOR FIRE EXTINGUISHING AND OTHER PURPOSES.

The use of river water for extinguishing fires would not result in a material saving of fresh water. The saving would result chiefly in a decreased loss from fires. There would be a saving of water now used for street sprinkling, but the great advantage would accrue from the increased cleanliness of the City, lowering the mortality and morbidity and increasing the attractiveness of the City.

The use of salt water for water-closets in large buildings and for other purposes, such as cooling, etc., is not practicable until fixed pumping plants are established. When salt water is supplied continuously and at a low cost it is probable that other economical uses will be found for it.

In the greater parts of the Boroughs of Bronx, Brooklyn, Queens and Richmond the salt water system must have fixed pumping plants, providing at once for all the possible uses, and in the aggregate their installation will save the City a material part of the future expenditure for additional water supply, and at the same time increase the health and comfort of its inhabitants.

The proposed use of salt water for fire service is not based so much on a hope of materially reducing the quantity of water used, stated as being only about 46,000,000 gallons per annum in Manhattan and the Bronx, as on a desire for an improved and more efficient fire service. But the use of salt water for sanitary purposes seems advisable, as sufficient water for thoroughly cleansing our streets in summer would draw too heavily on any fresh water supply.

Fire Extinguishing.

As set forth in Mr. Crowell's report hereto appended, of the nearly 17 miles of fire service mains laid in American cities about 16 miles are in Buffalo, Cleveland, Detroit and Miilwaukee, cities that draw on the Great Lakes for their supply of water for drinking as well as for fire-fighting. The mains, service pipes and house fixtures in those cities, as here, are not strong enough to withstand the high pressure desirable for fire-fighting; nor are the street mains large enough to supply the quantity of water that should be rapidly concentrated to promptly drown out a fire.

It will be seen by reference to the report that the smallest distribution pipes proposed have about double the capacity of those now in use, and that the water is to be supplied by the fireboats now owned by the City. The boats will have their present radius of effective action extended with the lengths of the pipes laid. This will more than double the value of the boats, because when depending on hose the efficiency falls very fast where a distance of a few hundred feet is exceeded.

Estimates of cost are given in detail for fire-pipe systems in the "Dry Goods District," *i. e.*, between Chambers, Canal, and Hudson streets and Broadway; also between Canal and Bleecker streets, from South Fifth avenue to Broadway; the area south of Chambers street; the tenement and factory district between East Broadway and Houston street, east of the Bowery, with and without fixed pumping plant; also the entire area south of Twenty-third street, including all of the above districts. In none of these cases will the cost of installation exceed the average annual loss by fires for the four years ending with 1897, while the annual cost of operation for the district south of Twenty-third street is estimated to be only 7.75 per cent. of the annual fire loss.

As stated in Mr. Crowell's report, the fire losses in Fire Department Districts 2 and 3, of which the Dry Goods District forms a part, average about $3,000 per acre annually, while the cost of installation is estimated at $1,100 per acre. For the whole area south of Twenty-third street the cost of installation is more nearly equal to the annual fire loss.

The system proposed would, as far as it might be extended, afford a supply of water at high pressure equivalent to the service of 15 fire engines.* By the aid of standpipes it would furnish streams from the tops of our highest buildings and would undoubtedly materially reduce the loss by fires, and hence, also, the annual cost of insurance, with the expense of conducting business in this City.

* This is the average effectiveness of our fireboats. By attaching the two largest boats it is possible to afford the equivalent to 45 fire engines.

The objection sometimes made to the use of sea water for extinguishing fires, that it injures merchandise, lacks indorsement from insurers. As 32 per cent. of the water thrown on fires is now drawn by the fireboats from our rivers without regard to sewer outlets and without complaint of damages, the objection is of no value. The only disadvantage of the system, aside from its first cost, seems to be the inconvenience of an additional line of pipes in our streets.

Sanitary Purposes.

For sanitary purposes the demands are different, as the water should be delivered at a lower pressure than for fire service, and particularly in hot weather it may be required continuously.

It is well known that the pavements of New York, except during and immediately after a shower, are never clean. As late as 1855 a headstone inscribed with appreciative lines to the memory of the then Street Cleaning Commissioner was erected in Union Square, at the end of a long, persistent windrow of dirt which had been scraped up with hoes. Since then the improvement in methods and results has been great and substantially continuous. But neither the unnameable filth exhibited on the pavements of the lower East Side nor the horse droppings that have been compressed on the pavements by passing wheels, can be removed until they are dried and thoroughly comminuted, or without the aid of water.

Either as a sodden layer on our pavements in damp weather or when blown about in dry weather, these excreta are dangerous to health. The prevalence of bacteria in air generally esteemed pure is shown by the fact that during a dust storm on Commonwealth avenue, Boston, Professor William T. Sedgwick, of the Massachusetts Institute of Technology, filtered out over 75,000 bacteria per gallon of air.

The results of the sanitary improvements made in this City, obtained through the efforts of our Health Board, cleaner streets, better pavements and a higher standard of living, are not generally appreciated. For the 10 years ending with 1876 the death-rate in Manhattan and Bronx averaged 28.5 per 1,000. In 1899 the rate was 19 per 1,000. If the average death-rate of the

10 years prior to 1876 had obtained during 1899, instead of less than 40,000 deaths there would have been over 60,000 deaths. As it is estimated that for every death in a community two persons are sick during a year, there would probably have been 40,000 more persons sick last year than was actually the case.

If, as is estimated by statisticians, the value of a human life in this country is taken at $1,000 and the loss by each invalid for a year is assumed as $200, we have a monetary saving for 1899, as compared with the average of the decade ending with 1876, of $28,000,000. The suffering, of course, cannot be estimated.

The City of New York can take pride in the fact that it has a larger proportion of its asphalt laid in streets bordered by tenement houses than any other city, and that no other locality has the streets inhabited by the poor more generally paved with impervious pavements than the Borough of Manhattan.

It would, therefore, not only be a matter tending to municipal self-respect, but also productive of sanitary and economic gain, if provisions could be made insuring the thorough and frequent washing of our streets. This would doubtless be accompanied by a salutary moral effect. The Board of Health declares in its report for 1896: "The cleanliness of the streets during the past year is an object lesson to the residents of the densely populated parts of the City, and more attention to the cleanliness of their apartments is the result." Few people will live in a house dirtier than the street on which it fronts.

A copious supply of water on the streets would further increase the comfort of our citizens and decrease death and sickness, by cooling the pavements and superincumbent air. A temperature of 124.5 degrees F. has been observed on asphalt pavements in this City, while 140 degrees F. has been reported in Washington. It is thought that a flush of water within the capacity of the fire hydrants proposed, lasting, say, 10 minutes, might reduce that temperature to 90, or even 80, degrees F. If this can be done, the danger of death by sunstroke would be nearly eliminated on the streets so treated. Although we have had 181 deaths in a single day and 671 in one week from sunstroke, very few occur until the maximum temperature has been for some days at least 90 degrees F.

The low conductivity of asphalt may require a longer applieation of water than mentioned above, but, as a shower in Washington reduced the temperature of the pavements 15 degrees, it seems that a liberal and long-continued application would be more effective.

In the area between East Broadway and Houston street, east of the Bowery, comprising the 10th, 13th and parts of the 11th and 17th Wards, the population is not only greater per acre than in any other locality, but the standard of living is thought to be lower than in any other American city.* The total paved area is 247,430 square yards, of which 164,550 yards, or two-thirds, is paved with asphalt, which now covers the wheelways of the most densely populated strets.

Mr. Crowell's estimate of cost shows that for a first expenditure of $326,700 and a yearly cost for operation and maintenance of the pumps and pipe system of about $32,000, in addition to the services of the Street Cleaning Department, all the streets in this district lying between East Broadway and Houston street, east of the Bowery, could be flushed to materially reduce the temperature, and throughout most of the year be kept in a state of nearly per-

* The relations of these wards to the rest of the Borough of Manhattan is shown by excerpts from reports of the Board of Health, based on the census of 1895 and the report of 1898, in the following table:

AREAS, POPULATION, ETC., IN THE BOROUGH OF MANHATTAN.

	Area in Acres.	1895. Population.	1895. Inhabitants Per Acre.	1898. Total Deaths.	1898. Deaths Under 5 Yrs. of Age.
Manhattan .	13,487.2	1,742,985	129.23	36,851	14,433
10th Ward .	109.0	70,168	643.80	1,071	529
13th Ward .	109.0	58,802	539.50	860	505
11th Ward .	213.0	86,722	407.10	1,487	751
17th Ward .	266.0	114,727	431.40	2,248	903
Total, 4 W'ds	697.0	201,449	474.03	5,668	2,688

It is computed from the above table that while the average inhabitant of the Borough of Manhattan has an area of 10 feet by 34 at his disposal, over 70,000 people in the tenth ward have only 10 feet by 7, and 200,000 in the four wards mentioned have an area of 10 feet by 9.2. These figures are for total areas, including parks, streets, houses, etc. It is further computed that while the percentage of infant mortality for the whole Borough was for 1898 39 per cent., in the four wards under consideration these deaths were 47.4 per cent. of the total.

fect cleanliness. By the same operation all the sewers of the district would be kept free from putrescible deposit and the area would be provided with an effective fire service. By taking the water from the above-mentioned district as proposed, from the point of Corlear's Hook, water of substantially equal purity to that used in the swimming bath of the Produce Exchange would be obtained. It is self-evident that no salt water should be taken from any point where it is not entirely free from sewage pollution.

Watering Macadam Pavements.

Of, approximately, 2,343 miles of streets now opened in the City of New York, 253 miles are paved with asphalt or vitrified brick, 710 with stone and 760 with macadam; 620 miles are unpaved. The cost of maintaining the present macadam surface and the large area yet to be laid, and the comfort of those who either live on or use the streets, will be greatly and favorably influenced by the City's ability to water these roads sufficiently to prevent their breaking up and becoming dusty.

The possibility of using salt water for this purpose not only offers relief from fears of a lack of supply, but as sea water is some three times as effective both in binding the surface of macadam and in laying dust, its use would result in a decided economy as compared with the use of fresh water.

Respectfully submitted,

THOMAS CURTIS CLARKE, *Chairman,*
Past Pres. Am. Soc. C. E.
RUDOLPH HERING, *Vice-Pres. Am. Soc. C. E.*
EDWARD P. NORTH, *M. Am. Soc. C. E.*
H. S. HAINES, *M. Am. Soc. C. E.*
D. McN. STAUFFER, *M. Am. Soc. C. E.*
H. G. PROUT, *M. Am. Soc. C. E.*
E. E. OLCOTT, *M. Am. Soc. C. E.*
HENRY R. TOWNE, *Past Pres. Am. Soc. Mech. Engrs.*
D. LE ROY DRESSER, *C. E.*
R. R. BOWKER, *Esq.*
Engineering Committee.

NEW YORK, June 15, 1900.

APPENDIX A.

REPORT ON

THE HISTORY, CONDITION AND NEEDS OF THE NEW YORK CITY WATER SUPPLY AND RESTRICTION OF WASTE OF WATER.

BY

J. JAMES R. CROES,

M. Am. Soc. C E., M. Inst. C. E.

CONTENTS OF APPENDIX A.

LIST OF PLATES.

THE HISTORY, CONDITION AND NEEDS OF THE NEW YORK CITY WATER SUPPLY AND RESTRICTION OF WASTE OF WATER.

By J. James R. Croes, C. E.

To the Engineering Committee of the Merchants' Association of New York, Thomas C. Clarke, Past Pres. Am. Soc. C. E., Chairman:

Gentlemen:

I have the honor to submit, in compliance with your request, the result of my investigations on the history, condition and needs of the New York City water supply and restriction of waste of water:

INTRODUCTORY.

The City of New York comprises a territory of 196,800 acres area on the east side of the Hudson River and its outlets to the ocean; 35 miles long, 7 miles wide at its northern boundary, widening to 15 miles at the New York City Hall, and then tapering to a point at the south end of Staten Island. Deep tidal channels, studded with islands, intersect it, dividing it into two large islands and two sections of mainland, to which there is a deep-water frontage of 120 miles, of which 40 miles are available for wharfage of sea-going vessels; 15 miles on which the waves of the ocean break, giving opportunity for resorts for popular recreation, and 20 miles, looking out upon the Lower Bay, guarded from the Atlantic's swells by the long, low spit of Sandy Hook, suitable for surburban residences. (Plate No. 1.)

Topographically, this territory is generally less than 100 feet above the sea-level. Along the upper third of the western front a ridge of 150 feet in height runs parallel to the Hudson River. From the centre of the westerly front another ridge runs off in a northeasterly direction on Long Island, and on Staten Island, in the lower third, another ridge, a little east of north, rises to 413 feet above the sea, the highest elevation in the City. The whole area, more than 100 feet above tide-level, is 30,000 acres. (Plate No. II.).

In the entire area of 196,800 acres there is a population of about 3,600,000, occupying 250,000 buildings on 2,712 miles of streets. The plans for the complete laying out of the territory, which have been prepared by the Topographical Bureau of the Board of Public Improvements, anticipate that there will in the future be 3,356 miles of streets within the City limits.

The population of the City is increasing at the rate of about 3 per cent. annually, and the problem to be now considered is how the present population, and its increment during the next half-century can be best supplied with water for domestic and business needs.

The present supply is derived from four general sources:

(1) The watershed of the Croton River, 33 miles north of the City.
(2) The watershed of the Bronx and Byram rivers, 15 miles north of the City.
(3) The watershed of a series of streams on the southern shore of Long Island, east of the City.
(4) The ground-water which is found underlying a stratum of clay on Long Island and on Staten Island.

The present condition is the product of one hundred years of progress.

I.

THE MANHATTAN WATER SYSTEM.

I.—Summary of History, Management, Etc.

In 1799, the population of Manhattan being 60,000, the City subscribed for two thousand shares of the stock of The Manhattan Company, a corporation organized for banking and supplying water. This company constructed a well, 25 feet in diameter and 30 feet deep, in Centre street, between Reade and Duane streets, and pumped the water to a tank on Chambers street, from which it was distributed through pipes of bored logs. By 1823 the population had increased to 150,000, and the company pumped daily 691,200 gallons, furnishing a supply to 2,000 houses and several manufactories.

In 1830 the City constructed a well at Thirteenth street, near Broadway, 16 feet in diameter and 112 feet deep, 97 feet being through rock. At 100 feet below the surface two lateral galleries were tunneled out from the main well, each 75 feet long. This well furnished 10,400 gallons a day of very hard water, which was conveyed in cast iron pipes down Third avenue and the Bowery to William street, with branches in the cross-streets. The Manhattan Company also sank a well at Broadway and Bleecker street, 442 feet deep, through rock, which yielded 44,000 gallons a day. In 1834 the City drilled down 100 feet in the Thirteenth street well, increasing the supply from this source to 21,000 gallons a day; and, about the same time, a well was dug near Jefferson Market, 30 feet deep, from which some water was derived. The supply of water from these various sources was so limited that 600 hogsheads of water were brought in daily from wells in the country, and sold at an average price of $1.25; and 415 hogsheads of water were daily imported from wells in Brooklyn, to supply shipping.

The inadequacy of the supply, from both The Manhattan Company and the Municipal Fire Service, led the Common Council to have examinations made for the introduction of water from other sources, and on March 11, 1835, a plan for procuring water from the Croton River was adopted by the Common Council, and afterwards ratified by the popular vote of 17,330 to 5,963. The work of construction was begun at once, and water was introduced into the City through the Croton Aqueduct on June 27, 1842, the population of the City being then about 375,000. The Aqueduct then constructed is still available for use, and its carrying capacity, after 57 years of service, is 90 million gallons per day.

By the year 1875 the consumption of water in New York City had so nearly approached the limit of capacity of delivery of the Aqueduct that it was necessary to take steps for increasing the supply. The discussions and examinations looking towards this end occupied eight years, and it was not until 1883 that the Legislature created an independent Aqueduct Commission to construct a new Aqueduct and additional storage reservoirs. The plans were matured, and work was begun on December 30, 1884, on the new Aqueduct, which has a capacity of delivery of 290 million gallons a day, and which began the delivery of water to New York in June, 1890.

The Aqueduct Commission was reorganized in 1891 and has been engaged in constructing storage reservoirs. At present they have one in progress at the upper terminus of the Aqueduct and one at Jerome Park, in Bronx Borough. Their official existence will terminate when these reservoirs are finished; and when they are completed, which will probably be in 1903, the entire practicable yield of the Croton Watershed will be available for use in New York City.

The duties of the Commission are confined to the construction of new works.

Management.

The management of constructed works and the distribution of the water to the citizens has always been under a separate organization.

For seven years after the introduction of water in 1842, the management was vested in a Commission appointed by the Common Council.

In 1849 the Croton Aqueduct Board was instituted, consisting of three members, one of whom was required to be a civil engineer. For twenty-one years this organization, with Alfred W. Craven, C. E., as its engineering member, succeeded by General George S. Greene, C. E., conducted the affairs of the Water Department.

The Charter of 1870 gave the duties of this Board to the Commissioner of Public Works. This organization controlled the water distribution for twenty-seven years. The first Commissioner was William M. Tweed. Of his eleven successors three have been Civil Engineers of high standing in their profession. The others have been selected rather for their efficiency as business managers, than as possessing any technical knowledge. The Chief Engineer is appointed by the Commissioner, and holds office at his pleasure. Since 1884 this position has been held by Mr. George W. Birdsall, who has been connected with the Department since 1870.

By the new Charter, which took effect January 1, 1898, the control and management of the water supply is vested in a Commissioner of Water Supply, appointed by the Mayor. The position is now held by Mr. William Dalton.

II.—Development of the Croton Watershed.

For twenty years after the introduction of the Croton Water Supply the natural fluctuating flow of the Croton River supplied the needs of the City. It became evident at an early day, however, that provision would have to be made for storing up the water of floods, to be used in the periods of small flow, and in 1857 the Croton Aqueduct Board, finding that more detailed information than they then possessed was necessary to enable provision to be made for the future supply of the City, caused a topographical survey to be made of the entire Croton Watershed, and sites for storage reservoirs selected.

By 1865 the use of water had so increased that the minimum daily flow of the Croton River was insufficient to supply the demand in dry seasons, and the construction of the first Storage Reservoir was begun at Boyd's Corners, in Putnam County. It was finished in 1872. Before its completion, however, it was found necessary to secure the right to draw the water of several natural lakes to supply the deficit of water in the drought of 1870. Since that time five other Storage Reservoirs have been built, another is now building, and several other natural lakes have been made available.

These reservoirs are distributed as follows, with reference to a plane of 400 feet elevation above tide-water:

Storage Reservoirs Croton System.

Between 150 and 400 Feet Elevation.

	Elevation.	Watershed. Sq. Miles.	Capacity. Mil. Gals.
Cornell Dam (now constructing)	196	180.95	32,000
Titicus	325	22.80	7,167
Middle Branch	380	20.51	4,004
Total	——	224.26	43,171

Storage Reservoirs Above 400 Feet Elevation.

	Elevation.	Watershed. Sq. Miles.	Capacity. Mil. Gals.
Sodom and Bog Brook	415	76.92	9,028
Muscoot	400	18.32	7,000
Carmel	503	19.51	9,000
Boyd's Corners	590	21.43	2,727
Natural Lakes (included in other watersheds)	—	——	2,810
Total	—	136.18	30,565
Aggregate	—	360.44	73,736

This division into two planes of supply is made in view of the possibility of its becoming desirable at some time to utilize a part of the water drawn from the Croton River for a high-service supply by gravity by constructing an independent conduit from Sodom Dam to Manhattan.

There is already a partial gravity supply at a higher level. Pending the discussions preliminary to the construction of the new Aqueduct from the Croton River, the Commissioner of Public Works in 1884 introduced from the Bronx and Byram Rivers, by a pipe fifteen miles long, a supply of water which is received in a reservoir at Williamsbridge, in Bronx Borough, at an elevation of 190 feet above tide. The watershed from which this supply is drawn may be safely estimated to yield an average of 17 million gallons a day. In most years it can furnish a supply of 20 million gallons a day.

The Croton Aqueducts deliver their water into the reservoirs in Central Park at an elevation of 120 feet above tide. If the Croton River can furnish more than enough water to supply the area lying below this level, it becomes a question whether it would be cheaper to pump the surplus to the Bronx supply level of 190 feet, or bring it down by an independent conduit from the Sodom Reservoir.

Areas of Maximum and Minimum Pressure.

As before stated, the Croton Aqueducts deliver the water into reservoirs in the Central Park at an elevation of 120 feet above tide-level. This elevation of the aqueducts and reservoirs determines the head, or pressure, under which water can be delivered to so much of the City of New York as can utilize the full capacity of the yield of the Croton River watershed without pumping. The least height above the surface to which the water supply from the reservoirs should rise, in order to furnish a supply to the ordinary New York residence, is about 60 feet; consequently, the plane of 60 feet elevation above tide-level is the extreme surface elevation on which houses can be supplied from the 120 feet elevation of the Croton Aqueduct and the reservoirs in Central Park. The delivery of the requisite amount to supply all parts of the City at this elevation is a question of the number and size of the distribution mains alone. The portion of the Borough of Manhattan which can be thus supplied is all of the Borough below Thirty-fourth street; the West side, between Thirty-fourth street and Sixth avenue, and the Hudson River at Seventy-second street; the East side, east of Third avenue, from Thirty-fourth street to One Hundredth street, and north of that to the Harlem River between Eighth avenue and the East River. There is also an area of low ground on the Harlem River and Spuyten Duyvil Creek. In the Borough of Bronx there is an extended area capable of being supplied from the Croton Reservoirs; making a total area of 25,000 acres in the Boroughs of Manhattan and Bronx which can be supplied with Croton water at a pressure sufficient for all ordinary domestic uses without its being necessary to pump the water, except to the upper stories of buildings over 60 feet in height. (See Map II.)

Into this area of 25,000 acres a supply of water at a greater elevation, creating a greater pressure in the pipes, cannot be introduced without shutting off entirely from the district so supplied the Croton water supply; and the Croton water supply itself is not available for the use of buildings situated on the 14,000 acres in Manhattan and Bronx Boroughs which lie above the elevation of 60 feet above tide-level, without being pumped to a higher level than the reservoirs in Central Park.

Prior to the year 1865 the consumption of water in the City was not sufficient to cause any serious inconvenience to the residents of any portion of the City less than 100 feet above tide-level, and the population was so small above that level that works for high-service supply were not needed. In 1865, however, it was necessary to supply the higher levels, and a pumping station was erected at High Bridge, where the water was taken from the Aqueduct and pumped into a reservoir at an elevation of 216 feet, and a tower at 324 feet above tide-level. The reservoir was put in use in 1870, and the tower in 1872. The greatly increased demand for water in the lower portion of the City continuing to reduce the available head above Thirty-fourth street, a second high-service pumping station was constructed at Ninety-eighth street in 1880; and in 1895 a third high-service pumping station was constructed north of High Bridge. About 18 per cent. of the water furnished by the Croton River is now pumped to supply the territory lying above the elevation of 65 feet above tide-level, which is about one-third of the entire area of the Borough.

III:—Capacity of the Croton Watershed.

The safe capacity of supply of the Croton Watershed is estimated by Mr. John R. Freeman, C.E., in his recent report to the Comptroller, to be 275 million gallons per day.

The thorough scientific analysis of the gaugings of the flow of the Croton River which Mr. Freeman has made, the results of which are so clearly set forth in his tables and diagrams, appears to me to establish the correctness of the conclusion he has reached, from the point of view which he has assumed, and which I may say is that which I have myself taken in the discussion of the projects for water supply for many years. I have assumed a supply of 280 million gallons a day. The accompanying Diagram III shows what the effect of such a draft would have been during the last thirty years. Only twice would the period of depletion of the storage reservoirs have exceeded two years.

The basis of this treatment of the subject is, that to ensure the sanitary purity of a supply of water from a natural stream of largely fluctuating flow, any period of depletion of the storage reservoirs, which are necessary to equalize the variable yield, must not exceed two years. No greater interval of time than this should be allowed to occur between the successive filling up and overflow of such reservoirs, be they natural lakes or artificial basins. If the average daily draught from the watershed is so great that the storage basins are depleted for several years in succession, and no overflow can occur, the sanitary quality of the water is likely to be seriously impaired by the lack of change and circulation, and the alternate flooding and exposure to air and sunlight of large areas of pond bottom for several years together.

Even shorter periods of alternate exposure, promoting vegetable growths on the bared bottom, and flooding, producing decomposition of such growths, cause ill effects and bad water for a time, and consequent bad tastes and odors, if the water must be delivered to the consumers without treatment.

In the advance of sanitary science in recent years it has been proved, however, that such ill effects can be entirely overcome by sand filtration of the water immediately before use, so long as the water does not contain unwholesome mineral constituents.

If the water from the Croton River can be properly filtered before delivery to the consumer, and be guarded from exposure to the air until such delivery, the safe capacity of the yield of the Croton watershed can be increased to 350 million gallons a day, provided that sufficient storage reservoirs can be constructed. It will be seen by the diagram that to furnish 350 million gallons daily there will be required 150 billion gallons storage capacity, or more than twice as much as is now provided for, and no water might run off over Croton Dam for ten years in succession. To render the water wholesome, filtration would be essential.

Whether the cost of such treatment would be less than the cost of introducing an equal supply from a new source is a matter of simple calculation. I would recommend that such comparisons of cost be made. In the present state of our knowledge of the sources of disease, it seems probable that the improvement in the sanitary condition of such a community as the City of New York, which would result from the filtration of any waters furnished to it from natural surface streams, would warrant the expenditure necessary to effect such filtration.

Whatever additional water may be required for the Manhattan and Bronx boroughs, one thing must be kept constantly in mind, and that is that there is now a supply of nearly 300 million gallons a day which cannot be delivered at a greater elevation than 120 feet above tide-level, and there is a sufficient area of the City lying below the elevation of 60 feet to enable all of this water to be utilized to advantage. Within this area no supply of water can be utilized under a greater head, without an entirely new and separate system of distributing mains and plumbing in the buildings. Two supplies under different heads cannot be maintained in the same system of pipes. If any new supply were introduced under 200 to 300 feet head, it could only be used on the west side of Manhattan above Thirty-fourth street, and in the upper portion of Bronx, to which the Croton supply will not rise by gravity.

II.

THE BROOKLYN, QUEENS AND RICHMOND SYSTEMS.

I:—Brooklyn.

In the Borough of Brooklyn there was no public water supply until after the population had reached 200,000. In 1856 a plan was matured for procuring water from ponds and streams on the south side of Long Island, east of the City, and a company was formed to construct the works, but the City took them in hand and constructed them, and a public water supply was introduced in 1859. The management of these works was for several years vested in the Nassau Water Board, of three members, appointed by the Mayor and Aldermen, and in 1874 was transferred to a Board of City Works, by which it was conducted until the consolidation of Brooklyn with New York in 1898, when the charge of the works was vested in the Water Commissioner. The supply of surface water has been supplemented by pumping the ground-water from driven wells along the line of the conduit which conveys the water from the ponds to the Ridgewood pumping station, where it is lifted by steam pumps to the Ridgewood Reservoir, 170.86 feet above tide-level. From this reservoir about 9,700 acres of the Borough of Brooklyn, which lie below the elevation of 90 feet above tide, are supplied. A pumping station at Mt. Prospect supplies about 1,400 acres with water at a higher elevation—about 1,000 acres being supplied from a reservoir, and 400 acres, lying above the elevation of 110 feet, from a tower. A further supply is furnished by water obtained from wells at two pumping stations in the southern part of the City and pumped directly into the mains, supplying 2,170 acres.

The Flatbush Water Company, a private corporation, furnishes water under its charter to 2,180 acres in the former town of Flatbush, and to 520 acres of adjacent property through private mains. The Long Island Water Supply Company has for years supplied an area of 1,224 acres in East New York, and the Blythebourne Water Company an area of 660 acres in the southwestern section, near Fort Hamilton. All of these works, and one or two smaller plants, draw their supplies from wells and pump, as a rule, directly into the mains. The district still unsupplied with water measures 21,476 acres, or 55 per cent. of the area of the borough.

II:—Queens.

The Borough of Queens, which has an area of 79,347 acres, has only a fragmentary supply obtained from wells, the water from which is pumped directly into the mains; works, supplying 2,770 acres, being owned by the City, and others, supplying 5,900 acres, by private corporations.

III:—Richmond.

The Borough of Richmond, with an area of 36,600 acres, has but a small supply of water for 3,130 acres, which is derived from wells.

Statistics of these various fragmentary and incomplete supplies are given in the maps and tables appended to this report.

In considering the future needs of the various boroughs, all consideration of the ground-water, from areas which are or may be thickly populated, must be eliminated. In portions of Brooklyn and of Queens and of Richmond it is probable that for several years to come a sufficient supply can be procured from ground-water uncontaminated; but, in considering the necessities of the district after the next twenty-five years at the most, it will not be safe to place any dependence upon water obtained within the limits of the boroughs. The limit of the Ridgewood supply for Brooklyn has now been reached, and additional water from some other and distant source should be immediately provided.

III.

EXTRAORDINARY CONSUMPTION AND LEAKAGE.

I:—Elements of Large Consumption.

The experience of the last third of the nineteenth century is the best guide in attempting to determine the quantity of water needed to supply the wants of New York in the future. The conditions of increase of the population, the length of water-pipe needed and the quantity of water required may be considered as pretty well determined by the experience of the last thirty years in Manhattan and Brooklyn. In the case of Manhattan there is, however, a disturbing element in the fact that the supply for several years prior to the completion of the new aqueduct was manifestly insufficient for the demand, and it was necessary to limit the supply of water by partly closing the gates at the reservoirs and stop-cocks in the main pipes. Then, when a full supply for all purposes was obtained, and the gates were opened wide, there was an excessive increase of consumption of water, greater than what would seem justified by the experience of Brooklyn, or of any other large cities.

An analysis of the conditions and principles governing the supply of these great seaboard cities is essential to forming a correct judgment of their needs. The experience of inland cities, where there is not an extensive water-front and a great amount of shipping, does not afford any criterion by which to compute the use of water in a seaboard city, taken as a whole. For simply domestic and manufacturing uses, valuable data for comparison may be obtained from a study of the conditions existing in inland towns. But in a centre of ocean and rail transportation, with numerous docks at which ocean and river steamers are supplied with water; terminal stations of great lines of railroads; large manufacturing plants; lines of local transportation, using water profusely for the generation of power, either in the form of horses which must be watered, locomotive engines which must make their own steam, power plants in which steam must drive the drums which keep in constant operation miles upon miles of steel cables, or must generate the electric currents to flow through many miles of wires; huge offices, in which are concentred for the working hours of the day a large proportion of the male population of the upper portion of the City and of the surrounding country within a radius of several miles, and great hotels, always full of non-residents of the City; conditions exist which render the application of any individual or per capita basis of computing the quantity of water required altogether impracticable.

The most reasonable and practical basis of computation for the amount of water used appears to be to consider the number of miles of distribution pipe in connection with the number of taps or separate connections supplying buildings.

The mileage of main pipes enters as a factor into the public use of water for street-cleaning, fire protection, sewer-flushing and like purposes. Such use is governed almost entirely by the length of pipe laid and not by the population.

II:—Underground Leakage.

There is much leakage underground from bad joints, breaks and defective stoppage of disused services. There are, on the 850 miles of mains in New York City, at least 18,000 old service taps which have been discontinued and more or less imperfectly plugged up. There is a great loss of water from these old taps. Thousands of them are leaking continuously; some but a mere dribble, but others carrying off into the subsoil and into the sewers thousands of gallons daily each. Sometimes the leakage from one of them increases sufficiently to come to the surface of the ground, and the water appears as a spring in the pavement of the street or sometimes flows off into vacant lots. If the underground channels become obstructed, the water will rise to the surface, and the leak will be reported. Every increase of pressure in the pipes increases the leakage from these old taps, and attention is called to them. The number of leaks which showed themselves, when the pressure on the mains was kept down on account of scarcity of water between 1883 and 1889, was about 700 annually. After the new aqueduct was finished, and the pressure was increased, the number of leaking services reported was over 1,000 annually; and last year, after the full pressure had been turned on downtown by the laying of the additional mains down Fifth avenue and Elm street, there were 2,500 such leaks that made themselves manifest; and in the basements of buildings, and in vacant lots lying below the surface of the street, and on the surface of the street itself, anywhere in the lower part of the City, springs may be noticed by an observer every day which are caused solely by leaks in the service pipes and the mains.

The mains themselves also leak largely. There are at least 500,000 joints in the main pipes underground, and from many of them water is escaping. Indeed, instances have occurred in which the excessive amount of water encountered in the excavation of a pit in the street has been traced to a joint in a main water-pipe which had never been leaded at all by the contractor, and from which several hundred thousand gallons a day had been flowing for years into a sandy subsoil and been carried off by the sewers. Cases of leakage are constantly occurring in which the source is traced to corroded cast iron mains. For several years the average amount of old pipe which has had to be taken up and replaced has been about two miles annually, but the deterioration and consequent leakage from the old pipes is progressing more rapidly than the work of replacing the pipes. These sources of consumption of water are manifestly entirely independent of the population of the City, but they do bear a definite relation to the length of pipes.

The location of the leaks in the main pipes which do not show at the surface of the ground, and the quantity of water which is lost from them, can only be determined by a systematic investigation. Such investigation is made by dividing the distribution system into sections, with appliances for measuring the inflow and outflow of the water through them. The difference between the amount of water which enters any division of the distribution and the quantity which flows from that into the next division is manifestly the amount which is used up in some way in passing through that section. Then the amount which is actually taken from the main for all purposes—for street-cleaning, fires and house-service—must be ascertained. The difference between these two amounts is the quantity of water lost by leakage from the mains within that district. If this amount is great, a detailed examination of the probable localities of the leakage has to be made, and with experienced persons in charge of the work, the exact location of bad leaks can generally be discovered with very little difficulty. This system has been used with excellent results in Liverpool and in Boston. The original design of meter for measuring such large quantities of water as it passes through the main pipes is a somewhat cumbersome machine, but in the advance of hydraulic science a much more simple apparatus has been devised for the purpose, and the application of the district system to the determination of the loss of water in main pipes is no longer an experiment, nor is it very difficult or expensive of application to any system of distribution pipes.

IV.

ACTUAL CONSUMPTION OF WATER.

I:—Divisions of Water Consumption.

The ascertaining of the amount which is actually taken from the mains and used in some way by the public is a somewhat complicated problem. This water is used in four ways: (1) for public purposes—which includes street cleaning and sprinkling, sewer flushing, extinguishing of fires, the water used in public parks, and that which is used in public buildings; (2) for manufacturing purposes—which includes that supplied to shipping, and also that which is used for the generation of power; (3) for all domestic purposes, including the supply for offices, stores and private houses, and (4) wasted by neglect or carelessness of all classes of consumers.

II:—Water Used for Public Purposes.

The quantity of water used for public purposes cannot be accurately measured. No effort has ever been made in New York City to determine this amount, but in a few American and in a large number of foreign cities, particularly in Germany, very careful investigations have been made, which show the average quantity of water thus used to be not far from five gallons a day per head of population. As before stated, this basis of computation in the case of such a city as New York does not appear to be reasonable, for the use of water for public purposes depends more upon the length of streets in which the water is used than on the number of people who reside on those streets and on other streets unsupplied with water. From a comparison of the various records obtainable, both in this country and abroad, I think that a fair basis of estimation of water used for public purposes is 15,000 gallons per mile of main pipes. Applying this to New York City, in which there are 850 miles of mains, the total would be 12,750,000 gallons a day, which would be equivalent to about six gallons a day per head of population. This may fairly be assumed as the amount of water used for public purposes.

III:—Water Used for Business Purposes: Records of Meters.

The amount of water used in manufacturing and business purposes in New York is large and manifestly is not directly proportional either to the population of the City or the total number of watertakers. The necessity for measuring the water so used, so that the large consumer of water should pay his fair proportion of the cost of furnishing it, has been recognized for fully forty years; but reliable water meters were not to be had as long ago as that, and any meters were very expensive. The absolute necessity of having the water for large consumers sold by measure rather than by guess-work was recognized by Mr. Tweed in 1870, when the Water Department was reorganized, and he entered into a contract with a manufacturing firm for the supply of ten thousand meters at seventy dollars each, which were duly manufactured and delivered to the City about the time that his official existence terminated. The legality of this contract was questioned, and, while the meters were delivered to the City, they could not be used pending the legal proceedings which were instituted to prevent payment for them; so that by the time the case was decided and the City compelled to pay for the meters, they had become rusted and unfit for service. The absolute necessity for metering large consumers grew more and more apparent, and the introduction of meters to the premises of such consumers was begun in 1875. For four years about 250 meters a year were added, and during the next seven years about

2,000 meters a year were added. The consumption of water per meter was very large at first, only the larger consumers being metered; but by 1887, when about 15 per cent. of the entire number of taps had been metered, the average consumption per meter per day became 1,500 gallons. Since that time there have been added an average of 1,500 meters each year, until now the entire number on January 1, 1900, was 36,068—about 30 per cent. of the entire number of taps, or house connections, through which water is drawn from the mains.

Official Meter Records.

For nearly twenty years the records of the amount of water measured by meters were in charge of the Chief Engineer, and in his reports for each year from 1880 to 1891 there was published a very valuable analysis and classification of the character of occupation of the premises to which meters were applied and the quantity of water used per day by each of such consumers. The following table, compiled from the reports of the Chief Engineer of the Croton Aqueduct, shows that the larger consumers were metered first, and that, as the number of metered premises increased, the average consumption of water through each meter decreased until 1887, since which time it has been practically a constant quantity. After 1891 the Chief Engineer was relieved from the duty of making a classification of meter records, and none has been made, except in 1894. The quantity of water which has been used by the meters since that date I have computed from the reports of the Water Registrar, which show the number of meters and the revenue derived from them each year.

It appears from these records that the daily consumption of water per metered tap since 1888, when there were 17,750 meters in use, up to the present time, when there are 36,068 meters in use, has averaged 1,450 gallons a day. A study of these tables shows conclusively that the number of meters of each class is increasing pro rata with the total increase, so that the amount used per meter of each class remains constant. There may be an exception to this rule in the case of office buildings. The construction of the very high buildings devoted to office uses began about 1894, the time at which the Chief Engineer's analysis of records terminates. The quantity of water used in the large office buildings of recent construction ranges from 8,000 to 50,000 gallons a day each; the older buildings, which they replaced, having used 2,000 to 6,000 gallons a day. But the fact remains that the average consumption per metered premise in the City remains constant at 1,450 gallons a day.

Private Meter Records.

To check the records of the Water Department as to the consumption of water by meters, a copy of the records of the monthly readings of 600 meters on buildings of various classes in the City for the past three years was procured from Mr. Joseph H. Bellis, who has been engaged on the monthly inspection of metered premises by the owners for the purpose of inspecting and checking useless waste of water, and a careful analysis of the records furnished by him shows the following result:

Year.	Number of Meters.	Number of Gallons per Day per Meter
1897	580	1,585
1898	584	1,674
1899	574	1,491

The quantity of water which passed through single meters of the 574 recorded in 1899 ranged from 64,885 gallons a day in a large manufacturing plant to 17 gallons a day in a Third avenue clothing store; but the average of all was 1,491 gallons a day, as against the average derived from the Water Registrar's report of revenue from 35,755 meters, which gave a consumption of 1,417 gallons per meter.

It may safely be estimated that the average consumption of water per metered tap in New York City is 1,450 gallons per day, and is likely to continue at that amount so long as the application of meters is confined, as at present, to premises in which some business is carried on, and which comprise about 30 per cent. of the entire number of buildings in which water is used.

IV:—Water Used for Domestic and General Purposes.

It may be assumed that none of the metered water is wasted; at all events, it is accounted for, and it produces a

CLASSIFICATION OF METERS IN MANHATTAN.

	Number of Meters.	Gallons per Meter per Day.	Number of Meters.	Gallons per Meter per Day.	Number of Meters.	Gallons per Meter per Day.	Number of Meters.	Gallons per Meter per Day.	Number of Meters.	Gallons per Meter per Day.	Number of Meters.	Gallons per Meter per Day.	Number of Meters.	Gallons per Meter per Day.
	1879.		1880.		1881.		1882.		1883.		1884.		1885.	
Gas works.....	33	16,620	31	18,695	31	23,023	37	18,605	37	22,481	38	21,695	40	19,540
Docks	93	11,452	96	12,969	100	13,450	106	12,170	112	12,848	111	12,750	116	13,302
Railroads	103	10,019	157	8,250	167	6,773	180	6,431	186	6,403	198	6,212	201	6,526
Hotels	282	4,830	307	4,037	314	4,602	330	5,092	336	5,083	343	4,977	347	4,882
Breweries	153	10,323	235	4,501	269	4,413	283	4,826	302	5,001	318	4,980	324	5,228
Charitable	—	—	78	4,046	80	5,213	86	4,690	95	4,400	97	4,237	97	4,186
Manufacturing	126	4,248	212	4,579	227	3,751	320	2,968	381	3,027	671	2,856	762	2,841
Apartments ...	—	—	41	3,606	54	3,494	79	2,537	93	2,449	117	2,180	133	2,188
Offices	—	—	421	1,223	1,478	937	1,655	929	1,760	937	1,785	936	1,830	946
Stables	204	2,315	1,070	788	1,201	807	1,223	747	1,388	734	1,575	698	1,624	695
Riverdale	—	—	26	327	31	484	39	872	—	—	—	833	—	—
Miscellaneous.	404	2,767	572	2,820	1,001	2,255	2,127	1,611	3,465	1,467	5,650	1,385	7,448	1,269
	1,398	5,517	3,246	3,022	4,953	2,408	6,465	2,111	8,155	1,990	10,963	1,824	12,922	1,712
	1886.		1887.		1888.		1889.		1890.		1891.		1894.	
Gas works.....	43	18,621	44	20,857	46	25,254	48	27,696	54	19,633	56	21,977	63	17,165
Docks	131	11,029	172	9,782	181	10,006	190	9,085	197	8,159	193	9,148	223	9,102
Railroads	206	6,515	216	7,730	216	7,547	223	8,101	230	8,361	234	9,436	341	9,370
Hotels	353	4,796	358	4,740	367	4,689	369	4,618	387	4,442	399	4,381	435	4,713
Breweries	336	5,044	350	4,803	383	4,482	388	4,503	405	4,390	414	4,498	480	4,575
Charitable	103	3,961	108	3,815	110	3,800	120	6,417	131	5,794	139	5,540	164	5,030
Manufacturing	840	2,742	1,010	2,396	1,150	2,188	1,305	2,225	1,475	2,181	1,733	2,046	1,974	2,043
Apartments ...	154	2,097	165	2,006	205	1,183	217	1,903	236	1,788	260	1,781	568	1,386
Offices	1,860	973	1,952	943	2,006	937	2,027	953	2,100	950	2,145	945	2,890	943
Stables	1,706	669	1,749	655	1,905	633	1,945	618	2,076	593	2,160	594	2,321	602
Riverdale	74	869	80	1,004	89	845	91	938	97	521	99	579	117	814
Miscellaneous.	8,294	1,215	9,878	1,103	11,082	1,011	12,330	956	13,882	918	15,627	864	19,175	850
	14,100	1,639	16,082	1,540	17,750	1,449	19,253	1,427	21,270	1,340	23,459	1,299	28,751	1,277

Year.	Average Number of Meters in Use.	Gallons per Meter per Day.
1879...	1,004	5,517
1880...	2,700	3,022
1881...	4,648	2,408
1882...	6,055	2,111
1883...	7,915	1,990
1884...	10,318	1,824
1885...	12,652	1,712
1886...	14,131	1,639
1887...	15,567	1,540
1888...	17,382	1,449
1889...	19,040	1,427
1890...	20,971	1,340
1891...	23,168	1,299
1892...	25,652	1,218
1893...	28,663	1,505
1894...	30,307	1,277
1895...	31,328	1,369
1896...	32,950	1,416
1897...	34,080	1,470
1898...	35,016	1,428
1899...	35,755	1,417

revenue to the City. But of the water which passes through unmetered service pipes, a portion is used legitimately and a portion runs to waste unused, some from wilful waste and some from defects in the plumbing of the houses which are unknown to the occupant. Attempts have been made in New York, as well as other cities, to determine the proportion of the premises on which water is used in which a constant waste occurs. The difference between a liberal use of water for legitimate purposes and a parsimonious use is really very slight, on the whole. It is the constant loss of water from deliberate wastefulness or unknown defects in plumbing which causes the great difference which is found to exist in the consumption per house in cities where the majority of buildings are metered and those in which a few or none are metered. When it became evident in New York that the demand for water was increasing at such a rate that the supply would soon be exhausted, an effort to determine the proportion of buildings in which waste occurred and to take steps to check such waste was begun by Mr. Allan Campbell, who was then Commissioner of Public Works. In December, 1876, an inspection was made of all the houses in the City, and such inspections were continued with more or less thoroughness for ten years by Mr. Campbell and his successor, Mr. Hubert O. Thompson.

The result of the inspections made for nine years was as follows:

Year.	Premises Inspected.	Premises on which Leaks were Found.
1877	106,577	15,718
1878	55,386	9,572
1879	46,307	8,845
1880	18,347	2,935
1881	19,392	2,122
1882	24,189	3,531
1883	15,308	1,770
1884	19,277	5,944
1885	47,590	5,231
Total	352,373	53,668

Leaks were found in only 15 per cent. of the premises inspected.

To determine the amount of water which ran to waste in buildings where leaks were found, inspections of the house drains leading to the sewers were made, from 1882 to 1884, with the following results:

Year.	Drains Inspected.	Leaks Discovered.
1882	9,268	1,411
1883	9,893	1,623
1884	9,275	939
Total	28,436	3,973

In this case the leaks discovered amounted to 14 per cent. of the total number of drains inspected.

The quantity of water flowing out of the house drains about two o'clock in the morning, was estimated in each case where it was found, and the aggregate—from the 3,973 cases in which water was found running—was at the rate of 13,232,160 gallons per day, which made the average for each of the 28,436 houses examined a waste of 465 gallons per day. This was not a close gauging, but an estimate from inspection of the water running in the drain pipes.

In Boston, during the last four years, an inspection of buildings has been carried on with the following results:

Year.	Houses Inspected.	Leaks Discovered.
1896	15,288	2,635
1897	47,778	7,652
1898	54,007	11,051
1899	52,425	13,440
Total	169,498	34,728

Proportion of premises on which leaks were discovered, 20.5 per cent. In 1899 it was 25 per cent.

In this case no effort seems to have been made to determine the amount of leakage from the several premises.

It would appear from these observations that in 75 to 85 per cent. of the premises on which water is used there is practically no leakage or excessive waste of water, when a systematic inspection of buildings is carried on. Continued inspection reduces the proportion of the premises on which leaks exist, but does not check waste entirely, which cannot be accomplished without putting a meter on the service pipe and requiring the consumer to pay for all the water that passes through it.

The introduction of a small additional supply of water from the Bronx River in September, 1884, seemed to relieve the minds of the authorities of that day, and the Board of Estimate refused to make appropriations to continue the house-to-house inspection, and it is believed that no effort has been made since 1885 to ascertain the number of premises on which leaks occur, or to discover the sources of waste, either above or below ground.

Waste in Domestic Use.

The efforts toward the restraining of waste have been confined to reducing the amount which is wilfully wasted, by placing meters on the services of business consumers, and making them pay by measure for the water they use. The placing of meters on private residences is not permitted by law, or, more properly speaking, the compelling of the private consumer to pay for a meter and for the water which passes through it is not authorized by the City Charter.

For several years a considerable reduction of waste from unseen and not readily discovered sources, such as leaking fixtures and main pipes, was effected by reducing the head of water in the pipes. This did not, as is generally supposed, diminish the quantity a consumer could use legitimately, but it did lessen the quantity lost by leakage, and so increased the quantity available for actual use. To explain this more fully:

If there was no leakage or waste and all the water delivered was used, the increase of consumers would diminish the supply to the original users, and all parties would have less water than they needed. But if there is a considerable leakage, the reduction of the head of water under which such leakage occurs will lessen its amount, and the water thus gained can be used by the additional consumers.

Thus when the number of consumers increased, as it did from 1885 to 1889, 7.6 per cent., and the same quantity of water had to supply the demand in each year, or about 100 million gallons a day, the extra supply for the latter years had to be made up out of the water which had been allowed to run to waste during the earlier years.

With 60 feet head on the mains, as is the case in the most of Manhattan except the high-service district, the loss of head caused by an increase of actual daily consumption of 5,000,000 gallons—there being at the outset a waste of 50 million gallons a day—would be 11.4 feet. This diminished head would reduce the loss from waste to 45 million gallons per day.

With the less head on his pipes the original consumer could get as much water as before, but the water would not rise as high in his house as it did by 11.4 feet. The water would not rise to the upper stories, but as much water could be drawn for all necessary uses as before. The consumer could draw as many pails of water, take as many baths, flush as many water-closets, and use as much for washing as before, and not know the difference. By having a tank which could be filled by pumping or by the water flowing into it at night, when the draught on the pipes is less and the head consequently greater, the inconvenience of the reduced head would not be seriously felt.

Under the most favorable conditions none of the buildings situated on ground above the elevation of 60 feet above tide can be fully supplied in the upper stories by gravity from the reservoirs, so that the residents above Thirty-fourth street on the west side of Manhattan have from the outset been compelled to use hand pumps in their houses, if they wanted water on the upper floors. This condition of affairs was obviated by the construction of the Ninety-eighth street high-service pumping station in 1880, so that the hand pump is not, or ought not to be, a necessary adjunct to a well-appointed residence. In fact, however, since there has been a plentiful supply the number of consumers in the high service district has increased to such an extent that the pumps cannot supply the demand and the waste and keep up the head at all hours of the day. Consequently hand pumping is still necessary in some districts.

Reduction of Pressure.

It was by a skillful application of the reduction of head that the supply of necessary water was kept up for the whole City during the years from 1883 to 1890, while the new Aqueduct was building. The gates at the reservoirs and the stop-cocks in the distributing mains were partly closed, so that just enough water would pass through them and into the several districts of different elevations, to rise not higher than the first or second stories of the houses, thus furnishing water enough for use and also for supplying the diminished leakage caused by the lessening of the head on the orifices which were constantly open, whether they were underground or in the plumbing of the houses. The deterioration of the pipes kept on increasing with little or no effort to stop it, and the defective plumbing was not repaired except when it caused inconvenience to the occupant of the house. The increasing loss from invisible leaks was overcome by decreasing the pressure on the pipes.

Then in July, 1890, the water from the new aqueduct was turned on and the throttled gates and stop-cocks were opened up, and the full pressure from the water in the reservoirs was turned on the pipes. The head on the distribution mains increased 20 to 25 feet. The result was an immediate enormous increase in the consumption of water. In the first half of 1890 the consumption was about 105 million gallons a day. In 1891, 153 million gallons a day were used, and by 1895 the consumption of water had increased to 180 million gallons a day. These quantities are those shown by Mr. Freeman's recent gauging, and are less than those of the Water Department.

Additional leading mains from the reservoir to the lower portions of the City were laid, and the increase during the next year was 20 million gallons a day; and in 1897 and 1898 the laying of a line of large mains from the reservoir to Chambers street enabled the head of water in the lower part of the City to be increased still more, and the consumption of water advanced to 226 million gallons a day in 1898 and 246 million gallons in 1899. That this increased consumption was not due to an increase in the actual rate of use of water by consumers is shown by the fact that the water used by 25 per cent. of the consumers was measured during the entire period from 1889 to 1899, and the rate of use by that 25 per cent. of the consumers was not materially increased, if at all.

In 1889 there were 19,040 consumers taking water through meters, and the average use of water by them was 1,428 gallons per day each. In 1899 there were 35,755 consumers taking water by meter, and they used 1,417 gallons a day each. There is no reason to suppose that the average actual use of water by consumers of any class increased materially during that period of ten years. The number of unmetered consumers increased about 40 per cent., but the amount of water furnished to them and which disappeared somewhere increased 160 per cent. Dividing the total unmeasured water by the number of unmetered taps, the daily rate increased from 907 gallons a day in 1889 to 2,248 gallons a day in 1899. It is not unreasonable to say that it was impossible that 75 per cent. of the water-takers doubled their use of water in about seven years, when it was proven that the remaining 25 per cent. taking water under the same conditions, except as to measurement of the use, did not appreciably increase their use. If the increase of pressure had increased the legitimate use of water in the metered buildings it would have shown in the records of the measured water. That it did not increase such legitimate use, but merely increased the waste from orifices either undiscovered or left open by design, is clearly established by the fact that where such orifices did not exist the use of water did not increase.

V.

LOCALIZING AND PREVENTING WASTE.

I:—Meter Tests of Domestic Consumption.

In attempting to discover the cause of so enormous an increase in the use of water, the first step to be taken was to find out whether the proportion of waste on unmetered premises to the actual use in the same differed materially in New York now from what it did formerly, or from what it is in Boston, where the inspection of waste from buildings is kept up.

In order to obtain an approximate idea of the proportion of the water used and wasted on unmetered premises in New York, the Committee in January last authorized me to place meters on a number of private residences in Manhattan and Brooklyn. Permission was obtained from the owners of twenty-five residences of various classes in Manhattan and twelve in Brooklyn to apply meters to their houses and keep a record of the daily consumption of water. The Neptune Water Company generously contributed to the obtaining of this important information, by furnishing and placing in position these thirty-seven meters, free of all expense to the Committee.

I have had the readings of these meters taken regularly for from sixty to ninety days. The results of the first three weeks' observations thereof were as follows:

RECORD OF TWENTY-FIVE WATER METERS ON RESIDENCES IN MANHATTAN. AVERAGE FOR THREE WEEKS IN JANUARY AND FEBRUARY, 1900.

No.	Nearest Street.	Nearest Avenue.	Gallons Per Day.	Number of Occupants.	Gallons Per Cap.	Stories.	Baths.	W. C.	Faucets
1	121	Manhattan	138.68	4	34.67	4	1	2	21
2	73	Boulevard	205.34	4	51.34	4	2	2	25
3	30	Lexington	205.70	7	29.39	4	2	3	12
4	88	Amsterdam	221.15	5	44.23	3	1	2	11
5	38	Third	236.10	5	47.22	4	1	2	15
6	15	Lexington	243.08	7	34.72	4	1	2	14
7	40	Park	286.05	4	71.51	4	2	3	21
8	69	Columbus	318.51	7	45.50	4	3	3	21
9	84	Eighth	354.36	4	88.59	4	2	3	25
10	48	Eighth	364.70	6	60.78	4	2	3	13
11	10	Fifth	369.38	10	36.94	4	2	3	17
12	18	Third	371.91	8	46.49	4	1	2	9
13	44	Fifth	387.68	8	48.46	4	5	6	29
14	8	Greene	399.68	6	66.61	4	1	4	4
15	55	Sixth	480.21	8	60.03	4	3	4	13
16	72	Riverside	577.43	11	52.49	4	2	4	22
17	18	Third	578.21	11	52.57	4	2	3	7
18	77	Riverside	622.64	10	62.26	4	3	4	27
	Average of 18 houses		353.38	6.95	50.84	—	—	—	—
19	121	Lenox	519.33	6	86.56	4	2	3	23
20	48	Madison	743.68	9	82.63	4	2	3	28
21	94	West End	914.28	8	114.29	4	2	3	24
22	71	Boulevard	916.70	9	101.86	4	3	4	15
23	88	Riverside	1,303.76	9	144.86	4	3	4	16
24	69	Eighth	2,351.74	6	391.66	4	3	4	23
25	Houston	First	4,521.91	21	215.33	4	—	3	6
	Average of 7 houses		1,610.20	9.71	165.75	—	—	—	—
	Average of 25 houses		705.28	7.72	91.36	—	—	—	—

It appears from this table that the quantity of water used per house, or per head of occupants of the buildings, varied very greatly. In only seven cases out of the twenty-five did there appear to be an excessive and unnecessary use of water. In the other eighteen houses, while the consumption varied from 139 to 622 gallons per day and the per capita consumption varied from 29.39 to 88.59 gallons, the use of water did not seem to be abnormal or excessive. Fluctuations occurred in the daily consumption which were sometimes unaccountable, but the very fact of such fluctuations occurring showed that the waste was not steady or due to permanent defects or wilful neglect. In these eighteen houses—being 72 per cent. of those inspected—there were used an average of 353.4 gallons per day per house, or 50.84 gallons per day per head of occupants. In the remaining seven houses the use of water was excessive and very regular, indicating a continuous leakage, and on inspection it was found that in three cases a ball-cock in a servants' water-closet was defective and a steady stream of water was flowing off into the sewer unknown to the occupants of the house. In another case, which was a tenement house with a saloon attached, the proprietor kept a steady stream of water running through the water-closet and urinal, passing off into the sewer 4,522 gallons per day. A new washer on the leaking ball-cocks and the closing of the stop-cock in the saloon reduced the consumption in each of these cases to normal limits. It may be added that the discovery of the fact that water was being wasted on their premises in this manner was a great surprise to the occupants of the building, except in the case of the saloon-keeper, which was wilful waste. The number of premises inspected is rather small to enable any general conclusions to be drawn, but they represent a fair average of the unmetered premises and they indicate that leaks prevail in 28 per cent. of the premises in Manhattan, as against 18 per cent. in Boston and 15 per cent. in New York when there was house inspection. The record of the use of water through these meters from January 15 to March 30 is given in full in Plate V.

This diagram will repay a careful perusal. It will be seen that the use of water is generally very uniform in the houses. One curious fluctuation occurs, however, in the record of No. 5. The use of water in that house during the first seven weeks was very uniform, about 236 gallons per day; then, between February 26 and March 9, the consumption suddenly increased to 1,025 gallons per day, after which it resumed the normal rate. For the last three weeks of the record the consumption averaged 274 gallons per day. On inquiry, it appeared that during the period of excessive consumption there were two extra occupants of the house, one of whom was a small boy who had a toy steamboat which he delighted in sailing in the bath-tub, and he was drawing water at all times for that purpose, using about 800 gallons per day.

The consumption in the seven houses which I have rated as being above the average has been materially modified on the attention of the occupants being called to the fact that they were using an excessive amount of water.

In No. 20 a leak was discovered in the servants' water-closet in the basement, the repairing of which diminished the use of water in the house from 743.68 gallons to 347.80 gallons per day.

In No. 23 a similar discovery caused a reduction in the use of water from 1,304 to 606 gallons per day.

In No. 24, where the occupant thought he was using water very moderately, but was in fact consuming 2,352 gallons per day, the stoppage of water-closet leaks reduced his consumption to 440 gallons per day.

In No. 25, which is the tenement house and saloon above mentioned, and in which the water was kept running freely through a water-closet and urinal, consuming 4,522 gallons per day, the proprietor shut off that water for three days and the consumption was reduced to 813 gallons per day, or about 40 gallons per occupant of the premises. Afterwards he probably opened the cock again, but not quite so wide, as the consumption during the last two weeks has been 2,250 gallons per day.

The occupants of two of the dwellings in which the use was excessive have apparently not taken any steps to remedy any defects there may be in their plumbing, and the use of water by them in the last three weeks has been somewhat greater than in the first three weeks above recorded.

The general result of the placing of meters in these seven houses and calling the attention of the occupants to the rate at which water was being used has been that the whole seven houses are now using 6,356 gallons per day, as against 11,271 gallons per day used in January, a saving of 702 gallons per day per house.

During the last three weeks, the average daily consumption in the whole 25 houses has been 506 gallons per day, or 65.55 gallons per head per day, a saving of 25.81 gallons per capita on rate which existed before inspection, without any reduction in the actual use of water.

The only way in which such waste as this can be checked is by the application of a meter to every building in which water is used, and a systematic and frequent inspection of the meter. No inconvenience or loss would result to the occupants of the premises in having the unnecessary waste checked, for the quantity of water which they would still use would be the same as before.

Deductions from Meter Records.

The average consumption of water in the 25 houses, before inspection, was 705.3 gallons per day. Assuming the use in the 72 per cent. of the houses to be the normal and legitimate use, there is an average wastage of 351.9 gallons a day from each of the twenty-five houses, or very nearly 50 per cent. of the water which passes through them. These 25 houses represent very fairly the average of the unmetered buildings in New York, and I feel justified in assuming that 50 per cent. of the water which is now furnished to them is used legitimately and properly, and that the remaining 50 per cent. flows off into the sewers unused and unwanted.

The average number of occupants of the houses we have tested is, it is true, only about 35 per cent. of the average number of occupants of residences in Manhattan and Bronx boroughs, which is estimated by the Health Department as 22, but the use of water in residences of this class is far greater in proportion to the number of occupants than in dwellings of a less expensive character. Moreover, a majority of the tenement houses in Manhattan are metered already.

As illustrating the unreliability of basing estimates of the use of water on a per capita allowance, it may be stated that the next house to the one designated as No. 25 in my meter table and diagram is a tenement of the same size, with 36 occupants, which has been metered by the Water Department. The daily use of water in it is 381 gallons, or 10.58 gallons per head of occupants. There is another tenement house on the west side of the city occupying two old residences, in which there are 50 tenants. It has been metered by the Water Department, and for two years the owner was misled by the idea that 50 gallons per capita, which was the consumption, was a fair allowance. But an inspector whom he engaged found a water-closet leaking continuously, and after that was stopped the consumption of water fell to 283 gallons per day, or 5.6 gallons per head of occupants, and has continued at that rate for a year.

The average consumption of water by the unmetered services is thus 705.3 gallons per day, but for convenience of computation it is taken at 710 gallons per day, half of which represents unnecessary waste, which may be easily checked.

There is no accurate record in the Water Department of the number of taps or service pipes in use in Manhattan and Bronx boroughs. In the report of the Commissioner of Public Works for 1873 the number of services supplied is given as 74,271, and in the report for 1887 the number in use is given as 96,487. The number of taps added each year is given in the annual reports since 1887, and in most instances the number of old taps cut off and plugged is given in the report of the Chief Engineer. From these data I have computed the number of taps in use on January 1, 1900, and find it to be 124,308, of which 36,068 are metered, leaving 88,240 unmetered. There were in use during the year 1899 an average of 35,755 meters and 86,764 unmetered taps in the boroughs of Manhattan and Bronx. From the Police and Health Boards and insurance map and Building Department records, I estimate the total number of buildings in Manhattan and Bronx boroughs to be 139,979, of which 95,546 are classed as inhabited houses, the average number of tenants to a house being 22.

In this connection it seems proper to call your attention to the very great difficulty of obtaining any exact and reliable information concerning the statistics of the municipality of New York. There is a Bureau of Municipal Statistics provided for by the Charter, but the Manager is restricted to simply asking information from the various departments; and in few of them does any system of collecting and recording data relating to their works prevail, and no power exists to compel such records to be kept or the data made public.

All available information regarding the statistics of the water supply of Manhattan and Bronx Boroughs for the last thirty years is condensed in the following table.

The figures in this differ from those in the printed annual reports only in the fact that the mileage of mains and number of taps and meters represent the average in use during the year named. In the reports the number in use at the end of the year is generally given.

Water Supply of Manhattan and Bronx Boroughs.

YEAR.	Miles of Pipe in Use.	Total Taps.	Taps per Mile.	Metered.	Unmetered.	Total.	Metered Taps.	Consumption per Meter.	Unmetered Taps.	Consumption per Unmetered Tap.
				Daily Consumption.						
				Million Gals.				Gals.		Gals.
1869	307.30	69,655	227	—	—	67.2	—	—	—	965
1870	339.87	70,680	208	—	—	70.1	—	—	—	992
1871	352.35	71,705	204	—	—	72.7	—	—	—	1,014
1872	368.78	72,730	197	—	—	75.4	—	—	—	1,037
1873	393.44	73,755	187	—	—	80.8	—	—	—	1,096
1874	414.51	74,826	180	—	—	82.2	—	—	—	1,099
1875	426.00	76,190	179	—	—	85.5	—	—	—	1,122
1876	436.20	77,412	177	—	—	80.5	260	—	77,152	1,040
1877	447.73	78,700	176	—	—	80.3	355	—	78,345	1,020
1878	467.12	79,863	171	—	—	86.0	533	—	79,330	1,089
1879	486.79	81,420	167	5.5	78.4	83.9	1,004	5,517	80,416	974
1880	506.49	83.246	164	8.2	75.0	83.2	2,700	3,022	80,546	932
1881	522.65	85,265	163	11.2	72.0	83.2	4,648	2,408	80,617	893
1882	536.93	87,296	163	12.8	72.0	84.8	6,055	2,111	81,241	886
1883	555.17	89,270	161	15.8	68.9	84.7	7,915	1,990	81,355	847
1884	570.81	91,190	160	18.8	69.2	88.0	10,318	1,824	80,872	855
1885	586.51	93,153	159	21.7	73.3	95.0	12,652	1,712	80,501	910
1886	607.29	95,527	157	23.2	75.9	99.1	14,131	1,639	81,396	933
1887	627.27	98,323	157	24.0	75.7	99.7	15,567	1,540	82,756	915
1888	644.17	100,770	156	25.2	79.4	104.6	17,382	1,449	83,388	952
1889	662.83	102,815	155	27.2	76.0	103.2	19,040	1,427	83,775	907
1890	677.55	104,980	155	28.1	89.8	117.9	20,971	1,340	84,009	1,057
1891	691.69	107,023	155	30.1	123.1	153.2	23,168	1,299	83,855	1,408
1892	707.25	109,025	154	31.2	131.9	163.1	25,652	1,218	83,373	1,582
1893	719.47	110,859	154	35.0	138.8	173.8	28,663	1,505	82,196	1,590
1894	732.63	112,549	154	38.7	135.9	174.6	30,307	1,277	82,242	1,652
1895	752.27	114,366	152	42.9	137.5	180.4	31,328	1,369	83,038	1,656
1896	770.70	116,180	151	46.7	155.0	201.7	32,950	1,416	83,230	1,863
1897	796.78	118,133	148	50.1	162.5	212.6	34,080	1,470	84,053	1,921
1898	824.94	120,457	147	50.0	176.5	226.5	35,016	1,428	85,441	2,066
1899	840.71	122,519	146	50.7	195.0	245.7	35,755	1,417	86,764	2,248

These data are shown graphically by the diagram on Plate IV.

The effect of the concentration of population and business in a limited area on Manhattan Island, appears in this table in the constant diminution of the number of taps per mile of pipe. The replacing of several small buildings, each of which had a separate water connection with the mains, by one large building with only one connection, but in which a greatly increased amount of water is used, not only reduces the number of taps in a district, but also renders it necessary to lay additional pipe to convey enough water to supply the district. Consequently the number of taps to each mile of distributing mains is decreased as the population and consumption of the district are increased.

II:—Demonstrations of Waste from Foregoing Data.

We have now data for a reasonably safe estimate of (1) the quantity of water used for public purposes; (2) the quantity used by each metered service pipe; (3) the quantity used legitimately by each unmetered service pipe, and (4) the quantity wasted from each unmetered service pipe. The difference between the sum of these and the total amount of water which is delivered into the main pipes is unaccounted for, and must be considered as leaking out of the main pipes and lost without being of any benefit to anybody.

In applying these data to the consideration of the present supply of New York, we have first the quantity of water which was delivered to the mains in 1899, as furnished to me by Mr. John R. Freeman, C.E., from the very thorough measurements of the flow of the water in the aqueduct and the rise and fall of water in the reservoirs in the City, which he made under his engagement by Hon. Bird S. Coler, Comptroller, to examine into the condition and needs of the New York water supply, in connection with the proposal made by the Ramapo Water Company to furnish an additional supply.

From the data furnished by Mr. Freeman it appears that the mean daily delivery of water to the mains in Manhattan and Bronx in 1899 was 245,700,000 gallons per day—an average of 10,240,000 gallons an hour for each hour of the day. Applying the figures above, the following table is obtained:

To the correctness of this estimate of the proportion of waste to the total consumption of water, the measurements of the hourly delivery of water to the mains, which were made by Mr. John R. Freeman, C.E., in December, 1899, furnish strong corroborative evidence. These valuable experiments were made with great care and accuracy, as detailed by Mr. Freeman in his report to Comptroller Coler. It is gratifying to me to find that

Distribution of Consumption in Manhattan.

	Miles of Streets.	Number of Services.	Gallons Per Day.	Total Gallons.	Percentage of Total.
Metered water.......	——	35,755	1,450	51,844,750	21.10
Unmetered water.....	——	86,764	355	30,801,220	12.54
Public purposes......	850	——	15,000	12,750,000	5.11
Total actually used........................				95,395,970	38.75
Amount delivered to mains.................				245,700,000	100.00
Amount wasted..............................				150,304,030	61.25
Deduct from this latter figure amount of waste from unmetered services—86,764x355 (20 per cent. of the waste)...............				30,801,220	12.54
Leaving the amount unaccounted for, and which must be wasted from the main pipes without reaching the surface of the ground (80 per cent. of the waste)...............				119,502,810	48.71

This waste amounts to 142,000 gallons per day from each mile of main pipes in use.

the conclusions reached by Mr. Freeman as to waste of water accord with the conclusions at which I arrived from the examination I made last summer, and set forth in my report on the Ramapo project which was presented by Comptroller Coler to the Board of Public Improvements, August 30, 1899. The results are shown on the accompanying Plate VII., which represents the proportion of the hourly consumption for each hour of the day to the average hourly consumption, as deduced from measurements made every six minutes for the entire week from December 8 to December 15, 1899, by Mr. Freeman.

The average hourly consumption being assumed at 100, it appears that between the hours of 8 P. M. and 7 A. M. the draught from the reservoirs is less than the average, being at its minimum, from 2 to 4 o'clock A. M., 81.75 per cent. of the average. After 7 A. M. it increases and reaches its maximum of 16 per cent. above the average at 10 A. M., after which it again decreases until at 8 P. M. it falls below the average daily rate again.

The average hourly consumption of water for the twelve night hours, from 7 P. M. to 7 A. M., is 89.45 per cent. of that for the whole day.

The correctness of this relation of night consumption to the average for the whole day is corroborated by the very elaborate and careful continuous gaugings of the flow in the sewers in a district of 271 acres southwest of Union Square made during the year 1888 by Mr. Rudolph Hering, C. E., at the request of General John Newton, then Commissioner of Public Works, and discontinued under the succeeding administration.

Mr. Hering's interesting and valuable report of these gaugings has never been published. It shows that the average daily run-off in the sewers which drained this separate watershed, in which there were 10 miles of streets, about 2,200 houses, and a population estimated at 37,692, was equivalent to a daily discharge of 96 gallons per head of population, or 1,650 gallons per house, and that the minimum run-off during the night hours was 84 per cent. of the mean hourly run-off for the whole day, amounting to 126,000 gallons per hour, or at the rate of 302,400 gallons per day per mile of street. The aggregate quantity of the discharge from the sewers was of course greater than the water consumption, by the amount of the rainfall which reached the sewers, but the mean relative discharge at night, as compared with that for the whole day, was not affected by rainfall.

The rate of night consumption is excessive. The actual use of water at night is not nearly so great.

Night Consumption of Water.

To obtain some idea of the actual night use, I had the meters which I had placed on residences read night and morning. Except where there was evident leakage, the use during the twelve night hours averaged 25 per cent. of the use for the whole day. Similar inspection of the meters in several large apartment houses showed the same result. In a number of large office buildings, where the steam is kept up in the boilers and the tanks are filled during the night, I found from the meter readings that the night use was also 25 per cent. of the total.

The night rate of use of the metered water in general must be greater than this, as there are many large establishments which are in operation and using the full rate all day and all night.

From a study of the classification of meters, as given in the reports of the Chief Engineer, I estimate that one-eighth of the meters in use pass 40 per cent. of the metered water, and have the same rate day and night.

The remaining seven-eighths of the meters, using 60 per cent. of the metered water, use 25 per cent. of their water during the night.

Of the water for public uses, I estimate that the night rate of use is the same as the day rate. The relative use and waste of water by night and by day are, therefore, as follows, the total daily consumption being assumed as 100, and the night hours as from 7 P. M. to 7 A. M.:

	Percentages of Total Consumption.		
	In 24 Hours.	By Night.	By Day.
Used by large industrial meters, 40% of 21.10%...	8.440	4.220	4.220
Used by other metered consumers, 60% of 21.10%.	12.660	3.165	9.495
Used by unmetered consumers..................	12.540	3.135	9.405
Used for public purposes......................	5.110	2.555	2.555
Total used..................................	38.750	13.075	25.675
Total consumption............................	100.000	44.725	55.275
Waste	61.250	31.650	29.600

The night waste by this computation is 6.9 per cent. greater than the day waste. This is natural and proper. The night rate of use being only about 52 per cent. of the day rate, the water flows through the pipes with less velocity and it rises to a higher level and increases the pressure, and, consequently, the leakage through old orifices, whether above or below ground.

To check this computation I have had the variation of pressure in the pipes noted in two instances, one at the corner of Broad and Beaver streets, one at Third avenue and Fifteenth street, and the Chief Engineer has also furnished me with a record of pressure gaugings taken on the main pipe in Elm street.

The gauging at Broad and Beaver streets, in a district in which there is probably as great underground waste as in any portion of the city, indicated a night leakage 18 per cent. greater than the average for the whole day. The other two gaugings, representing the relation between day and night consumption in large districts, showed, when taken in connection with the observations on night use in those districts, that the night pressure was such as to produce from 6 to 7 per cent. greater leakage than that caused by the day pressure, thus verifying the above computation. On Plate VII. the proportion of water used to that furnished from the aqueducts is shown in accordance with these gaugings and computations.

Night Use and Waste in Boston.

To compare these conditions with those existing in other cities, I have procured data regarding the hourly consumption of water in Boston and Fall River.

In the City of Boston, the distribution system has for several years been divided into districts, each containing from 150 to 250 services. Deacon meters on the main pipes are periodically used to record the hourly consumption of water. When the night use is excessive, an examination of the use of water in the buildings is made and defective plumbing caused to be repaired, after which the record of the district meter is again taken.

Mr. William Jackson, the City Engineer, has kindly furnished me with several of these records, taken during the year 1899, together with maps of the districts and memoranda regarding the class of buildings and their occupancy. From these

I have computed the hourly consumption in three districts, which include the poorest class of tenements, the best class of apartment houses and a high-grade suburban district, the combination of the three comprising 511 services or separate houses, on 3.54 miles of main pipe. The number of occupants is estimated to be 7,250.

The relative hourly consumption of water in this representative section of the residence portion of Boston is shown on Plate VII. by two broken lines, the upper one showing the consumption before inspection by the district system in 1899, and the lower one the proportional consumption after the inspection and checking of the house waste.

The midnight consumption, which in Manhattan is 81.7 per cent. of the all-day rate, was 70.7 per cent. in Boston before house waste was checked, and after it was checked was 59.8 per cent.

Assuming that the night use of water in the Boston district under consideration bears the same proportion to the total daily use as we find to prevail in Manhattan, namely, 25 per cent.; that the public use is at the same rate per mile of street as in Manhattan, and that the house waste is as shown by the district inspection, a calculation proves that the daily consumption per tap or house is 275 gallons per day, the house waste is 205 gallons per tap and the waste from the mains 45,000 gallons per mile per day. The total waste is 66 per cent. of the entire consumption. But much as these figures are below the Manhattan rates, they are altogether too high to apply to the whole of the Boston supply.

The daily consumption in Boston in 1899 was 65,573,000 gallons per day, as given to me by Mr. F. P. Stearns, the Chief Engineer of the Metropolitan Water Board.

	Gallons.
Of this, 4,822 meters used	15,121,655
The rest must be apportioned among 80,365 taps and 696 miles of street mains. A reasonable distribution ot this, taking into account the fact that during the year the house waste was reduced 200 gallons per tap over a large part of the city by the district inspectors, is as follows:	
80,365 taps used 275 gallons each	22,100,375
80,365 taps wasted 100 gallons each	8,036,500
On 696 miles pipe, public purposes took 15,000 gallons per day	10,440,000
And from 696 miles of pipe there was wasted	9,874,470
	65,573,000

On this assumption the street main waste amounts to 14,187 gallons per mile of pipe per day, and the total waste is 27.3 per cent. of the total consumption.

Night Use and Waste in Fall River.

In the City of Fall River, Mass., which is one of the very few cities in which care is taken to repress waste and to keep records of the consumption, Mr. Patrick Kieran, the Superintendent of the Water Works, had hourly observations of the consumption of water taken, at my request, for a week continuously, in February, 1900. The result is shown on Plate VII. by a fine line. The average night consumption was 78.5 per cent. of the all-day average, the minimum being 64 per cent. The night consumption was thus 39.25 per cent. of the total, and the day consumption 60.75 per cent. The use of water for public purposes is 15.4 per cent. of the total, or 6,410 gallons per mile of pipe.

The use of water by consumers is 320 gallons per tap per day, and this notwithstanding the fact that there are many large manufacturing establishments using water continuously in great quantities. The night waste is 24 per cent. greater than the day waste, and the total waste is stated by Mr. Kieran to be 24.4 per cent. of the consumption. As 94 per cent. of all the taps are metered, this waste must be leakage from the street mains. It amounts to 892,000 gallons per day from 86 miles of pipe, or 10,400 gallons per day per mile of pipe.

The Fall River works are twenty-five years old, and the Boston works fifty years old.

It is invariably found that the loss of water from leaks in street mains increases with the age of the works.

In both Fall River and Boston it must be borne in mind that the consumption measured included the waste from all causes; the same as was the case with Mr. Freeman's measurement of the Manhattan hourly variations in consumption.

On Plate VII. is also shown the hourly rate of consumption in Brooklyn, as determined by a test made by Mr. Freeman for three days in April. This will be seen to agree quite closely with the first Boston rate and indicates that the waste is not as great in Brooklyn as in Manhattan.

This, then, is the condition in Manhattan at present.

The Croton and Bronx aqueducts deliver 245,700,000 gallons daily to the City.

Of this amount 38.75 per cent. is used, and 61.25 per cent. is unaccounted for. Of this last 12.54 per cent. is wasted from houses and the rest from mains, amounting to 142,000 gallons per mile of pipe.

In Boston, 73 per cent. of the water delivered is used, and 27 per cent. is unaccounted for, the waste from the mains amounting to 14,187 gallons per mile of pipe.

In Fall River, 76 per cent. of the water delivered is used, and 24 per cent. is unaccounted for, amounting to 10,000 gallons per mile of pipe.

The problem to be solved is how to reduce the waste of water to the proportions which prevail in other cities, where care is taken to stop waste.

If the waste of water from street mains can be reduced from 142,000 gallons to the Boston rate of 14,000 gallons per day per mile of street mains, the result will be a saving of 107,520,000 gallons a day.

If a further reduction of waste from houses can be effected to the amount of 80 per cent. of the waste, the saving will be 25,000,000 gallons. The consumption would then be:

	Gallons.
Metered water used	51,844,750
Unmetered water used	30,801,220
Public purposes	12,750,000
Waste from mains	11,760,000
Waste from houses	6,000,000
	113,155,970

An average of about 56 gallons per capita of the total population of the city, a supply ample for all purposes.

I believe that such a result can be attained by the application of the district system of inspection of mains and houses, and the placing of meters on all buildings in which water is used. This can be done at the expense of the city, and the consumer charged for the water he uses, by measure.

Under the existing law, the cost of a meter cannot be charged to a consumer, unless he is engaged in some business.

There is no necessity, however, for the consumer paying for the meter. Under the provisions of the New York Charter the Municipal Assembly has power to prescribe that all water used shall be paid for by measure. The language of the Charter is explicit on this point, and is as follows:

Municipal Assembly: Power to Fix Rents, Etc., for Water Supply.

SEC. 473: The Municipal Assembly shall hereafter have all power, on recommendation of the Board of Public Improvements, to fix and establish a uniform scale of rents and charges for supplying water by the City of New York, which shall be apportioned to different classes of buildings in said City in reference to their dimensions, values, exposures to fires, ordinary uses for dwellings, stores, shops, private stables and other common purposes, number of families or occupants, *or consumption of water*, as near as may be practicable, and modify, alter, amend and increase such scale from time to time, and to extend it to other descriptions of buildings and establishments.

There is really no conflict between this and Section 475, which says that the Water Commissioner may place water meters on stores, workshops, hotels, manufactories, office buildings, public offices, and also at wharves, ferry-houses, stables and all places where water is used for business consumption.

There is a decision of the Court to the effect that this permission to place meters and compel the owner to pay for the meter and for the water by measure does not apply when the sole actual consumption of water is for the use of employées of the building. If, however, the owner is not called upon to pay for the meter, it is difficult to see how the Commissioner could be restrained from compelling him to pay for water furnished through a meter owned by the City, at a rate fixed by the Municipal Assembly under the provisions of Section 473.

Let meters once be placed on buildings and the water used be required to be paid for, no inspection of houses or plumbing will be required on the City's part; the owner will attend to that. This is evidenced by the experience of several hundred of the metered premises in New York. In one notable instance, that of one of the first of the large office buildings erected near City

Hall Park, the use of water during the first year of its occupancy was 73,000 gallons a day. The owners investigated the causes of such large use, and for the last three years the use in that building, with the same number of tenants, has been 55,000 gallons a day; and yet, everybody has had all the water they wanted.

Reduction of Street Waste.

The reduction of the amount of waste from the old mains is of more importance than the repression of the house waste. This can be accomplished only by the organization of a Bureau of Waste Detection, under a Civil Engineer of experience in water works management, and the division of the city into districts controlled by Venturi meters on the mains, and the keeping of regular records of the amount of water used in each district, at stated intervals of time. For this system no elaborate machinery is required. The meter is simply a specially constructed pipe, with attachments to which an electric recording apparatus can be applied as needed, being placed in a small vault at the curb line.

In inspecting any district the Venturi meter on the main must be recorded for a stated time, and the house meters read also. This need not require any intrusion on private premises at inconvenient hours.

Where the district meters show an excessive consumption of water, the tracing of a leak will not be a difficult matter to an experienced and intelligent man. In nine cases out of ten I believe that an intelligent examination of the surface and inquiry among the residents would result in locating the leaks speedily. I know that my inspector of meters has reported to me a number of instances he observed, in making his rounds, where there was evident leakage from the mains or abandoned service pipes.

The Time Required.

The reduction of waste which is suggested as practicable could not be effected all at once. It need only be carried out at such a rate as to keep the supply equal to the demand, and might be extended over a period of fifteen years for the house waste and forty to fifty years for the waste from the mains.

The City should be divided into about 500 districts by Venturi meters. These might be put in at the rate of 100 a year, at a cost of $60,000.

Of house meters, there are now about 1,000 added every year. There ought to be 10,000 put in yearly at a cost of $180,000.

If by such a system the regulation of the consumption were effected, the consumption of water in 1915 would be, as shown on Plate VIII.—allowing 1,500 gallons per day to be used by 30 per cent. of the taps, and 400 gallons per day by the remainder, all taps being metered, and 100,000 gallons a day to be wasted from each mile of mains:

	Gallons.
46,800 meters at 1,500	70,200,000
109,200 taps at 400	43,680,000
Public uses, 1,130 miles	16,950,000
Waste, 1,130 miles pipe at 100,000 gals. per mile	113,000,000
Gallons per day	243,830,000

The reduction of waste being continued systematically, in 1930 the consumption would be:

	Gallons.
56,250 meters at 1,500 gallons	84,375,000
131,250 taps at 400 gallons	52,500,000
Public uses, 1,405 miles pipe at 15,000 gallons	21,070,000
Waste, 1,405 miles pipe at 60,000 gallons	84,300,000
Gallons per day	242,245,000

By 1950 the waste from the mains might be reduced to a reasonable amount for works 100 years old, or 40,000 gallons per mile per day, and the consumption would be:

	Gallons.
68,400 meters at 1,500 gallons	102,600,000
159,600 taps at 400 gallons	63,840,000
Public uses, 1,765 miles pipe at 15,000 gallons	26,475,000
Waste, 1,765 miles pipe at 40,000 gallons	70,600,000
	263,515,000

That such reduction of waste and placing of the distribution system in Manhattan on an efficient basis can be accomplished at a cost much less than that of introducing a new supply of water from another source, I consider certain.

Taking the question of the house waste alone, which I estimate as amounting to 30,000,000 gallons per day, and of which a large proportion would be saved by the placing of meters on all houses, the introduction of an additional supply of water to that amount from an outside source would require the construction of works furnishing a supply of 60,000,000 gallons per day, as in the present condition of the distribution service one-half of the water introduced is wasted. Any source of supply capable of furnishing 60,000,000 gallons per day would have to be of at least 100 square miles drainage area, and it would be necessary to construct storage reservoirs holding at least 11,000,000,000 gallons. The least possible cost of introducing such a supply would be $3,000,000.

To place meters on all the unmetered services in New York City would not cost half that amount.

To effect the same object by reducing the amount of water wasted from the mains would probably cost about the same as placing meters on all the houses, or less than half of what the introduction of a new supply would cost.

The stoppage of leaks and prevention of the escape of water is a much more efficient method of keeping up a good supply for domestic use, and especially for fire purposes, than the introduction of additional water into leaking mains already taxed to nearly their full capacity. For protection against fire in New York or any other large city which is supplied with an efficient Fire Department, the volume of water which can be drawn from pipes within a limited area is of much more importance than the head under which such water can be delivered from the hydrant, and the volume which can be drawn from tight pipes is greater than can be drawn from leaking mains.

Whether an additional supply of water is introduced into Manhattan from some other source or not, the unnecessary waste which now occurs ought to be checked immediately, and that can only be done by the application of the district system of inspection to the mains and placing of meters in buildings.

The first step toward the betterment of the supply of Manhattan should be, however, the erection of additional pumping engines to supply the High Service districts. There is a serious deficiency of supply in those districts.

I believe the carrying out of this system to be practicable, and that no further additional supply than can be procured from the Croton watershed will be needed in Manhattan before the year 1950.

Brooklyn and Queens.

The data of the distribution system are given in the following table:

WATER SUPPLY OF THE BOROUGH OF BROOKLYN.

YEAR.	Miles of Pipe in Use.	Total Taps.	Taps per Mile.	Metered.	Unmetered.	Total.	Metered Taps.	Consumption per Meter.	Unmetered Taps.	Consumption per Unmetered Tap.
				Daily Consumption.						
				Million Gals.				Gals.		Gals.
1859	121.99	—	—	—	—	—	—	—	—	—
1860	130.26	9,302	71	—	—	3.3	—	—	—	—
1861	141.08	12,856	91	—	—	4.1	—	—	—	—
1862	151.52	15,105	100	0.5	4.5	5.0	157	2,881	14,948	301
1863	161.05	17,145	106	—	—	6.5	202	—	16,943	—
1864	168.18	18,935	113	0.7	7.4	8.1	266	2,480	18,669	396
1865	173.52	20,382	117	—	—	9.2	301	—	20,081	—
1866	179.55	22,244	124	—	—	10.9	330	—	21,914	—
1867	191.43	24,888	130	1.0	11.4	12.4	369	2,655	24,519	465
1868	206.73	28,173	136	—	—	15.7	375	—	27,798	—
1869	225.80	32,097	142	—	—	17.6	394	—	31,703	—
1870	248.14	35,930	145	1.5	17.2	18.7	406	3,608	35,524	488
1871	268.25	39,760	148	1.4	18.0	19.4	446	3,077	39,314	458
1872	284.39	42,906	151	1.3	21.4	22.7	573	2,241	42,333	505
1873	299.85	45,876	153	1.6	23.3	24.9	695	2,265	45,181	516
1874	315.86	49,791	158	1.8	23.0	24.8	755	2,416	49,036	469
1875	325.30	51,102	157	1.7	25.5	27.2	805	2,076	50,297	507
1876	329.96	53,083	161	1.8	26.3	28.1	847	2,169	52,218	504
1877	335.36	54,879	164	2.3	28.1	30.3	898	2,506	53,981	521
1878	341.03	56,685	166	3.0	27.5	30.5	843	3,538	55,842	492
1879	345.74	58,293	168	2.8	30.1	32.9	808	3,462	57,485	524
1880	349.91	59,880	174	3.8	26.9	30.7	972	3,870	58,908	457
1881	353.52	60,568	171	3.6	29.1	32.7	1,147	3,097	59,421	491
1882	356.67	63,286	177	4.0	30.6	34.6	1,335	2,996	61,951	492
1883	362.37	64,460	178	4.6	31.5	36.1	1,514	3,135	62,946	500
1884	370.29	65,918	178	5.6	33.3	38.9	1,639	3,426	64,279	518
1885	376.74	70,890	188	5.6	37.8	43.4	1,808	3,073	69,082	549
1886	383.36	73,992	193	5.7	39.6	45.3	1,944	2,957	72,048	549
1887	392.06	77,327	197	5.8	40.5	46.3	2,003	2,891	75,324	537
1888	402.05	80,529	200	5.3	44.5	49.8	2,073	2,556	78,456	567
1889	412.03	83,973	204	6.7	45.5	52.2	2,187	3,070	81,786	556
1890	424.02	87,727	207	7.0	48.1	55.1	2,289	3,079	85,438	562
1891	437.33	91,219	209	7.4	50.7	58.1	2,371	3,125	88,848	570
1892	453.32	94,603	209	7.3	60.3	67.6	2,336	3,146	92,267	653
1893	468.98	97,626	208	8.6	67.2	75.8	2,310	3,719	95,316	705
1894	479.85	100,078	209	9.1	67.0	76.1	2,337	3,877	97,741	686
1895	498.66	103,444	207	10.1	72.5	82.6	2,405	4,192	101,039	718
1896	535.76	106,753	199	10.9	73.0	83.9	2,564	4,277	104,189	700
1897	567.25	108,916	192	10.7	79.5	90.2	2,598	4,126	106,318	748
1898	577.83	111,100	192	10.8	82.8	93.6	2,640	4,107	108,640	763
1899	587.67	113,154	193	12.5	83.4	95.9	2,880	4,444	110,274	756

In this case, the diminution of taps per mile of pipe during the last five years was not due to concentration of population, but was caused by the extension of the distribution system into the sparsely populated districts of Gravesend and New Utrecht, where there were not more than about 60 taps to each mile of pipe.

The condition of the distribution service in Brooklyn is much better than in Manhattan. The statistics of the growth of the distribution service and the quantity of water used are given in the accompanying table and are shown on Plate IV.

Notwithstanding the small number of meters in use, only 2,880 out of a total of 113,154 services, the average consumption of water per unmetered service, including all public uses, house waste and waste from the mains, is 756 gallons per day per service, as against 2,248 gallons in Manhattan. The record of twelve water meters which I placed in residences in Brooklyn is shown in the following table and the accompanying Plate VI.:

RECORD OF 12 WATER METERS ON RESIDENCES IN BROOKLYN.

Average for three weeks in January and February, 1900.

No.	Nearest Street or Avenue.	Gallons Per Day.	Number of Occupants.	Gallons Per Cap.	Stories.	Baths.	Water Closets.	Faucets.
12	Lafayette Ave.	86.87	5	11.37	3	—	1	6
11	Grand Ave.	156.92	4	39.23	3	—	—	—
10	Livingston St.	181.88	5	36.38	3	1	2	23
9	Lafayette Ave.	209.61	5	41.92	3	1	2	19
8	Berkeley St.	218.33	5	43.67	3	1	2	19
7	Hancock St.	239.48	5	47.90	3	1	2	17
6	Henry St.	306.51	7	43.80	4	1	2	15
5	Gates Ave.	321.75	6	53.63	3	1	2	15
4	Carroll St.	332.72	5	66.54	3	3	3	19
3	Willow St.	575.90	9	63.98	3	2	3	25
Average of 10 houses		263.00	5.6	46.96	—	—	—	—
2	S. Portland Ave.	781.95	9	86.88	4	1	2	—
1	Halsey St.	1282.67	8	160.33	3	1	2	19
Average of 2 houses		1032.31	8.5	121.45	—	—	—	—
Average of 12 houses		391.22	6.1	64.31	—	—	—	—

Of the twelve houses metered, two were found to be using the water excessively. The average of water used in the other ten was 263 gallons per day, and on the attention of the occupants being called to the waste in the other houses, it was promptly checked in one instance, and in the other was allowed to continue for some time merely for the purpose of fuller examination of the causes of leakage. For the last three weeks, March 8 to 29, the average consumption in these twelve houses was 320 gallons per day, or 52.5 gallons per capita of occupants. These houses are very fair samples of the residences in Brooklyn, and show that from 265 to 300 gallons per day is an ample supply for the average house. A considerable saving can doubtless be effected by the application of meters to all residences and the application of the district system to the inspection of mains before they have reached the stage of deterioration which prevails in the Manhattan distribution service.

The Brooklyn water works are not as old as the Croton water works by about seventeen years, and the leakage from the mains cannot be expected to be as great. As nearly as can be estimated, it is in the neighborhood of 60,000 gallons per day per mile of pipe.

Very full statistics of the pumping engines and pipe system are given in the accompanying table prepared by Mr. Lebbeus B. Ward, C. E., from personal inspection.

The sources of supply of Brooklyn are nearly exhausted, and, as I have before stated, the introduction of a new supply from sources outside the city is greatly needed for the Boroughs of Brooklyn and Queens. Such supply ought to have a capacity of at least 300,000,000 gallons per day, and it would be desirable to have it delivered in the City at an elevation of 170 to 200 feet above tide level.

Richmond.

The Borough of Richmond is and for many years will remain a suburban district. All obtainable data regarding the present water supply are furnished in the statement prepared by Mr. Ward. For five years it is probable that water can be obtained from local sources on Staten Island, but investigation should at once be undertaken for the furnishing of an additional supply from other sources and the abandonment of the supply derived from Staten Island itself.

Purchase of Private Companies.

The public interest demands that all the works supplying water to New York should be owned and controlled by the city. On the expiration of existing contracts, the works now owned by private corporations should be acquired by the city.

All of which is respectfully submitted.

J. JAMES R. CROES,

April 15, 1900. Consulting Engineer.


THE WATER SUPPLY
OF THE
CITY OF NEW YORK.
1900
Showing the areas now supplied and the sources and ownership of the several supplies.
Prepared for the Committee on Water Supply of the Merchants Association of New York. To accompany report on the History, Condition and Needs of the New York City Water Works.
J. JAMES R. CROES.
M. AM. SOC. C. E., M. INST. C. E.
APRIL 1900.
EXPLANATION.
Low service, Municipal Plants, shown,
High " " " "
Tower " " " "
Low " Private Companies "
" " " Dependent " "
High " " " "
Low " The Bronx "
High " " " "
Municipal Pumping Stations "
Private Co. " " "
Municipal Stand Pipes "
Private Co. " " "
WATTS POND STATION .6 Miles East of CLEAR STREAM
SMITHS POND " 3.5 " " " " "
MILBURN " 6.5 " " " " "
AGAWAM " 8.3 " " " " "
MERRICK " 9.0 " " " " "
MATOWA " 9.8 " " " " "
WANTAGH " 11.0 " " " " "
MASSAPEQUA " 13.8 " " " " "
CLEAR STREAM.
QUEENS CO. W. CO.
ATLANTIC OCEAN
JAMAICA BAY
LONG ISLAND SOUND
LITTLE NECK BAY
FLUSHING BAY
EAST RIVER
HUDSON RIVER
HARLEM RIVER
LOWER BAY
UPPER BAY
RARITAN BAY
NEWARK BAY
THE NARROWS
KILL VON KULL
ARTHUR KILL
BUTTERMILK CHANNEL
Governor's Island
Ellis Island
Bedloe's Island
Blackwells Island
BROOKLYN
RICHMOND
CENTRAL PARK
PROSPECT PARK
FLUSHING MUNICIPAL
GERMAN AMERICAN IMP. CO.
NEW UTRECHT MUNICIPAL
GRAVESEND MUNICIPAL
FLATBUSH W. CO.
STATEN ISLAND W. CO.
CRYSTAL W. CO.
N.Y. & WESTCHESTER
SCALE OF FEET
0 4000 8000 12000 16000


MAP OF
THE
CITY OF NEW YORK.
Showing by color the areas which can not be supplied with water directly from the present sources of supply, but for which additional pumping is necessary.
J. JAMES R. CROES.
M. AM. SOC. C.E., M. INST. C.E.
APRIL 1900.
ATLANTIC OCEAN
JAMAICA BAY
LOWER BAY
RARITAN BAY
THE NARROWS
UPPER BAY
LONG ISLAND SOUND
LITTLE NECK BAY
FLUSHING BAY
EAST RIVER
HUDSON RIVER
KILL VON KULL
ARTHUR KILL
NEWARK BAY
BROOKLYN
RICHMOND
PROSPECT PARK
CENTRAL PARK
Blackwells Island
Wards Island
Governor's Island
Ellis Island
Bedloe's Island
Jerome Park Reservoir
Harlem
PELHAM BAY
EASTCHESTER BAY
City Island
Hart Island
BUTTERMILK CHANNEL
GOWANUS BAY
FLATLANDS
NEW LOTS AVE
OCEAN
AMBOY ROAD
TURNPIKE
SCALE OF FEET
0 4000 8000 12000 16000

PLATE III

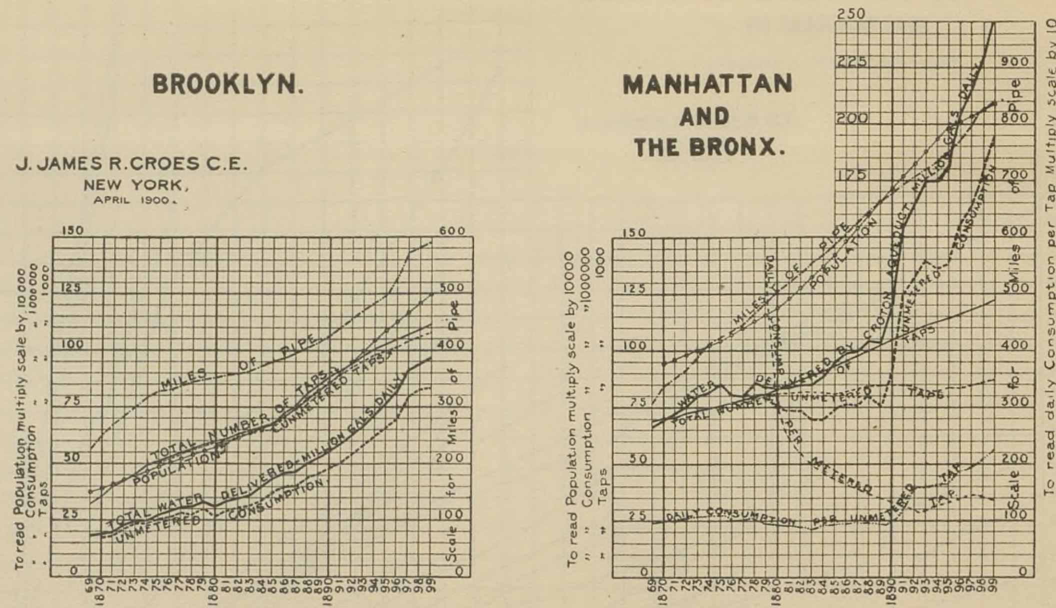
CURVES SHOWING DEPLETION OF CROTON RESERVOIRS FOR DAILY DRAFT OF 280,000,000 GALLONS AND 350,000,000 GALLONS.

Curve for 280,000,000 Draft. ‐ ‐ ‐ ‐ ‐ ‐ ‐ ‐

" " 350,000,000 " ————————

J. JAMES R. CROES C.E.
NEW YORK.
APRIL 1900.

PLATE IV



BROOKLYN.
J. JAMES R. CROES C.E.
NEW YORK,
APRIL 1900.
To read Population multiply scale by 10 000
" " Consumption " " " 1000000
" " Taps " " " 1000
Scale for Miles of Pipe
MILES OF PIPE
TOTAL NUMBER OF TAPS
UNMETERED TAPS
POPULATION
TOTAL WATER DELIVERED-MILLION GALS DAILY
UNMETERED CONSUMPTION
MANHATTAN
AND
THE BRONX.
To read Population multiply scale by 10000
" " Consumption " " "1000000
" " Taps " " " 1000
To read daily Consumption per Tap Multiply scale by 10
Scale for Miles of Pipe
MILES OF PIPE
POPULATION
CROTON AQUEDUCT
WATER DELIVERED BY CROTON
TOTAL NUMBER OF TAPS
UNMETERED TAPS
UNMETERED CONSUMPTION
DAILY CONSUMP
PER METERED TAP
DAILY CONSUMPTION PER UNMETERED TAP

RECORD OF 25 WATER METERS ON RESIDENCES IN MANHATTAN.

JANUARY 15, TO MARCH 30, 1900.

J. JAMES R. CROES C.E.
NEW YORK.
APRIL 1900.

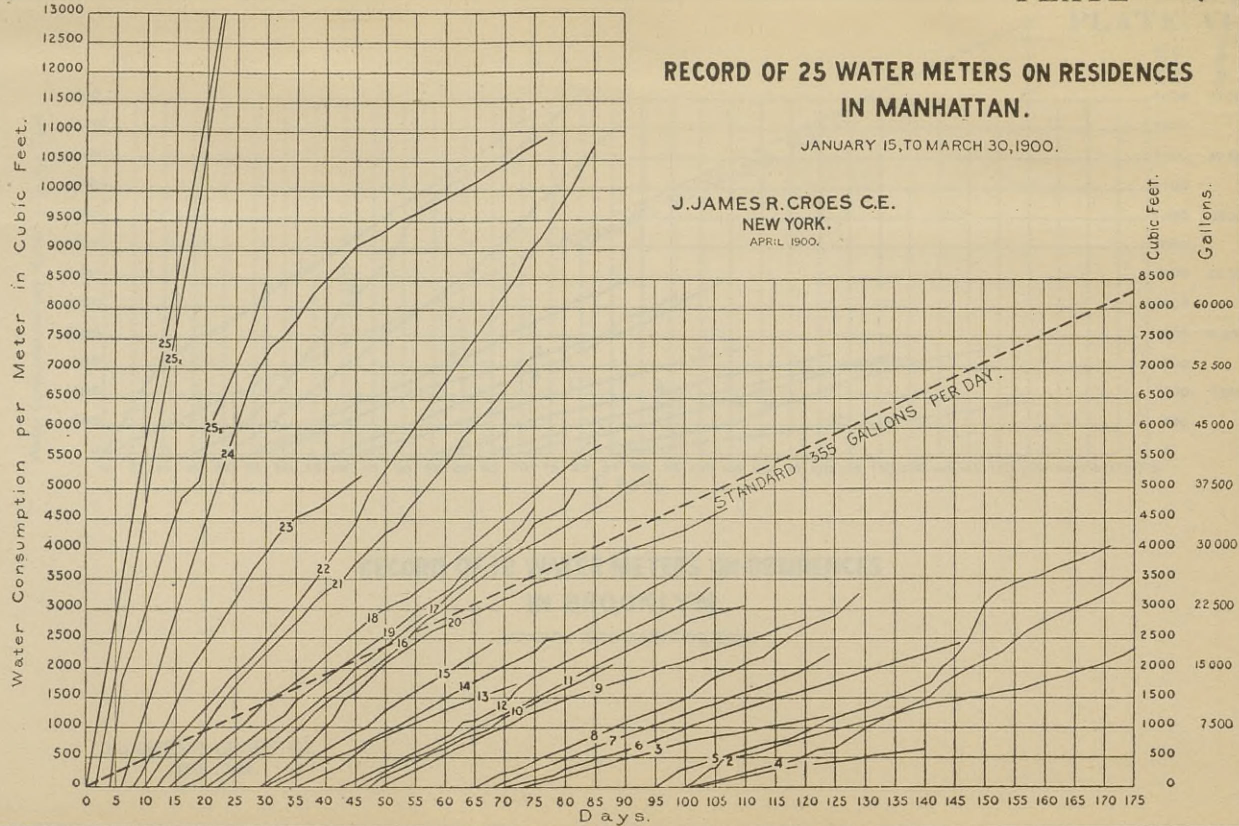
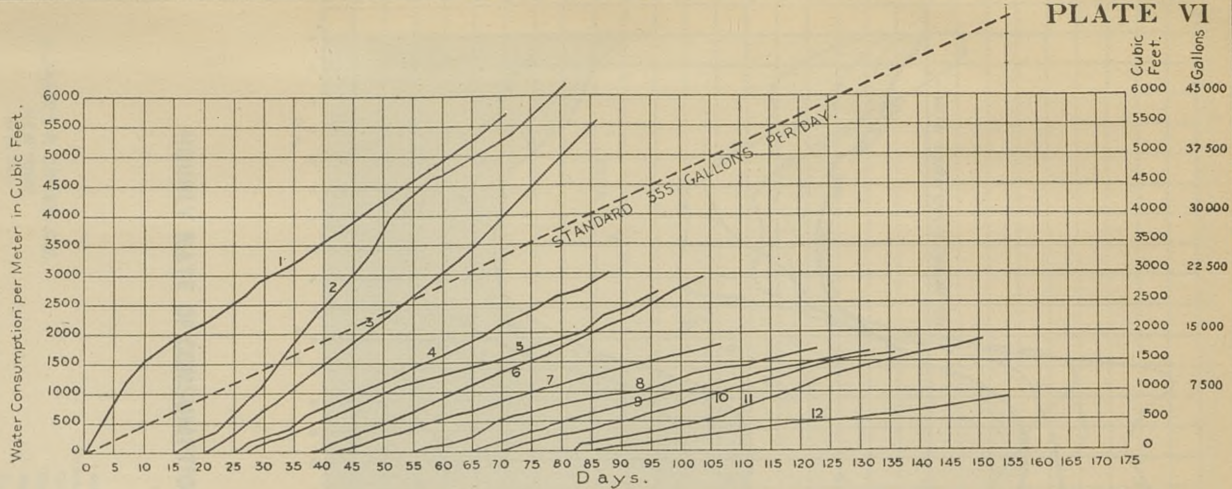


PLATE VI

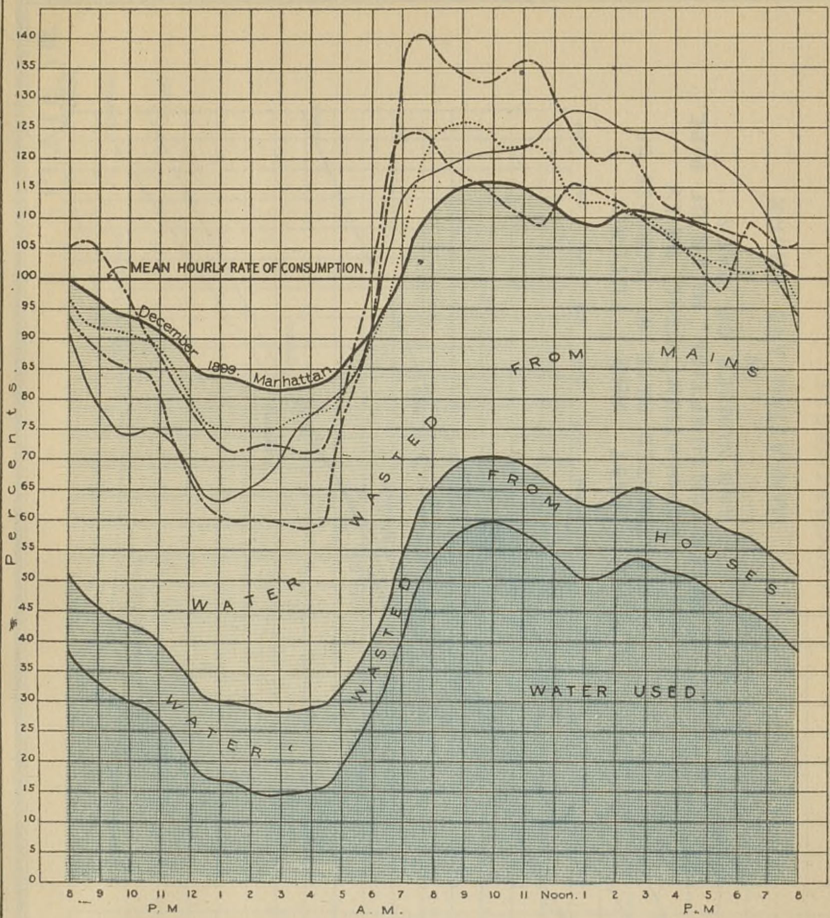


RECORD OF 12 WATER METERS ON RESIDENCES IN BROOKLYN.

JANUARY 15, TO MARCH 30, 1900.

J. JAMES R. CROES C.E.
NEW YORK.
APRIL 1900.

PLATE VII



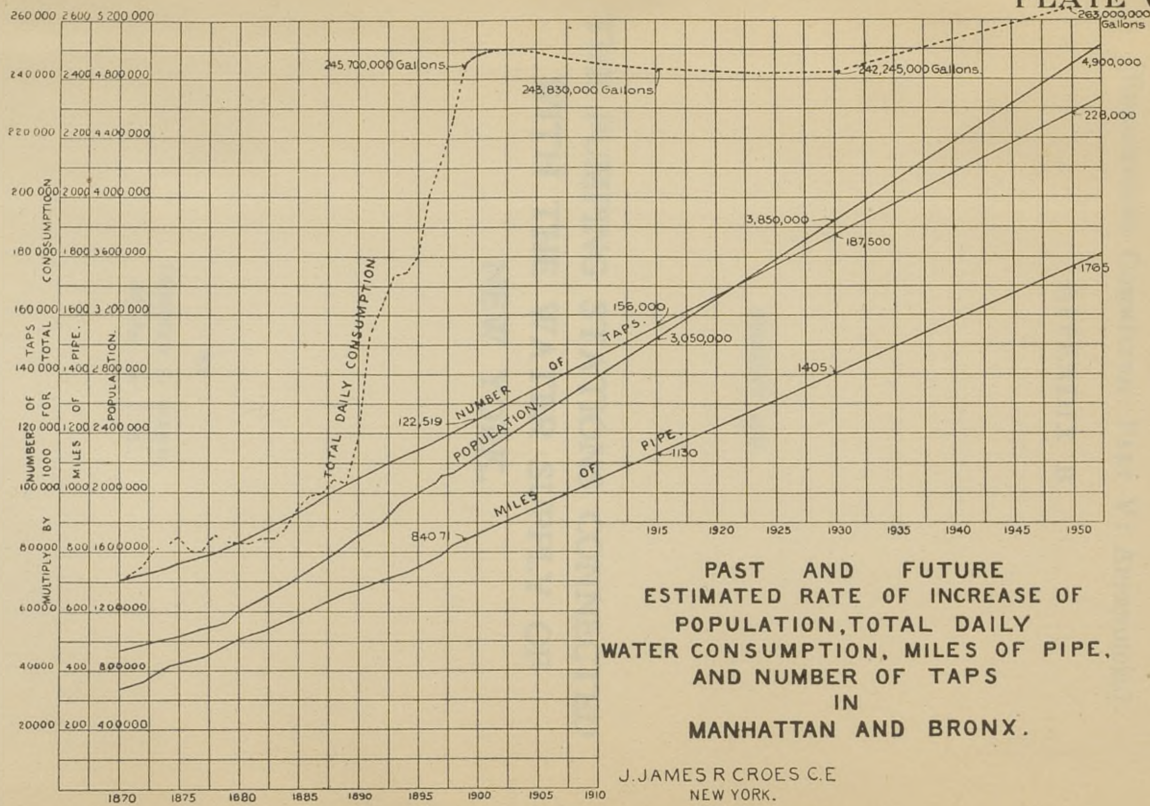
HOURLY RATE OF CONSUMPTION OF WATER.

HOURLY RATE OF CONSUMPTION OF WATER.

In Manhattan ━━━━ Dec. 1899.
Fall River ———— Feb. 1900.
Boston —·—·— Before checking house waste June 1899.
Boston —··—··— After checking house waste Sept. 1899.
Brooklyn ·········· April. 1900.

J. JAMES R. CROES C.E.
NEW YORK.
APRIL 1900

PLATE VIII.



PAST AND FUTURE
ESTIMATED RATE OF INCREASE OF
POPULATION, TOTAL DAILY
WATER CONSUMPTION, MILES OF PIPE,
AND NUMBER OF TAPS
IN
MANHATTAN AND BRONX.

J. JAMES R CROES C.E
NEW YORK.
APRIL 1900.

[Engineering Committee: Part V: Appendices]

APPENDIX B

REPORT ON

THE PUMPING STATIONS CONNECTED WITH THE WATER SUPPLY OF NEW YORK.

BY

LEBBEUS B. WARD,

M. Am. Soc. C. E.

CONTENTS OF APPENDIX B.

THE PUMPING STATIONS CONNECTED WITH THE WATER SUPPLY OF NEW YORK.

By Lebbeus B. Ward, C. E.

To the Engineering Committee of the Merchants' Association of New York, Thomas C. Clarke, Past Pres. Am. Soc. C. E., Chairman:

Gentlemen :

In accordance with your instructions, I submit the following report upon the pumping stations connected with the water supply of New York:

I.

Summary of the Distributing Service.

The pumping of a large proportion of all the water at present furnished to the inhabitants of New York City is a necessary consequence (1st) of the low elevation of the sources of Brooklyn's water supply, all of which are near sea-level, and (2d) of the existence of a high-service area in the central and northern portions of Manhattan, containing a large and increasing population, and which is above the level at which the Croton water can be distributed by gravity. Large areas in the northern and western portions of the Borough of The Bronx are also above any possible distribution of water by gravity from either the Croton or Bronx Aqueducts. The Boroughs of Queens and Richmond are wholly dependent upon water pumped from wells and springs for their public water supply; Brooklyn to a large extent, and the Borough of The Bronx to a limited extent, depend upon ground-water from driven wells. Of the total water supply of the city, 45 per cent. is delivered by the agency of 32 municipal and 19 private pumping stations.

Calling the daily consumption of the Croton and Bronx waters

230,000,000 and 20,000,000 gallons respectively, the quantities of water from all sources furnished to the several boroughs of the City of New York in 1899, reduced to a daily average for the year, stated in the aggregate and sub-divided into gravity and pumped supplies, and into surface and ground-water supplies, are as follows:

Quantity and Distribution of Water.

The aggregate quantity of water supplied daily in each Borough is:

	Gallons.	
In Manhattan	230,000,000	
In Bronx	21,000,000	
In Brooklyn	102,663,000	
In Queens	12,925,000	
In Richmond	5,190,000	
Total for the city	371,778,000	

The quantity distributed by gravity alone is:

	Gallons.	
In Manhattan	186,000,000	
In Bronx	18,500,000	
Total gallons distributed by gravity		204,500,000

The quantity distributed by the aid of pumps is:

	Gallons.	
In Manhattan	44,000,000	
In Bronx	2,500,000	
In Brooklyn	102,663,000	
In Queens	12,925,000	
In Richmond	5,190,000	
Total gallons distributed by pumping		167,278,000
Total daily consumption for the city		371,778,000

The quantity of surface water distributed is:

	Gallons.	
In Manhattan	230,000,000	
In Bronx	20,000,000	
In Brooklyn	61,126,500	
Total gallons of surface water		311,126,500

The quantity of ground water distributed is:

	Gallons.	
In Manhattan	none	
In Bronx	1,000,000	
In Brooklyn	41,536,500	
In Queens	12,925,000	
In Richmond	5,190,000	
Total gallons of ground water		60,651,500
Total daily consumption for the city		371,778,000

Service Furnished by Private Water Companies.

Of the entire water supply of New York 5.89 per cent. is furnished by private water companies, whose sole dependence is ground-water, drawn from wells located in the vicinity of the points of consumption, and within the borough limits, as a rule. The number and importance of these pumped supplies varies in the different boroughs.

These private works have originated in the urgent need of water experienced by the numerous suburban communities. They have appropriated the ground-water in the various localities, as the only available source of supply. The yield of water obtainable at a single station varies greatly, the maximum of the private works being 4,330,600 gallons and the average 1,376,500 gallons. The older companies have, therefore, been compelled, with one or two exceptions, to construct additional stations from time to time to develop new gathering grounds, in order to meet the growing demands of their business. As a result of these extensions there are now few favorable or available locations open to selection.

For information as to the details of the operation of the various companies, reference is made to the annexed table of plants of private water companies operating in the several boroughs, and to the general tables of details of pumping stations.

In the following table the area served, miles of pipe in use and so much of the water taken from each company's private sources as is actually distributed in each borough are shown:

Borough and Company.	Area Served with Water. Acres.	Miles of Pipe.	Water Distributed in the Borough Daily. Gallons.
Manhattan	none	none	none
Bronx:			
N. Y. & Westchester Water Co.	1,764	50	1,000,000
Brooklyn:			
L. I. Water Supply Co.	1,224	49.16	4,330,600
Flatbush Waterworks Co.	2,693	72.	2,155,400
Blythebourne Water Co.	662	30.	200,000
German-American Imp. Co.	197	8.6	70,000
Borough total	4,776	159.76	6,756,000
Queens:			
Citizens Water Co.	1,758	56.92	4,185,700
Jamaica Water Supply Co.	2,000	60.	1,500,000
Woodhaven Water Supply Co.	840	32.	548,000
Montauk Water Co.	——	9.5	1,800,000
Queens County Water Co.	1,277	37.17	1,000,000
Borough total	5,875	195.59	9,033,700
Richmond:			
Staten Island Water Supply Co.	1,985	66.	3,810,000
Crystal Water Co.	1,198	46.	1,200,000
South Shore Water Co.	98	3.	100,000
Borough total	3,281	115.	5,110,000
Grand total for the city	15,696	520.35	21,899,700

RECAPITULATION.

Borough.	Number of Companies.	Number of Stations.	Daily Supply. Gallons.	Per Cent. of Entire Supply to Borough.
Manhattan	none	none	none	none
Bronx	1	2	1,000,000	4.76
Brooklyn	4	4	6,756,000	6.58
Queens	5	7	9,033,700	69.89
Richmond	3	6	5,110,000	98.46
Total for the city	13	19	21,899,700	

Municipal Water Supply in the Several Boroughs.

An aggregate of 348,500,000 gallons of water is delivered daily in the city by municipal water-works; the proportion distributed by gravity alone is 204,500,000 gallons, and the balance, 144,000,000, is pumped for the supply of the different boroughs, as follows:

Borough and Service.	Area Served with Water. Acres.	Miles of Pipe.	Daily Pumpage in 1899. Gallons.
Manhattan:			
Low service	8,656	543.25	none
Main high service	2,275	121.80	39,992,400
Upper high service	438	12.20	3,960,000
Borough total	11,369	677.25	43,952,400
Bronx:			
Low service	3,700	157.0	none
High service	1,170	8.0	130,000 (Taken from Yonkers)
Borough total	4,870	165.0	130,000
Brooklyn:			
Low service	11,145	501.75	85,662,800
Main high service	1,841	80.76	7,324,700
Upper high service	382	14.20	2,919,500
Borough total	13,368	596.71	95,907,000
Queens:			
Long Island City	858	33.19	2,107,600
Flushing	1,912	15.4	1,783,700
College Point		15.42	
Whitestone		10.42	
Borough total	2,770	74.43	3,891,300
Richmond:			
Tottenville	202	6.1	80,000
Grand total for the city	32,579	1519.49	143,960,700

RECAPITULATION.

Borough.	Daily Supply Pumped by Municipal Works.	Per Cent. of Entire Supply of Borough.
Manhattan	43,952,400	19.11
Bronx (Yonkers)	130,000	0.62
Brooklyn	95,907,000	93.42
Queens	3,891,300	30.10
Richmond	80,000	1.54
Total	143,960,700	——

II.

BOROUGH OF MANHATTAN.

The water supply of Manhattan since the completion of the new Croton Aqueduct in 1891 has been wholly drawn from the Croton Watershed. Between 1884 and 1891 the Bronx Aqueduct contributed a limited quantity of Bronx water to the service of Manhattan. Since 1891 the demand for water in the Borough of The Bronx has outgrown the capacity of the Bronx and Byram watersheds, and it has become necessary to supplement the Bronx service with water from the Croton, which is the reliance for maintaining an adequate supply in the future in that borough.

Manhattan Island has within recent years been intersected by the Harlem Ship Canal. That part of the island lying north of the canal, 45 acres in extent, is now attached to the Bronx system of distribution; and all that part lying south of the canal, embracing an area of 12,700 acres, is confined to the Croton system of distribution. Within the borough limits are included Governor's, Ward's, Randall's and Blackwell's Islands, and the Sunken Meadows, aggregating 722 acres. The Croton is distributed on Ward's, Randall's and Blackwell's Islands; Governor's Island is supplied from Brooklyn. The aggregate land area of the Borough of Manhattan is 13,487 acres.

Gravity and High Service Zones.

The zone of direct gravity distribution of the Croton on Manhattan Island is the area included between the water front and the contour line of 60 feet above tide, approximately 8,400 acres. The aggregate area included by the 60-foot contour, amounting to 4,300 acres, and extending with one or more breaks, from Thirty-fourth street to the northern boundary of the borough, requires a high service, which is furnished up to the present requirements of the population by pumping Croton water from the aqueducts and reservoirs within the borough. The greater elevation of the ground at the northern end of the island, reaching a maximum of 258 feet above tide on Washington Heights at 181st street, has made two grades of high service necessary. Accordingly, the area above the 60-foot contour has been divided into (1) a main high service district, ending at 169th street and having a maximum surface elevation of 140 feet at 116th street—this district is operated under 215 feet head; (2) an upper high service district under a head of 321 feet, extending from 169th street to the Harlem Ship Canal at the northern end of the island.

The low service terminates at 162d street. In the area of 1,540 acres bounded by the Hudson and Harlem rivers, and lying between the Harlem Ship Canal and the northern limits of the main high service and low service districts, at 169th and 162d streets respectively, the only distribution of water is that of the upper high service, covering an area of 438 acres.

Eliminating Central Park as an exceptional area not liable to urban occupation, the net areas, present and prospective, pertaining to the designated services on Manhattan Island are as follows:

Service Areas: Manhattan.

		Acres.
Manhattan Island south of Ship Canal		12,700
Deduct Central Park		840
Net area		11,860
Low Service (Gravity Supply):		
Area now covered below 162d street	8,043	
Area of less than 60 feet elevation north of 162d street	613	
Total area of Low Service zone		8,656
Main High Service (Head of 215 Feet):		
Area between 34th street and 169th street covered by present distribution system		2,275
Upper High Service (Head of 321 Feet):		
Area covered by present distribution system north of Main High Service	438	
Area not yet covered as above	491	929
Aggregate area now served, or to be served		11,860

The average daily consumption of Croton water in the several districts, based on a total of 230,000,000 gallons, is as follows:

	Gallons.
Low Service	186,000,000
Main High Service	40,000,000
Upper High Service	4,000,000
Aggregate Croton consumption in Manhattan	230,000,000

Mileage of Pipes and Streets.

The mileage of streets actually included in the distribution systems of the High Service, Upper High Service and Low Service districts, respectively, has been carefully computed, taking the aggregate length of pipe laid since the introduction of the Croton water, as reported by the Department, and deducting therefrom the length, as shown on the official maps, of the multiple lines of pipe laid in numerous streets and avenues and in the parks, including the mains connecting the aqueducts with the distributing reservoirs, aggregating 168 miles.

The aggregate length of pipe laid by the City in Manhattan and Bronx is 848 miles, divided as follows:

	Miles.
In the Borough of the Bronx	165
In the Borough of Manhattan, north of Ship Canal	1
In the Borough of Manhattan, south of Ship Canal	682
Total	848

From the total length of 682 miles of water mains on Manhattan Island south of Harlem Ship Canal is to be deducted the 168 miles of multiple lines and aqueduct pipes, making the net length of streets served with Croton on Manhattan Island 514 miles.

The relation between the total length of pipes laid and that of the streets piped in the three divisions of the distribution system is as follows:

	Miles of Street.	Add for Multiple Lines in Same Street.	Miles of Pipe.	Gallons per Day per Mile of Street.
Upper High Service....	7.85	4.35	12.20	504,500
Main High Service......	99.80	22.00	121.80	400,700
Low Service............	406.00	137.25	543.25	458,200
Totals	513.65	163.60	677.25	447,775
Connections in parks...			4.75	
Aggregate, including streets and parks....			682.00	

High Service Pumping Stations.

The following pumping stations supply the high service in Manhattan; details of their operation are given in the general table of pumping stations annexed to this report:

	Active Working Capacity of Stations in Gallons Daily.
High Bridge Station, located at 174th street, on Harlem River, built in 1871 and enlarged in 1888: two pumping engines (one a reserve pump). This station delivers into High Bridge Reservoir, 215 feet above tide, and thence into main high service. The pumps draw from the old Aqueduct, 118 feet above tide............	6,000,000
West Ninety-eighth Street Station, located near Columbus avenue; built in 1880 and enlarged in 1892: three pumping engines. This station delivers directly into the main high service. The pumps have direct connection with Central Park Reservoir, 115 feet above tide, through 3,500 feet of independent 36-inch main, and with the new Aqueduct at 135th street, through an independent 48-inch main from 99th street and Eighth ave.	25,000,000
West One Hundred and Seventy-ninth Street Station, located near Harlem River on the line of the new Aqueduct; completed in 1896; four pumping engines. The pumps draw from the new Aqueduct, 122 feet above tide. Two pumps, of 10,000,000 gallons capacity each, deliver into the main high service, overflowing into the High Bridge Reservoir. Two pumps, of 4,000,000 gallons capacity each, deliver into the upper high service, overflowing into the High Bridge Water Tower, 321 feet above tide	28,000,000
Total	59,000,000

The average daily pumpage to each service for the year 1899 was as follows:

		Gallons: Daily Average.
Main High Service:		
At High Bridge Station	542,400	
At West 98th street	20,802,000	
At West 179th street	18,648,000	
Total pumpage to Main High Service		39,992,400
Upper High Service:		
At West 179th street		3,960,000
Total pumpage to Main and Upper High Services		43,952,400

There is no separate account kept in the records of the Water Department of the cost of maintaining and operating the pumping stations of the Borough of Manhattan.

The pumping stations at Ninety-eighth and One Hundred and Seventy-ninth streets are suitably located, and arranged to successfully maintain the required pressure in the pipes of the Main High Service and Upper High Service districts. Each can draw its supply directly from either of the great distributing reservoirs in the City—the Ninety-eighth street station more directly from the Central Park Reservoir, and the One Hundred and Seventy-ninth street station from the Jerome Park Reservoir. Each is also in direct connection, through the new aqueduct, with the Croton River.

The works at each station have been arranged with a view to receiving additions to the pumping plant, and in the near future additional and more powerful pumps should be erected for the main high service at One Hundred and Seventy-ninth street, and more modern and efficient machines should be substituted for the older pumps at Ninety-eighth street.

The Jerome Park Reservoir, upon its completion, will be connected by mains of large calibre with the distribution system of Manhattan, and with that of the Bronx, constituting it the principal distributing reservoir of both boroughs. If the pumping station which it is designed to construct at Jerome Park is arranged to deliver to a high service, at the same elevation as the present main high service in Manhattan, its overflow passing into the High Bridge Reservoir, the pumping stations in The Bronx and Manhattan will form a combined system. The combination will secure perfect control at all times over the service pressure on the high grounds in both boroughs. The advantages of the highest head that is desirable in practice can thus be realized, together with the certainty of supply which is afforded by large reservoirs located within the city limits, and practically at the immediate point of consumption. The capacities of the Central Park and Jerome Park reservoirs are respectively 1,000 million and 2,000 million gallons.

III.

BOROUGH OF THE BRONX.

The aggregate land surface of the borough, with all its islands, is approximately 26,800 acres. Including City Island, but not the detached islands, the area is 26,235 acres. There is appropriated for park, cemetery and reservoir purposes in all 4,747 acres of land, leaving a net area of 21,488 acres available for urban occupation within the borough, 11,548 acres of which lies on the east and 9,940 acres on the west side of Bronx River, the eastern division of the borough taking its supply from a private water company and the western from municipal works.

Service Areas: Bronx.

The areas east and west of the Bronx subdivide, according to elevations, into service districts, corresponding to those of Manhattan as follows:

East of Bronx River:

	Acres.
Area of more than 140 feet elevation; maximum elevation at 16th avenue and 4th street, Wakefield, 205 feet above tide	630
Area included between 60 foot and 140 foot contours	2,528
Area of less elevation than 60 feet above tide	8,390
Total area served or to be served east of the Bronx	11,548

West of Bronx River:

		Acres.
Areas of more than 140 feet elevation:		
1. Ridge forming easterly side of Harlem Valley from Washington Bridge north: maximum elevation at East 189th street, 180 feet above tide; a subdivision of this area (University Heights, East 183d street) is now supplied from High Bridge Reservoir, Manhattan	204	
2. Woodlawn Heights: maximum elevation 200 feet above tide; adjoining Van Cortlandt Park to the west and Woodlawn Cemetery to the south	78	
3. Area south of Woodlawn Cemetery, including Williamsbridge Reservoir: maximum elevation 190 feet above tide	133	
4. Ridge parallel to Hudson River, extending from Spuyten Duyvil to northern boundary of city: maximum elevation at West 260th street, 260 feet above tide	768	
		1,183
Area included between 60 and 140 foot contours		3,483
Area of less elevation than 60 foot above tide		5,274
Area served or to be served west of the Bronx		9,940

RECAPITULATION OF AREAS.

		Acres.
Low Service, area of less than 60 feet elevation:		
East of the Bronx	8,390	
West of the Bronx	5,274	
Total area of Low Service zone		13,664
Main High Service, area included between 60 foot and 140 foot contours:		
East of the Bronx	2,528	
West of the Bronx	3,483	
Total area requiring head of 215 feet		6,011
Upper High Service, area of more than 140 feet elevation:		
East of the Bronx	630	
West of the Bronx	1,183	
Total area requiring an Upper High Service		1,813
Total area served or to be served in the Borough		21,488

Three distinct water supply districts are at present operated in the borough, with a separate service in each.

The first of these embraces all that part of the borough lying east of the Bronx, the supply being under the control of a private water company. As the city has no mains in this district, the inhabitants receive a pumped water supply purveyed to them under a head not exceeding 215 feet above tide, by the New York and Westchester Water Company, 60 per cent. of which is drawn from the Bronx aqueduct. This company has 50 miles of pipe laid in the borough, in addition to its service outside the city, and delivers daily within the borough 2,360,000 gallons of water. Its pumping stations are outside the city limits. The distributing system serves an area of 1,764 acres within the city.

The second, or High Service District, consists of two disconnected areas abutting upon the Yonkers boundary, both of which recive a pumped supply from the Yonkers City Waterworks under a head of 305 feet above tide. One of these areas extends from Yonkers southerly along the Hudson River to Spuyten Duyvil, and is bounded easterly by Riverdale avenue and the 140-foot contour, covering an area of 1,090 acres, in which there is laid a length of 6.7 miles of pipe. A second area takes in so much of Woodlawn Heights as is above the 150-foot contour, covering an area of 80 acres, with a length of 1.3 miles of pipe. The High Service daily consumption for 1899 averaged 130,000 gallons. The supply is provided by the City of New York, which owns the pipes and purchases the water from the City of Yonkers.

So much of the borough as lies west of the Bronx, and is not included in the High Service District, is supplied by gravity from the Williamsbridge reservoir of the Bronx aqueduct under a head of 190 feet above tide. The municipal distribution system connected with the Bronx aqueduct contains 157 miles of pipe; or, allowing for the duplication of pipes in the same street, it takes in 155.6 miles of streets, and actually covers an area of 3,700 acres.

The average daily delivery of the Bronx aqueduct for the year 1899 is reported as 20,000,000 gallons. Allowing for 1,500,000 gallons taken out of the aqueduct at the Glen Hill Pumping Station of the New York and Westchester Water Company in the city of Yonkers, the amount distributed in the city from the Williamsbridge reservoir was 18,500,000 gallons daily. The city maintains no pumping station in the Borough of the Bronx.

IV.

BOROUGH OF BROOKLYN.

The aggregate area of the borough, including islands in Jamaica Bay, is 42,095 acres; excluding them, the land area is 40,700 acres. Taking out Prospect Park and Greenwood Cemetery also, the net area available for urban purposes is 39,710 acres.

The highest ground in the borough is occupied by Mount Prospect reservoir, and rises 165 feet above tide.

Of the 39,710 acres available for urban purposes, an aggregate area of 18,292 acres is supplied with water, as follows:

Service Areas: Brooklyn.

		Acres.
Area covered by City Distribution System, as Low Service, High Service and Upper High Service	13,368	
Area covered by Private Distribution Systems, all Low Service	4,866	
		18,234
Area not yet piped in the Borough		21,476
Aggregate area now served or to be served		39,710

The zone of Low Service is included between the water front and the contour of 90 feet above tide, and has an area of 37,080 acres.

Of the 37,080 acres lying below the 90-foot contour, and included in the zone of Low Service, a total area of 18,234 acres is supplied with water; 13,368 acres by the city's Low Service distribution system, under a head of 170 feet above tide, and 4,866 acres by the plants of private corporations and individuals.

The area of greater elevation than 90 feet above tide measures 2,630 acres.

Of the 2,630 acres lying above the 90-foot contour, a total area of 2,223 acres is supplied with water; 1,841 acres by the Main High Service distribution system, under a head of 198 feet, and 382 acres by the Upper High Service distribution system, under a head of 278 feet.

Daily Consumption and Supply.

The average daily consumption of water from the municipal works in the Borough of Brooklyn for the year 1899 was 95,863,571 gallons, divided among the several districts as follows:

		Average per Day: Gallons.
Low Service District:		
From Ridgewood Reservoir, head of 170 feet..	83,172,074	
From Gravesend Pumping Station, head of 154 feet	2,355,033	
		85,527,107
Main High Service District:		
From Mt. Prospect Reservoir, head of 198.5 feet	6,207,375	
From New Utrecht Pumping Station, head of 200 feet..................................	1,209,596	
		7,416,971
Upper High Service District:		
From Mt. Prospect Tower, head of 278.4 feet..		2,919,493
Aggregate Municipal Supply to Brooklyn............		95,863,571

The total length of city pipe laid in Brooklyn to and including the year 1899 was 596.7 miles, consisting, as nearly as can be ascertained, of 38.7 miles of large mains and 558.0 miles of distributing pipes, the latter representing the actual mileage of streets in which water is distributed.

The length of piped streets in the several divisions of the high-service system, according to information furnished by the Water Department of the borough, supplemented by measurements made upon the city map, is as follows:

		Miles of Street Served.
Upper High Service..........................		14.20
Main High Service.		
Mt. Prospect Division......................	48.40	
New Utrecht Division......................	32.36	80.76
Low Service, balance not included in the above..		463.04
Aggregate length of streets piped for municipal service............................		558.00

The daily consumption per mile of piped street in the three services, respectively, is as follows:

	Gallons.
Upper High Service	205,600
Main High Service	
Mt. Prospect Division	128,250
New Utrecht Division	37,380
Low Service	184,700

For the three services collectively, the daily consumption, averaged on a length of 558 miles of piped streets, is 171,800 gallons per mile.

The aggregate daily supply of water to the borough is 102,-656,000 gallons, divided as follows: 6,756,000 gallons are supplied by private companies, and 95,907,000 gallons by municipal service; of the latter, 92,342,000 gallons are furnished by the Brooklyn Waterworks, and 3,365,000 by the separate pumping plants at Gravesend and New Utrecht. Ninety per cent. of the entire water supply is obtained from that portion of the southern slope of Long Island the drainage of which is collected into the city aqueduct.

Sixty-six per cent., or two-thirds, of this drainage, consists of the surface water of streams and ponds, and the balance of ground-water pumped into the aqueduct from driven wells, at sixteen pumping stations located adjacent to the aqueduct in its length of twenty-two miles. The water thus collected is delivered by the aqueduct lines to the main pumping station at Ridgewood, at an elevation of seven feet above tide, where it is raised by steam pumps to the Ridgewood reservoirs. These have a capacity of 304,000,000 gallons and an elevation of 170 feet above tide, and provide a supply by gravity from that point to the greater part of Brooklyn, at Low Service.

The Brooklyn Waterworks, as originally projected, were completed in 1862, and provided a minimum daily supply of 20,-000,000 gallons, derived exclusively from small streams whose courses, at right angles to the axis of the island, the aqueduct intersected; the most easterly of these was Hempstead Brook, twelve miles from Ridgewood. The several streams were dammed, and their flow diverted into the aqueduct by means of short branch aqueducts. The aggregate area drained by these streams into the aqueduct was fifty square miles.

In 1871 the original supply was fully absorbed, and additions to the works in the way of increasing the yield of the watershed commenced in 1872. Hempstead Storage Reservoir was formed on Hempstead Brook by constructing a dam at a point higher up the stream than the original reservoir; and before 1880, on two of the streams additional dams were built, forming Watts' and Smith's ponds at levels below the grade of the aqueduct, and pumping stations provided to lift the water from them into the aqueduct. In 1880 open wells were sunk, from which the water is pumped into the aqueduct in the same way, at Springfield and Watts ponds. By these means the capacity of the works was brought up to 30,000,000 gallons per day. There has been since 1880 a further development of the old watershed on a large scale, by means of driven wells exclusively, causing an artificial draft upon the ground-water supply, which is unprecedented for so large an area.

The area of the old watershed tributary to the aqueduct by gravity supplemented by the system of pumping is now 65.6 square miles.

The extension of the line of works, a distance of 7½ miles, into what is known as the new watershed was begun in 1889 and completed in 1893. The gravity yield from the new works not being sufficient to provide for the increasing consumption, five driven well stations were established on the line of the aqueduct extension, the combined yield of which in 1899 was 3,114,739 gallons daily. The area of the new watershed tributary to the aqueduct is 88.5 square miles.

Auxiliary Driven Well System.

In order to keep pace with the increasing consumption the following driven well plants, with their respective pumping stations, have been installed at the dates named, in the old watershed, delivering into the aqueduct:

Year.	Name of Pumping Station.	Capacity in Gallons per day.
1882	Spring Creek	5,000,000
1882	Baiseley's	2,500,000
1885	Forest Stream	5,000,000
1885	Clear Stream	5,000,000
1890	Jameco	6,000,000
1894	Spring Creek (temporary)	4,500,000
1895	Watts' Pond	2,500,000
1897	Oconee	2,500,000
1897	Shetucket	3,500,000

The introduction of the driven well system has been attended by a marked decrease in the surface water supply received from the streams which are tributary to the Brooklyn aqueduct in the old watershed. The diminution of the surface water of the streams in seventeen years from 1883 to 1899 has amounted to 47 per cent. of the normal flow. The constant increase in the draft made upon the ground-water by the multiplication of these wells and pumping stations has resulted in a continuous lowering of the water table, and inferentially such a depletion of the underground storage as, if it goes on for a sufficient time, threatens to bring the plane of saturation down to the level of tide in the vicinity of the pumping stations, with the result that salt or brackish water will be delivered by the pumps.

In the five-year period, 1895 to 1899, the average daily yield of the driven wells in the old watershed was 24,555,000 gallons, and the stream flow delivered by gravity to the ponds tributary to the aqueduct was 16,356,000 gallons, including an allowance of 5,000,000 gallons daily for the flow of Baiseley's and Springfield ponds, wasted for sanitary reasons. Had the percentage of rainfall which entered the streams been as large in this period as in the last five-year period (1878-82) preceding the initiation of driven wells the flow tributary to the aqueduct would have been 31,000,000 gallons per day.

Table II annexed to this report shows in inches and per cent. of rainfall, and in gallons per square mile, the effect of ground-water pumping in diminishing the stream flow in the watershed; by comparison of five periods of five years each of approximately equal average rainfall, two of these periods antedating the use of driven wells.

Pumping Stations, Brooklyn.

The main pumping stations of the Brooklyn Waterworks are as follows:

	Active Working Capacity in Gallons Daily.
Millburn Station, located at the western terminus of the new aqueduct; built in 1892; five horizontal direct-acting pumping engines, each of 10,000,000 gallons capacity. All the supply of the new watershed is collected here and pumped to the Ridgewood Station, through a 48-inch main, 15 miles in length. The work done by these pumps is the equivalent of a direct lift of 56 feet........	50,000,000
Ridgewood Old Station, located on the north side of Atlantic avenue at Richmond street, East New York; built in 1859; six pumping engines. The pumps draw from the aqueduct, seven feet above tide, and deliver into Ridgewood Reservoir, 170 feet above tide........	90,000,000
Ridgewood New Station, located on the south side of Atlantic avenue, adjoining the last station; built in 1891; five vertical duplex pumping engines, each of 10,000,000 gallons capacity. The pumps draw from the aqueduct, and deliver into Ridgewood Reservoir...............	50,000,000
Mount Prospect Station, located at Underhill avenue and Prospect place; built in 1859; two pumps. of 9,000,000 gallons combined capacity, deliver into Mount Prospect Reservoir, for Main High Service, 198 feet above tide; three pumps, of 5,500,000 gallons combined capacity, deliver into Mount Prospect Tower, 278 feet above tide, for Upper High Service. The pumps draw from Ridgewood Reservoir..........................	14,500,000

The average daily pumpage at each of the stations was as follows for the year 1899:

		Gallons, Daily Average.
Millburn Station............................		40,089,213
Ridgewood, both stations....................		92,342,400
Mount Prospect Station:		
Main High Service......................	6,204,100	
Upper High Service.....................	2,919,500	
		9,123,600

The cost of pumping at each of the above stations was as follows for the year 1899:

Millburn Station:

	Aggregate Cost.	Cost per Million Gals. Lifted 100 ft.
Coal in bunkers ($2.73 per ton)	$12,141.75	$1.48
Material, supplies and repairs	2,523.78	0.31
Salaries, including workmen	18,625.89	2.26
Interest and sinking fund	16,507.92	2.01
Total	$49,799.34	$6.06

Ridgewood Old Station:

Coal in bunkers ($2.50 per ton)	$45,419.01	$1.27
Material, supplies and repairs	9,713.34	0.27
Salaries, including workmen	71,176.11	2.00
Interest and sinking fund	37,665.00	1.06
Total	$163,973.46	$4.60

Ridgewood New Station:

	Aggregate Cost.	Cost per Million Gals. Lifted 100 ft.
Coal in bunkers ($3.59 per ton)	$51,319.04	$2.17
Material, supplies and repairs	6,166.05	0.26
Salaries, including workmen	64,604.85	2.74
Interest and sinking fund	32,539.92	1.38
Total	$154,629.86	$6.55

Mt. Prospect Station:

Coal in bunkers ($3.49 per ton)	$9,321.91	$2.74
Material, supplies and repairs	1,222.39	0.36
Salaries, including workmen	20,431.63	6.02
Interest and sinking fund	6,973.08	2.05
Total	$37,949.01	$11.17

The cost of pumping into the city distribution system from the municipal driven well plants was as follows:

New Utrecht Station:

	Aggregate Cost.	Cost per Million Gas. Lifted 100 ft.
Coal in bunkers ($3.49 per ton)	$3,040.76	$3.97
Material, supplies and repairs	600.10	0.79
Salaries, including workmen	8,671.88	11.33
Interest and sinking fund	1,590.36	2.08
Total	$13,903.10	$18.17

Gravesend Station:

Coal in bunkers ($3.49 per ton)........	$5,163.28	$3.64
Material, supplies and repairs..........	819.67	0.58
Salaries, including workmen..........	9,444.12	6.67
Interest and sinking fund.............	1,433.76	1.01
Total	$16,860.83	$11.90

The combined interest and sinking fund charge consists of interest at the rate of 3½ per cent. per annum upon the cost of plant and the aggregate of annuities at 3 per cent., which will provide for the renewal of the buildings in fifty years, engines in thirty years and boilers in fifteen years.

The cost of pumping from the ponds and wells delivering into the aqueduct in the old and new watersheds was as follows for the year 1899:

Old Watershed (36,618 gallons pumped daily):

	Cost Per Year.	Cost per Million Gallons.
Operating expenses....................	$90,407.88	$6.76
Interest and sinking fund.............	20,091.96	1.50
Total	$110,499.84	$8.26

New Watershed (3,114,739 gallons pumped daily):

Operating expenses....................	$25,487.79	$22.40
Interest and sinking fund.............	5,918.88	5.23
Total	$31,406.67	$27.63

The aggregate annual cost of pumping in connection with the Brooklyn municipal water service for the year 1899 was as follows, including interest and sinking fund charges:

At City Stations.........................		$387,316.26
At Stations in Old Watershed............		110,499.84
At Stations in New Watershed:		
Millburn	$49,799.34	
Driven Well Plants..................	31,406.67	81,206.01
Aggregate cost..................		$579,022.01
Deduct interest and sinking fund......		122,720.88
Aggregate of operating expenses..		$456,301.23

The aggregate cost of pumping, averaged per million gallons of the total supply furnished by the municipal water service in the borough is as follows:

Operating expenses..................................	$13.035
Interest and sinking fund............................	3.505
Total cost of pumping per million gallons of the supply	$16.54

V.

BOROUGH OF QUEENS.

The aggregate land area of the Borough of Queens is 79,347 acres; or, excluding islands in Jamaica Bay, 76,659 acres. The range of low hills which intersects the borough from east to west rises at the highest points, near Jamaica, to about 200 feet above tide, necessitating a High Service district in the case of Hollis-wood. The area of greater elevation than 60 feet above tide is 2,630 acres.

Municipal waterworks supply the former Long Island City and the former villages of Flushing, College Point and White-stone. Private water companies to the number of five operate exclusively in the other parts of the borough.

Long Island City.

The water plant of Long Island City, the present First Ward of the borough, consists of three pumping stations located in the ward, and 23.19 miles of pipe. In addition to the public mains, about five miles of private mains are laid in the streets. There is no reservoir or standpipe. The average daily consumption for the year 1899 was 4,444,000 gallons, of which 2,107,600 gallons were furnished by the city's pumping stations and 2,336,400 gallons were purchased by the borough from the Citizens' Water Company of Newtown. There are 3,800 taps.

Station No. 1, located in Vandam street, contains two pumping engines; combined capacity, 5,000,000 gallons; average daily pumpage in 1899, 682,800 gallons.

Station No. 2, located in Cabinet street, contains two pumping engines; combined capacity, 4,000,000 gallons; average daily pumpage in 1899, 803,000 gallons.

Station No. 3, located in Grove street, contains one pumping engine; capacity, 1,000,000 gallons; average daily pumpage for 1899, 621,800 gallons.

Flushing.

The water plant of Flushing consists of a pumping station, a standpipe and 15.4 miles of pipe. The average daily consumption for the year 1899 was 980,000 gallons, taken from the city's wells. Number of taps, 2,257.

Pumping Station, located on Broadway, Bayside, contains two pumping engines; combined capacity, 3,500,000 gallons. Average daily pumpage in 1899, 980,000 gallons.

College Point.

The water plant of College Point consists of a pumping station, a standpipe and 15.42 miles of pipes. The average daily consumption for the year 1899 was 622,700 gallons. Number of taps, 1,064.

Pumping Station, located on Fresh Meadow Road, Flushing, contains two pumping engines; combined capacity, 3,200,000 gallons; average daily pumpage in 1899, 622,700 gallons.

Whitestone.

The water plant of Whitestone consists of two pumping stations, a standpipe and 10.42 miles of pipe. The average daily consumption for the year 1899 was 181,000 gallons. Number of taps, 510.

Station No. 1, located on Lawrence avenue, Whitestone; contains one pumping engine, of 1,000,00 gallons capacity; average daily pumpage in 1899 was 181,000 gallons.

Station No. 2, located on Thirty-first street, Whitestone; contains one pumping engine of 900,000 gallons capacity. This is a reserve station, and was not used in 1899.

For details of pumping plants, municipal and private, in Queens, reference is made to the tables accompanying this report.

VI.

BOROUGH OF RICHMOND.

The aggregate land area of Staten Island, constituting the Borough of Richmond, is 36,600 acres. Much of its surface is hilly and quite elevated. An aggregate area of 700 acres lies at an elevation greater than 300 feet above tide; 2,900 acres at an elevation greater than 200 feet above tide; and 7,975 acres at an elevation greater than 100 feet above tide. Within the more populated area the ground rises, in Edgewater, to an elevation of 375 feet, and in New Brighton to an elevation of 288 feet above tide, necessitating the formation of High Service districts in these places. The maximum elevation within the borough is 413 feet above tide, on Ocean Terrace Road in the former Town of Middletown. The entire water supply of the island is obtained by pumping from driven wells within its limits, some of which are located upon elevated ground.

A small municipal plant supplies water to the village of Tottenville, at the southern extremity of the island. The village of New Dorp, on the south side of the island, and the larger communities of New Brighton and Edgewater, at the eastern end of the island, are each supplied by private water companies.

Tottenville.

The city's waterworks at Tottenville consist of a pumping station, standpipe and 6.1 miles of distributing mains. The average daily consumption for the year 1899 was 80,000 gallons. Number of taps, 181.

Pumping Station, located on Central avenue, contains two pumping engines; combined capacity, 1,000,000 gallons. Average daily pumpage in 1899, 80,000 gallons.

For details of the municipal and private pumping plants and the service furnished by them in Richmond, reference is made to the tables accompanying this report.

Respectfully submitted,

LEBBEUS B. WARD.

NEW YORK, *April 15, 1900.*

Tables Accompanying Report on Pumping Stations.

I. Plants of Private Water Companies Operating in the Several Boroughs.

II. Effect of Ground Water Pumping in Diminishing Stream Flow in Brooklyn Watershed, Etc.

III. Table of Details of Pumping Stations in the Several Boroughs.

The location of each pumping station in the city is designated upon the map, showing the present distribution of water in the city, attached to the report of J. J. R. Croes, C. E.

Every organized water company in the city has its own pumping works; the only dependent areas of distribution are those of certain real estate companies.

TABLE I.

PLANTS OF PRIVATE WATER COMPANIES OPERATING IN THE SEVERAL BOROUGHS.

Borough and Company.	Year Service Began.	Miles of Pipe.	Acres Covered by Distribution.	Number of Taps in Service.	Area of Operation and Details of Water Service.
(1)	(2)	(3)	(4)	(5)	(6)
Manhattan:					No private water company supplies water in the borough.
Bronx: New York and Westchester Water Company.........	1891	50.	1,764	2,250 in city	This company has contracts covering the part of the borough east of the Bronx River (area, 13,640 acres). It has one pumping station at Pelham, one pumping station and a standpipe at Yonkers, and supplies water outside the city limits. Of the total taps, estimated at 2,500, 90 per cent. are assumed to be within the city. The aggregate daily service is 2,625,000 gallons. The Bronx Aqueduct furnishes 1,500,000 gallons of this amount, and the balance, 1,125,000 gallons, is drawn from driven wells at its Pelham station.
Brooklyn: Long Island Water Supply Company	1881	49.16	1,224	7,500	The works of this company supply the Twenty-sixth Ward (area, 3,590 acres). They include one pumping station and a reservoir of 5,000,000 gallons, 150 feet above tide. Its daily pumpage is 4,330,600 gallons, and it receives an additional 379,000 gallons from the city. The company supplies 90,600 gallons of water daily to the German-American Improvement Co. for distribution in its tract No. 2. The entire supply is pumped from wells.

Flatbush Waterworks Company	1882	72.	2,173 and 520	4,039 and 565	This company has a franchise to supply the Twenty-ninth Ward (area, 3,800 acres.) It has one pumping station and a standpipe, and draws its supply from wells. Outside of its own district, the works supply water for distribution on the following tracts, aggregating 520 acres: Germania R. E. and Imp. Co., Ardmore R. E. Co., W. P. Rae R. E. Co., Oak Crest, Fiske Terrace and Henderson tract. The additional service in the above tracts includes 20.16 miles of pipe and 565 taps.
Blythebourne Water Company	1891	30.	662	850	This company has no municipal contract. Its area of operation comprises Blythebourne and Borough Park tracts, situated in the Thirtieth Ward. The supply is pumped from open wells at a depth of 80 feet. The works consist of one principal pumping station and one reserve station, also five elevated tanks (wooden structures) of 25,000 gallons each. Daily pumpage, 200,000 gallons. An average of 106,000 gallons per day is also received from the city.
H. C. Pfalzgraf Estate.....	1891	1.7	90	41	This tract of 90 acres, located in the Thirtieth Ward, between 15th and 18th avenues and 53d and 60th streets, has an independent water service, with 1.7 mile of distributing pipes and one pumping station located at 17th avenue and 60th street, supplied from a single well.

TABLE I.—(Continued.)

Borough and Company.	Year Service Began.	Miles of Pipe.	Acres Covered by Distribution.	Number of Taps in Service.	Area of Operation and Details of Water Service.
(1)	(2)	(3)	(4)	(5)	(6)
Brooklyn—Continued: German-American Improvement Company.....	1892	8.6	197	451	This company operates under the franchise of the Long Island Water Supply Co. in the Twenty-sixth Ward, where its property is situated. It pumps 70,000 gallons of water daily from driven wells for the supply of houses built on its tract No. 1, and takes 90,600 gallons additional from the Long Island Water Supply Co. for use in its tract No. 2. The works consist of a pumping station and standpipe. One hundred and seventy-six houses are supplied on tract No. 1, and 275 houses on tract No. 2.
Queens: Citizens' Water Company of Newtown	1894	56.92	1,758	2,918	The area of operation of this company is the Second Ward, formerly the Town of Newtown. It leases and operates the pipes of the Wyckoff Heights Water Company in the Fourth Ward (1.85 miles), and also, under contract with the city, furnishes 2,336,400 gallons of water daily for distribution in Long Island City. Its plant consists of three pumping stations in actual use and one under construction. The supply is drawn from wells; daily pumpage, 4,185,700 gallons. Taps include 119 on mains of the Wyckoff Heights Co.

Woodside Water Company.	1897	7.5	—	—	The works of this company are located in the Second Ward, and were erected to supply Long Island City. They consist of three pumping stations, each containing one pumping engine, also 178 driven wells and 7.5 miles of 12-inch and 16-inch pipe in three force mains laid to connect with the Long Island City distribution system. The pumps and pump houses are of a provisional character, and the works are idle except for the formal operation of one small pump.
Jamaica Water Supply Company	1887	60. in city	2,000 in city	2,155 and 20	The operations of this company cover Jamaica, Richmond Hill and Hollis, in the Fourth Ward, also Floral Park, outside the city. The plant consists of one pumping station and two standpipes. Daily pumpage, all drawn from wells, is stated at 1,500,000 gallons. Holliswood forms a private high service district in addition, with 20 additional taps. It has an area of 195 acres, 2 miles of small mains, a pumping station of 75,000 gallons capacity, and a standpipe 210 feet above tide.
Woodhaven Water Supply Company	1894	32.	840	1,200	The works of this company supply the former district of Woodhaven, now embraced in the Fourth Ward. They consist of a pumping station in connection with a manufactory, and two reservoirs of 4,000,000 gallons combined capacity, 125 feet above tide. The supply is drawn from wells, and averages 548,000 gallons per day.

TABLE I.—(Continued.)

Borough and Company.	Year Service Began.	Miles of Pipe.	Acres Covered by Distribution.	Number of Taps in Service.	Area of Operation and Details of Water Service.
(1)	(2)	(3)	(4)	(5)	(6)
Queens—Continued:					
Montauk Water Company.	1895	9.5	—	—	This organization is owned by the Long Island Railroad Co., and furnishes no public service. The works consist of a pumping station at Jamaica (Dunton), one standpipe at Glendale station, and one at Long Island City. Daily pumpage, 1,800,000 gallons, all drawn from wells. The force main is laid on the railroad right-of-way.
Queens County Water Company	1884	37.17 in city	1,277 in city	1,574 in city	The works of this company include one pumping station and two standpipes; area covered by the distribution includes Far Rockaway and Rockaway Beach, in the Fifth Ward, and Cedarhurst, in Nassau County, where the pumping station and filter beds are located. The supply is obtained from wells. The aggregate daily pumpage is 1,123,581 gallons, 1,000,000 gallons being distributed in the city. Houses supplied outside the city, 193.
Richmond:					
Staten Island Water Supply Company...........	1881	66	1,985	4,378	This company supplies New Brighton and adjacent places in the First and Third Wards. The works consist of two pumping stations delivering into a reservoir of 825,000 gallons capacity, 215 feet above tide, for low service; also a high service pumping station and 2.3 miles of pipe, supplying an area of 85 acres at Brighton Heights. Daily pumpage, 3,810,000 gallons, all drawn from wells.

Richmond—Continued:					
Crystal Water Company of Edgewater	1885	46	1,198	2,600	This company supplies the former village of Edgewater and adjacent territory lying in the Second and Fourth Wards. Its works consist of two pumping stations, one reservoir of 3,200,000 gallons capacity, 251 feet above tide, for low service, and one standpipe, 418 feet above tide, for high service. The high service district includes the area in Edgewater above the 200 feet contour line, with 3.4 miles of distributing pipe covering 300 acres. The daily pumpage is 1,200,000 gallons, all drawn from wells.
South Shore Water Company	1889	3	98	104	The area served is the village of New Dorp, in the Fourth Ward. The works include a pumping station and standpipe. The daily pumpage is 100,000 gallons, all drawn from wells.

TABLE II.

TABLE SHOWING THE EFFECT OF GROUND-WATER PUMP ING IN DIMINISHING STREAM FLOW FROM 1883 TO 1899, IN THE OLD WATERSHED OF THE BROOKLYN WATERWORKS, COMPARING 5-YEAR PERIODS.

Average Annual Rainfall in each 5-Year Period.		Collectible Rainfall Referred to Watershed as a Whole. Annual Average for Each Period.			Driven Well Supply.	Other Pumped Sources of Supply.	Total Gallons Daily per Square Mile, derived from all Sources in the Watershed.	Rainfall Collected as Stream Flow, referred to 50 Square Miles of Watershed. Annual Average for Each Period.		
Years.	Inches.	Per Cent.	Inches.	Square Miles of Watershed.	Inches of Annual Rainfall and Gallons Daily per Sq. Mile.	Inches of Annual Rainfall and Gallons Daily per Sq. Mile.		Gallons Daily per Square Mile.	Inches Rainfall.	Per Cent. Rainfall.
1873 to 1877	43.33	25.07	10.86	52.30	Began in 1883.	0.18 8,659	517,206	532,034	11.17	25.79
1878 to 1882	41.58	29.60	12.31	55.14		0.99 47,063	585,978	594,310	12.48	30.02
1883 to 1887	43.30	31.60	13.68	64.42	2.95 140,392	2.30 109,041	651,506	518,071	10.88	25.13
1889 to 1893	45.05	38.43	17.31	65.54	5.85 278,383	4.17 198,605	824,195	455,153	9.56	21.22
1894 to 1899	43.14	36.32	15.67	66.44	7.76 369,581	2.74 130,224	745,983	327,122	6.89	15.96

ERRATUM.

'age 186. Table II., in last line of first column, read "1895 to 1899" for "1894 to 1899."

BOROUGH OF MANHATTAN

Pumping Stations connected with the Croton High Service

Station	Location	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. gal's)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. gal's for 24 hours)	Dimensions of Steam & Water Ends (inches)	Diameter of pump rod (inches)	Theoretical displacement (U.S. gal's)	Loss of action allowed (per cent)	Assumed efficient displacement (U.S. gal's)	Elevation of center of pump (feet above tide)	Average suction measured to center of pump (feet)	Total dynamic lift (feet)	Average elevation of water as supplied to pump (feet above tide)	Elevation of ground at Station (feet above tide)
High Bridge	West end of High Bridge West 174th Street	old Aqueduct at West end of High Bridge	to High Bridge Reservoir 215 feet above tide	Reserve pump→ 542,400	Delamater	1875	Vertical, direct acting, crank and fly wheel, bucket and plunger pump, condensing.	5,000,000	32×72×32×72		250.67	5	238.14	100.5	17.5 (head)	97.	118.	125
					Worthington	1883	High duty, double compound, duplex, condensing. (two months in operation)	6,000,000	19¼×36⅛×24×36	3½	279.01	5	265.06	128.	10. "			
West 98th Street	West of Columbus Ave	Central Park Reservoir	into Main High service, overflowing into High Bridge Reservoir	20,802,000	Worthington	1880	Double compound, condensing, duplex	7,500,000	21×36⅛×26×48	3½	437.30	7½	404.50	88.	17. (head)	100. to 110.	105	85
					"	"	" " "	"	"	"	"	"	"	"	" "			
					"	1891	High duty, double compound " condensing.	10,000,000	18×36×26×36	3¾	327.52	5	311.14	"	" "			
West 179th Street	Between Amsterdam Ave and Harlem River	new Croton Aqueduct at West side of Harlem River	into Main High service overflowing into High Bridge Reservoir	18,648,000	Blake	1897	Three throw triple expansion, crank and fly wheel, double acting pumps, condensing.	10,000,000	15×27×42×17½×40	5½	237.54	2½	231.60	94.	27	93.	122	109
					"	"	" " " " " "	"	"	"	"	"	"	"	"			
			into Upper High service connecting with High Bridge Tower 321 feet above tide	3,960,000	"	"	" " " " " "	4,000,000	15×27×42×11¾×40	3¾	106.92	"	104.25	"	"	200		
					"	"	" " " " " "	"	"	"	"	"	"	"	"			

BOROUGH OF QUEENS

Pumping Stations connected with the City's Waterworks

Station	Location	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. gal's)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. gal's for 24 hrs.)	Dimensions of Steam & Water Ends (inches)	Diameter of pump rod (inches)	Theoretical displacement (U.S. gal's)	Loss of action allowed (per cent)	Assumed efficient displacement (U.S. gal's)	Vacuum on suction (feet)	Pressure of discharge (feet)	Service head (feet above tide)	Elevation of Water in pump well or test well (feet above tide)	Elevation of ground at Station (feet above tide)
Long Island City No1	VanDam St. L.I. City	7-6" wells 70' deep 1 open well 47½' dia. 30' deep pumped alternately	Direct service	Reserve pump → 682,800	Holly	1875	Quadruplex, inclined, crank and fly wheel, non-compound, condensing.	3,000,000	16×9×27	2½	57.2	10	51.5	10	115.	130.	Average of pump well −6	18
					Worthington	1883	Direct acting, double compound, horizontal, duplex "	2,000,000	14×24½×14×18	2¼	47.4	"	42.7	"	"			
Long Island City No2	Cabinet Str L.I City	28-4" wells 45' deep. 1 open well 16' dia 22' deep	Direct service	803,000	Guild & Garrison	1886	Direct acting, double compound, horizontal, duplex, condensing	2,500,000	16×28×16×20	2½	68.8	10	68.1	20	170.	184	No data	14
					Worthington	1892	" " " " "	1,500,000	14×24½×14×18	2¾	47.0	"	42.3	"	"			
Long Island City No3	Grove Str L I City	12-4" wells 41' deep	Direct service	621,800	Snow	1894	Direct acting, double compound, horizontal, duplex, condensing.	1,000,000	14×20×14½×12	2½	33.8	10	30.4	26.	110.	157	32	42
Flushing	Broadway Bayside	21-3"4"&6" wells 40' deep and Springs	Direct service overflowing into standpipe 218' above M.H.T	980,000	Holly	1874	Quadruplex, inclined, crank and fly wheel, non-compound, condensing	1,500,000	12×7½×22	1¾	32.7	10	32.4	16	162	175 to 218	No data	8
					Blake	1888	Direct acting, double compound, horizontal, duplex, condensing	2,000,000	14×28×14×18	2½	47.2	"	42.5	11.	167			
College Point	Fresh Meadow Rd. Flushing	Reservoir fed by Springs	Direct service overflowing into standpipe 188.8' above M.H.T	622,700	Worthington	1874	Direct acting, cross compound, horizontal duplex, condensing	1,200,000	17¼×34½×13 & 14×24	2½	58.6	10	58.0	8	163.	188	20	25
					Snow	1899	Crank and fly wheel, cross compound, horizontal duplex, "	2,000,000	15×30×9¾×18	2⅛	20.4	"	18.35	"	"			
Whitestone No1	Lawrence Ave Whitestone	17-4"&6" wells 55' to 75' deep	Direct service overflowing into standpipe.	181,000	Worthington	1892	Direct acting, double compound, horizontal duplex, condensing.	1,000,000	12×20×10×10	2⅛	13.3	10	11.95	12.	164.	182	No data	16
Whitestone No2	31st Str. Whitestone	5-3"&4" wells 80' deep	Direct service overflowing into standpipe	Reserve station	Worthington	1888	Direct acting, double compound, horizontal duplex, condensing.	900,000	12×18×10×10	2⅛	13.3	10	11.95	1	161	182	"	

Pumping Stations connected with Waterworks of Private Companies

Company	Location of Station	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. gal's)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. gal's for 24 hours)	Dimensions of Steam & Water Ends (inches)	Diameter of pump rod (inches)	Theoretical displacement (U.S. gal's)	Loss of action allowed (per cent)	Assumed efficient displacement (U.S. gal's)	Vacuum on suction (feet)	Pressure of discharge (feet)	Service head (feet above tide)	Elevation of Water in pump well or test well (feet above tide)	Elevation of ground at Station (feet above tide)
Citizen's Water Supply Co.	No1 82 Claremont Ave. Elmhurst	28-6" wells 45' to 62' deep	Direct service	608,000	Worthington	1894	Direct acting, double compound, horizontal duplex, condensing	500,000	12×18½×8½×10	2¼	9.5	10	8.6	23.	208.	227	No data	19.
					"	1895	" " " " "	1,000,000	12×18½×10¼×10	"	13.9	"	12.5	"	"			
					"	1898	" " " " "	2,000,000	16×25×14×18	3	46.9	"	42.2	"	"			
Citizen's Water Supply Co	No2 Jackson Ave & 12th Str. Woodside	78-4½" wells 45' to 80' deep	Direct service.	1,510,000	Worthington	1897	Direct acting, triple compound, horizontal duplex, condensing	2,000,000	10×16×25×13×18	2½	40.6	10	36.5	21	185.	206	"	21.
					"	"	" " " " " "	"	"	"	40.6	"	"	"	"			
Citizen's Water Supply Co.	No3. Union Ave head of Flushing Creek	31-6" wells 45' to 90' deep.	Direct service	2,067,700	Worthington	1899	Direct acting, triple compound, horizontal duplex, condensing.	4,000,000	9½×15×25×11×48	2½	76.9	10	69.2	32.	238.	247	"	9.
Jamaica Water Supply Co.	Cor. Vine & Cumberland Str. Jamaica	7-10" 12-5" } wells 50' to 60' deep.	Direct service overflowing into standpipe 175' above M.H.T	1,500,000	Deane	1898	Direct acting, double compound, horizontal duplex, condensing	2,750,000	12×24×14×18	2¾	47.0	10	42.3	12.	150	175	"	51.
					Snider-Hughes	1900	" " " " "	4,000,000	20×36×18×36	3	156.4	"	140.8	"	"			
Woodhaven Water Supply Co.	Thrall Str Woodhaven	10-4" 6-6" } wells 80' to 150' deep.	Direct service overflowing into standpipe 125' above M.H.T	548,000	Worthington	1896	Direct acting, non-compound, horizontal duplex, condensing	1,500,000	20×12×10	2½	19.2	10	17.3	18.	104.	125.	20	50.
					Knowles	1890	" double " " " "	"	8½×17×8½×18	"	16.9	"	15.2	"	"			
Montauk Water Company	Dunton Station, Van Wyck Ave Jamaica	17-10" wells 30' to 50' deep.	Direct service overflowing into standpipe at Glendale 175' above M.H.T	1,800,000	Worthington	1894	Direct acting, triple compound, horizontal duplex, condensing.	2,000,000	9×14×22×12×18	2½	34.5	10	31.1	28.	170.	175	No data	40.
					"	"	" " " " "	"	"	"	"	"	"	"	"			
Queens County Water Co.	Valley Stream, or Cedarhurst Nassau County	16-3"&4" wells 145' to 180' deep 45-3" " 30' to 50' " pumped into filter beds	Direct service & to standpipes	1,000,000	Worthington	1899	Direct acting, triple compound, horizontal duplex, condensing. } pumping from filter beds into distributing pipes.	4,000,000	13×21×34×16×24	3	82.1	8	73.9	8.	118.	116.	−7.	4.
					"	1891	" double " " " "	2,000,000	14×24½×14×18	2¾	47.0	"	42.3	"	"			
					"	1893	" " " " " "	"	"	"	"	"	"	"	"			
					"	1896	" " " " " " } pumping from wells into filter beds.	4,000,000	9×14×19×15	2¼	73.1	10	65.8	14.	6.			
					Davidson	1899	" " " " " "	5,000,000	12×22×24×24	3	181.4	"	163.3	"	"			

BOROUGH OF RICHMOND

Pumping Stations connected with the City's Waterworks

Station	Location	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. gal's)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. gal's for 24 hours)	Dimensions of Steam & Water Ends (inches)	Diameter of pump rod (inches)	Theoretical displacement (U.S. gal's)	Loss of action allowed (per cent)	Assumed efficient displacement (U.S. gal's)	Vacuum on suction (feet)	Pressure of delivery (feet)	Service head (feet above tide)	Elevation of Water in pump well or test well (feet above tide)	Elevation of ground at Station (feet above tide)
Tottenville	Central Ave Tottenville	1-6" well 60' deep. 1-8" " 85' " 1-10" " 85' " Receiving well 10' dia. 20' deep	To standpipe 140' above M.H.T	80,000	Worthington	1897	Direct acting, double compound, horizontal duplex, condensing	500,000	6×9×6½×10	1¾	5.5	5	5.2	2	95.	140	in tube wells 0.	40
					"	"	" " " " "	"	"	"	"	"	"	"	"			
					Blake	"	" non-compound, vertical, single, non-condensing } auxiliary low lift pumps delivering from wells into pumpstation		10×4×24		1.3	10	1.17	No data	No data			
					"	"	" " " "		"		"	"	"	"	"			
					Knowles	"	" " " "		10×6¾×26		4.0	"	3.6	"	"			

Pumping Stations connected with Waterworks of Private Companies

Company	Location of Station	Source of Supply	Delivery of Water	Average daily pumpage in 1899	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. gal's for 24 hours)	Dimensions of Steam & Water Ends (inches)	Diameter of pump rod (inches)	Theoretical displacement (U.S. gal's)	Loss of action allowed (per cent)	Assumed efficient displacement (U.S. gal's)	Vacuum on suction (feet)	Pressure of delivery (feet)	Service head (feet above tide)	Elevation of Water in pump well or test well (feet above tide)	Elevation of ground at Station (feet above tide)
Staten Island Water Supply Co.	No1. Columbia Str West New Brighton	156-6" wells 100' to 120' deep siphoning into Receiving well 15' dia. 25' deep.	Low direct service overflowing to Reservoir 215' above M.H.T.	3,657,800	Holly-Gaskill	1892	Direct acting, crank and fly wheel, double compound, horizontal, duplex, condensing	5,000,000	21×42×19¼×36	4	182¼	20	145.8	8.	340.	215	in pump well −12	5.
					Knowles	1882	" " " " " "	2,000,000	12×22×12×24	2½	46	"	36.8	"	"			
					"	1881	" " " " single "	1,000,000	16×32×15×24	2¾	36.1	"	28.9	"	"			
Staten Island Water Supply Co.	No2. Ridgewood Pl. Brighton Heights	8-6" wells 60' deep	Direct high service	739,00	Worthington	1898	Direct acting, non-compound, horizontal, duplex, non-condensing.	300,000	10×6×10	1¾	4.7	10	4.2	No data	231.	400.	No data	180.
Staten Island Water Supply Co.	No3. Union Ave. New Springville	42-6" wells 38' to 50' deep	Low direct service overflowing to Reservoir 215' above M.H.T.	77,200	Worthington	1899	Direct acting, triple compound, horizontal, duplex, condensing. in operation since Nov. 1st 1899	1,500,000	9×14×22×9½×18	2½	21.3	10	19.2	14.	325.	215	"	5.
					"	"	" " " " " " " " " "	"	"	"	"	"	"	"	"			
Crystal Water Co of Edgewater	Richmond Turnpike near head of Clove Lake	52-6" wells 60' to 120' deep.	Direct service into Reservoir 251' above M.H.T.; High service to tank 418' above M.H.T.	1,000,000; 200,000	Worthington	1897	Direct acting, double compound, horizontal, duplex, condensing.	1,800,000	12×18×12×15	2½	28.7	10	25.8	18.	12.3	251 418	"	130
					Deane	1886	" " " " "	2,000,000	12×22×14×18	2¾	46.1	"	41.5	"	"			
					"	"	" " " " "	500,000	10×16×7×10	2¼	6.0	15	5.1	"	335			
Crystal Water Co of Edgewater	Richmond Turnpike near Bulls Head	46-6" wells 50' to 75' deep.	Direct service and to Reservoir	Reserve station	Worthington	1884	Direct acting, double compound, horizontal, duplex, condensing.	1,500,000	12×20×12×15	2½	28.7	10	25.8	24.	245	251	"	10.
					Deane	1885	" non- " " single, non- " : low lift pump delivering from wells into pump cistern	1,000,000	12×14×16	2	31.1	"	28.0	"	"			
South Shore Waterworks Co.	Beach Ave. New Dorp	2-8" wells 45' deep	To standpipe 135' above M.H.T	100,000	Worthington	1889	Direct acting, non-compound, horizontal, duplex, non-condensing.	300,000	10×6×10	1¾	4.7	10	4.2	10.		135.	"	20.
					"	1897	" " " " "	500,000	12×8½×10	2	9.6	"	8.6	"	81			

BOROUGH OF THE BRONX

Pumping Stations connected with Waterworks of Private Companies

Company	Location of Station	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. gal's)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. gal's for 24 hours)	Dimensions of Steam & Water Ends (inches)	Diameter of pump rod (inches)	Theoretical displacement (U.S. gal's)	Loss of action allowed (per cent)	Assumed efficient displacement (U.S. gal's)	Vacuum on suction (feet)	Pressure of discharge (feet)	Service head (feet above tide)	Elevation of Water in pump well or test well (feet above tide)	Elevation of ground at Station (feet above tide)
N.Y. & Westchester Water Co.	Glenhill Park West Yonkers	Bronx Aqueduct	direct service overflowing into standpipe	1,500,000	Unknown	1892	Rotative, cross compound, horizontal, non condensing	1,500,000	14×28×10×20	3	26	10	23.4	water received under head	135	216	No data	81
N.Y. & Westchester Water Co.	3rd Street Pelham	16 driven wells dia ×45 deep	direct service	Reserve pump→ 1,125,000	Blake	1891	Direct acting, duplex, non condensing	1,000,000	14×10×12	2¾	15.6	10	14.0	16	160	170.	"	10
					Worthington	1895	" " compound duplex non condensing	1,250,000	12×18½×11¾×10	3	17.4	"	15.6	"	"			

BOROUGH OF BROOKLYN

Pumping Stations connected with Distribution Service of the Brooklyn Waterworks

Station	Location	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. Gals.)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. Gal's. for 24 hrs.)	Dimensions of Steam & Water Ends (Inches)	Diameter of pump rod (Inches)	Theoretical displacement (U.S. Gal's.)	Loss of action allowed (Per cent)	Assumed efficient displacement (U.S. Gal's.)	Elevation of pump discharge Valve (Feet above tide)	Average Suction measured to discharge Valve (Feet)	Total dynamic lift (Feet)	Elevation of Water in pump well or test well (Feet above tide)	Elevation of ground at station (Feet above tide)
Ridgewood	Atlantic Ave. & Logan St. at Terminus of Aqueduct	pump well, supplied by main conduit. (North side)	Water delivered into Ridgewood Reservoir 170' above M.H.T.	92,342,400	Worthington	1897	High duty, direct acting, triple compound, vertical, duplex, condensing. (North side of Avenue)	20,000,000	23×36×66×33.56×60	3¾	907.6	0.84	900	23.95 (Elevation of center of pump)	17	180. (North side)	in pump well 7.0	30.
					"	"	" " " " " "	"	"	"	"	"	"	"	"			
					"	1899	" " " " " "	"	23×36×66×33.53×60	"	905.9	0.65	"	"	"			
					Hubbard & Whittaker	1869	Rotative, bucket and plunger, beam, single, "	15,000,000	85×50½×40×120		1040.5	13.50	"					
					Davidson	1884	Direct acting, double compound, horizontal, duplex, "	7,500,000	26×48×24×36	3⅛	295.1	8.51	270	23.89	17.			
					"	"	" " " "	"	"	"	"	"	"	"	"			
		pump well, supplied by main conduit and 48" force main from Millburn pumping station (South side)			Worthington	1891	High duty, direct acting, double compound, vertical, duplex. " (South side of Avenue)	10,000,000	25×50×28×48	4½	526.	4.94	500	20.04 (Elevation of center of pump)	13	169. (South side)		
					"	"	" " " " " "	"	"	"	"	"	"	"	"			
					"	1894	" " " " " "	"	"	"	"	"	"	"	"			
					"	"	" " " " " "	"	"	"	"	"	"	"	"			
					"	"	" " " " " "	"	"	"	"	"	"	"	"			
				Reserve pump →	"	1892	" " " horizontal " "	7,500,000	29×50½×22×48	4	310.7	"	295.4					
Mt. Prospect	Underhill Ave. and Prospect Place	Ridgewood Reservoir (170' above M.H.T.) through 6500'± of 30" main connecting with 36" & 48" supply mains 26000'± from Ridgewood Reservoir	to Mt. Prospect Reservoir 198.55 above M.H.T. for main high service by Engine 1 & 2 and into Mt. Prospect tower for upper high service by Engine 3, 4, & 5 at 278.4 above M.H.T.	6,204,100 main high	Wright	1890	Rotative, double compound, vertical } supplying main high service	5,000,000	18×26×24×42		164.5	0.30	164	No data	24. (head)	High service = 70. Upper high service = 170.	128	120.
					"	1886	" non- " "	4,000,000	27×23×39		140.3.	0.21	140	"	" "			
				2,919,500 upper high.	Davidson	1894	Direct acting, triple compound, horizontal. } supplying upper high service	1,250,000	8×14×24×14×24	2⅜	32.5	7.69	30	126.14	" "			
					"	"	" " "	"	"	"	"	"	"	"	" "			
					"	1898	" " "	3,000,000	11½×20×34×21×24	3¼	71.1	1.53	70	127.	" "			
New Utrecht	between Ave's U. & V. near East 14th Str.	120-2" wells 30' deep	direct service connecting with Mt. Prospect Reservoir	1,120,596	Worthington	1885	Direct acting, double compound, horizontal, duplex } supplying M. H. S.	2,000,000	15×30×15×18	3	54.0	11.11	48	13.23	20.	200.	1.4	5.
					"	"	" " " " "	"	"	"	"	"	"	"	"			
					Knowles	"	" single " " single	1,500,000	18×12×24	2½	11.7	5.10	11	12.06	"			
Gravesend	between Ave's. R. & S. near East 17th Str.	113-2" wells 50' deep	direct to distribution	2,444,032	Deane	1892	Direct acting, double compound, horizontal, duplex, condensing	5,000,000	16×30×19×24	3¼	115.8	5.87	109	12.31	16.	158.	0.6	18.
					Worthington	1890	" " " "	2,000,000	12×22×14×18	2½	47.2	4.66	45	14.31	"			

Pumping Stations connected with Aqueduct Service of the Brooklyn Waterworks

Station	Miles distant from Ridgewood	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. Gals.)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. Gal's. for 24 hrs.)	Dimensions of Steam & Water Ends (Inches)	Diameter of pump rod (Inches)	Theoretical displacement (U.S. Gal's.)	Loss of action allowed (Per cent)	Assumed efficient displacement (U.S. Gal's.)	Elevation of pump discharge Valve (Feet above tide)	Average Suction measured to discharge Valve (Feet)	Total dynamic lift (Feet)	Elevation of Water in pump well or test well (Feet above tide)	Elevation of ground at station (Feet above tide)
Spring Creek (Temporary)	1.	13-6" wells 42' to 75' deep	into main conduit which conveys it to Ridgewood P.S.	2,997,945	Chase	1894	Direct acting, non-compound, duplex, non-condensing.	3,500,000	14×20×20	1⅞	54.1	No data	No data	8.85	27.	41	–19	9.2
					Davidson	"	" " single "	'	16×22×22	2	72.1	"	"	7.87	"			
Spring Creek (Old)	1.	100-2" wells 36' deep, 1-6" well 150' ", 7-8" wells 150' "	"	3,973,160	Knowles	1883	Direct acting, double compound horizontal, duplex, condensing.	3,000,000	6½×11⅛×16×24	2	82.9	No data	No data	12.63	28.	34	–2.9	9.2
					"	"	" " " " "	"	"	"	"	"	"	"	"			
					Davidson	1896	triple " " single "	4,000,000	8×14×24×24×24	2⅛	96.5	"	"	14.12	"	31.7		
Shetucket	3.2	12-8" wells 180' deep	"	1,678,219	Davidson	1897	Direct acting, triple compound, horizontal, single, non-condensing	5,000,000	8×14×24×24×24	2⅛	93.6	No data	No data	9.49	26.	37.	–3.8	6.5
Oconee	3.8	12-8" wells 195' deep	"	1,634,408	Davidson	1897	Direct acting, triple compound, horizontal, single, non-condensing.	5,000,000	8×14×24×24×24	2⅛	93.6	No data	No data	10.75	31.	36	7.8	7.
Baisley's	4.6	100-2" wells 44' deep	"	1,527,051	Knowles	1883	Direct acting, double compound, horizontal, duplex, condensing	3,000,000	6½×11⅛×16×24	2	82.9	30.03	58	7.64	29.	38	–3.2	8.5
					"	"	" " " " "	"	"	"	"	"	"	"	"			
Jameco	4.9	16-8" & 10" wells 160' deep, 183-2" wells 27' to 73' ", 4-4" " 160' ", 3-6" " 153' "	"	4,935,482	Davidson	1890	Direct acting, triple compound, horizontal, single, condensing.	5,000,000	9×14×24×24×24	2⅛	97.4	13.76	84	9.96	26.	27.8	0.3	3.7
					Andrews	1891	Crank and fly wheel, non compound, vertical, "	6,000,000	16×40×8		43.52	10.39	39		"			
					Worthington	1890	Direct acting, double compound, horizontal, duplex, "	"	9×18⅛×26×18	2⅛	173.9		No data	10.24	"	29.8		
Springfield	6.5	20-8" wells 170' deep	"	2,133,890	Davidson	1882	Direct acting, double compound, horizontal, single, condensing.	5,000,000	14×24×24×24	2⅛	95.5	9.95	86	15.82	21.	24.3	1.3	10.9
Forest Stream	7.3	110-2" wells 41' deep	"	3,439,039	Knowles	1885	Direct acting, crank and fly wheel, cross compound, horizontal, duplex, condensing	5,000,000	11×19×15×24	2¼	72.6	32.51	49	9.39	20.	31.	2.1	6.8
					"	"	" " " " "	"	"	"	"	"	"	"	"			
Clear Stream	8.5	150-2" wells 38' deep	"	2,568,055	Knowles	1885	Direct acting, crank and fly wheel, cross compound, horizontal, duplex, condensing.	5,000,000	11×19×15×24	2¼	72.6	No data	No data	7.97	28.	38.	–0.9	10.7
					"	"	" " " " "	"	"	"	"	"	"	"	"			
Watts Pond	9.1	12-6" wells 50' deep & Watts Pond	"	3,213,763	Worthington	1885	Direct acting, double compound, horizontal duplex, condensing.	3,000,000	9×17×17×15	2½	60.3	8.79	No data	16.28	18.	22.1	5.7	10.9
Smith's Pond	12.	Smiths Pond	"	8,517,299	Davidson	1890	Direct acting, double compound, horizontal, single, condensing.	5,000,000	14×24×24×24	2⅜	97.4	11.70	86.	15.15	11.	14.8	4.4	10.6
					"	1883	" " " " "	"	"	"	"	"	"	"	"			
								10,000,000										
Millburn	15.	pump well fed by conduit extension from Smiths Pond to Massapequa	25,000,000 Gallons into pump well of Ridgewood pumping station through 48" main. 15,000,000 gallons through 36" branch into main conduit at Smiths Pond	40,089,213	Davidson	1892	Direct acting, triple compound, horizontal, single, condensing.	10,000,000	11½×20×36×36×36	3¼	323.6	2.66	315	22.40	17.	55.8	5.7	14.4
					"	"	" " " " "	"	"	"	"	"	"	22.42	"			
					"	"	" " " " "	"	"	"	"	"	"	22.46	"			
					"	1895	" " " " "	"	"	"	"	"	"	22.60	"			
					"	"	" " " " "	"	"	"	"	"	"	"	"			
Agawam	16.8	32-6" wells 33' to 91' deep	into conduit which conveys it to Milburn pumping station	520,305	Edwards	1896	10" "Cataract" centrifugal pump, 75 H.P. Erie engine, non-condensing	6,000,000	13		non-reciprocating			8.35	26.	36.	3.8	8.
					"	"	" " " "	"	"		"			8.37	"			
Merrick	17.5	62-4½" wells 40' to 110' deep	"	325,813	Edwards	1896	10" "Cataract" centrifugal pump, 75 H.P. Erie engine, non-condensing	6,000,000	13		non-reciprocating			9.55	28.	36.	7.3	15.
					"	"	" " " "	"	"		"			9.53	"			
					Worthington	"	Direct acting, non-compound, horizontal, duplex, "	3,000,000	14×19×15	1⅞	73.1	4.24	70	13.47	"			
Matowa	18.3	46-4½" wells 38' to 97' deep	"	890,939	Edwards	1896	10" "Cataract" centrifugal pump, 75 H.P. Erie engine, non-condensing.	6,000,000	13		non-reciprocating			10.79	25.	33.	4.8	11.
					"	"	" " " "	"	"		"			"	"			
Wantagh	19.5	43-4½" wells 24' to 89' deep, 6-6" " 92' "	"	1,377,682	Edwards	1896	10" "Cataract" centrifugal pump 75 H.P. Erie engine, non-condensing.	6,000,000	13		non-reciprocating			9.69	22.	31.	5.3	8.
					"	"	" " " "	"	"		"			9.72	"			
					Worthington	"	Direct acting, non-compound, horizontal, duplex, "	2,000,000	10×14×10	1⅞	26.4	5.30	25	11.26	"			
Massapequa	22.3	53-4½" wells 37' to 106' deep	"	not running	Edwards	1896	10" "Cataract" centrifugal pump 75 H.P. Erie engine, non-condensing.	6,000,000	13		non-reciprocating			10.68	27.	36.	6.9	9.
					"	"	" " " "	"	"		"			"	"			
					Worthington	"	Direct acting, non-compound, horizontal, duplex, "	2,000,000	10×14×10	1⅞	26.4	5.30	25	12.17	"			

Pumping Stations connected with Private Companies supplying water in Brooklyn

Company	Location of Station	Source of Supply	Delivery of Water	Average daily pumpage in 1899 (U.S. Gals)	Maker of Engine	Date of Installation	Description of Engine	Rated Capacity (U.S. Gal's for 24 hours)	Dimensions of Steam & Water Ends (Inches)	Diameter of pump rod (Inches)	Theoretical displacement (U.S. Gal's)	Loss of action allowed (Per cent)	Assumed efficient displacement (U.S. Gal's)	Average Vacuum on suction (Feet)	Average Pressure of delivery (Feet)	Average Service head (Feet above tide)	Elevation of Water in pump well or test well (Feet above tide)	Elevation of ground at Station (Feet above tide)
Long Island Water Supply Co.	New Lots Road and Fountain Ave. East New York	22-2" wells 45' to 50' deep, 14-6" " 80' to 90' ", 4-6" " at bottom of 1 open well 29' Dia. × 24' deep	Direct service overflowing to Reservoir. 150 feet above M.H.T.	4,330,600	Davidson	1896	Direct acting, double compound, horizontal, duplex, condensing	3,000,000	16×32×16×24	3	82.1	10	73.9	27.	190.	150.	No data	10.
					"	1883	" " " single "	1,500,000	18×34×16×24	"	41.0	"	36.9	"	"			
					"	"	" " " " "	"	"	"	"	"	"	"	"			
Flatbush Waterworks Co.	Ave. E near New York Ave. Flatbush	3-5" wells 18' deep in each of 12 open wells 8' Dia. × 26' deep, 19-5" wells 55' deep	Direct service overflowing to standpipe 194 feet above M.H.T	2,155,400	Worthington	1893	Direct acting, double compound, horizontal, duplex, condensing.	5,000,000	19¾×33⅝×21×24	3¾	141.6	10	127.4	12.	170.	180.	No data	10.
					"	1885	" " " " "	2,500,000	14×24½×16×18	2½	61.9	"	55.7	"	"			
					Knowles	1889	" " " " "	3,000,000	16×24½×14×18	"	47.2	"	42.5	"	"			
Blythebourne Water Co.	Eleventh Ave. & 74 Str. Bay Ridge Park	1 open well 5' Dia. × 90' deep, 1 " " 20' " × 90' "	Direct service overflowing to Tanks 160 feet above M.H.T.	200,000	Worthington	1891	Direct acting, non-compound, horizontal, duplex, non-condensing.	115,000	5¼×3½×5	2	0.7	10	0.6	10.	150.	160.	5.0	88.
					"	"	" " " " "	216,000	7½×5×6	"	1.9	"	1.7	"	"			
					"	"	" " " " "	216,000	"	"	"	"	"	"	"			
German Am. Impvt. Co.	Pennsylvania & Stanley Aves. East New York	3-6" wells 60', 65', 70' deep	To stand pipe and mains	70,000	Worthington	1892	Direct acting, double compound, horizontal, duplex, condensing.	500,000	8×12×7×10	2	6.4	10	5.8	10.	128.	90.	No data	10.

APPENDIX C

REPORT ON

THE USE AND WASTE OF WATER IN NEW YORK CITY.

BY

FOSTER CROWELL.

M. Am. Soc. C. E., M. Inst. C. E.

CONTENTS OF APPENDIX C.

LIST OF PLATES.

THE USE AND WASTE OF WATER IN NEW YORK CITY.

BY FOSTER CROWELL, C. E.

To the Engineering Committee of the Merchants' Association of New York, Thomas C. Clarke, Past Pres. Am. Soc. C. E., Chairman:

GENTLEMEN:

In response to your communication of March 7, 1900, requesting me to investigate and report upon the questions therein submitted relating to the use and waste of water in the Boroughs of Manhattan and the Bronx, I present the following report:

I.

PRESENT WATER CONSUMPTION IN MANHATTAN AND THE BRONX.

According to the gaugings of the Croton water supply made in 1899 under the direction of Mr. John R. Freeman, M. Am. Soc. C. E., which gaugings are the latest and most reliable, and which you have requested me to take as the basis of my investigations, the daily delivery in November and December to the distributing reservoirs averaged 226,000,000 gallons per day. This is 92 per cent. of the combined Croton and Bronx supplies. The entire population supplied from the Croton and Bronx being 2,117,090, the population supplied from the Croton alone is 92 per cent. of that, or 1,947,000.

The average delivery during the period mentioned is thus found to be 116.07 gallons per head per day.

Average Daily Consumption.

In addition to measuring the flow, Mr. Freeman caused observations to be taken of the rise and fall of the surface of water in the distributing reservoirs, while the aqueduct was delivering at the constant flow given above. The observations were made at six-minute intervals for an entire week, as shown in the tables and diagrams accompanying his report to the Comptroller, advance copies of which I have been permitted to study. See Diagram VI.

These show that the average total daily consumption for that week was 226,964,286 gallons, at the rate of 116.56 gallons per head per day of 24 hours.

The average night rate of consumption from 2 to 4 A. M. was 7,773,000 gallons per hour, which is at the rate of 95.81 gallons per head per day of 24 hours. The average night rate of consumption was 76.08 per cent. of the average day rate from 6 A. M. to 9 P. M., and 81.86 per cent. of the average rate of consumption for the entire 24 hours as above stated. This relation between the rates of day and night will be considered below.

To avoid confusion in terms the quantities of water hereafter to be mentioned in this report will be expressed in U. S. gallons per head of population per day of 24 hours; but the tables contain aggregate quantities also. The figures of gallons per head per day if multiplied by 1.947 will give the aggregate consumption in millions of gallons per day.

The average total consumption per head per day, very nearly 117 gallons, includes all water wasted in addition to that which is legitimately consumed. This figure would not remain constant throughout the year, but the relations of use and waste would probably not vary appreciably, and I may adopt it as the groundwork of my further investigation.

Waste Defined.

The term waste, in its present application, is susceptible of division into two components, incurable waste and preventable waste; before analyzing them the endeavor will be made to determine definitely their total. Waste in this connection does not relate to lavishness in the actual use of water, but means only the water which passes away and is lost without being used.

II.

LEGITIMATE USES OF A PUBLIC WATER SUPPLY AS APPLIED TO NEW YORK.

The legitimate uses of a public water supply are as follows:

(1) PUBLIC USES OF ALL KINDS.
Including Fire Protection, Street and Sewer Cleansing, Charitable Institutions, Fountains, etc., etc.

(2) TRADE USES.
Including Manufacturing, Gas Works, Brewing, Shipping, Docks, Transportation, Power, Use in Stores and Office Buildings, Hotels, etc., etc.

(3) DOMESTIC USES OF ALL KINDS.

Use in Other Cities.

In the endeavor to arrive at the proper value to be assigned the several divisions of use, comparison with other cities may profitably be made. It has been found that in American cities the average public uses require from 4 to 6 gallons per head per day; taking into consideration the season of the year when the gauging was made, and the sparing use of water for street purposes in New York, 5 gallons per head per day may be fairly considered as an outside figure for this item.

The quantity used for trade purposes in any city varies according to local circumstances, and general rules do not apply. In many American cities the mill supply is obtained from separate sources, and the total amount taken from the public supply for manufacturing purposes is very small.

New York's Trade Consumption.

New York is the largest manufacturing center, and being at the same time almost entirely dependent upon the public supply, has a very large trade consumption. Fortunately, the figure for trade purposes in New York can be very closely approximated, for the reason that, with perhaps occasional unimportant exceptions, all consumption for trade purposes is metered.

A small portion of the water used for public purposes is metered also. A very small part of the metered consumption is used for domestic purposes.

It was formerly the custom of the New York Water Department to publish annually a classification of meters in use for various purposes and the amount of consumption per meter. This was a very valuable and instructive practice, which for some reason or other has since 1895 been abandoned.

Analysis of Metered Consumption.

From these reports, I have made a careful analysis, the results of which are given in Table I. A study of this table will show clearly that the portion of metered consumption used for manufacturing and trade purposes for ten years prior to 1894 bore a very nearly constant relation to the total metered consumption, and the same is practically true of the portion used for public purposes, which latter, however, is extremely small, most of the water used for public purposes not being metered. It is found that the percentage for all trade purposes averaged 91.65, and for public uses 2.55, the former being remarkably constant, and the latter very slowly decreasing.

In grouping the figures to form Table I, I have taken as part of the trade consumption, the large item classified by the water department as "Miscellaneous." This I have done after consultation, in the absence from the city of the Chief Engineer, Mr. Birdsall, with Mr. J. E. McKay, First Assistant Engineer of the Water Department, who was actively concerned in the preparation of the reports on meterage, and who informs me that that category includes for the most part establishments in which manufacturing is carried on, though not always to the exclusion of other uses of the buildings; in such cases, some part of the consumption is domestic use by the resident population of the buildings, and this cannot be exactly separated from the trade use.

Applying the above percentage to the total metered consumption in 1899, and dividing the result by the entire population, we find that the total trade consumption amounts to 23.85 gallons per head per day of 24 hours, which we may call 24 gallons for convenience of reference. This is for the estimated population of 1,947,000 now being supplied with Croton water.

It is obvious that a portion of this is waste, the extent of which is to be separately determined.

Analysis of Meter Records.

In the endeavor to arrive at a fair estimate of the amount of waste in the consumption for trade purposes, I have made an analysis of the records of 510 meters obtained from Mr. J. H. Bellis, covering the years 1897, 1898 and 1899. The results of this analysis may be found in Tables II, III, and IV.

The data of these tables should be considered with great discrimination, lest they prove altogether misleading. For instance, Table II shows the net decrease in consumption as registered by the entire number of meters during the three years as only 5.3 per cent., whereas, Table III, which shows the results in 282 cases, and gives a total reduction of more than 30 per cent., and Table IV., giving the results of the other 228 cases, shows an increase of 38 per cent.

Reduction of Waste in Metered Consumption.

In the absence of any figures giving the population in these establishments in 1897 and 1898, and in view of the uncertainty attaching to those given for 1899, it is impossible to reach an intelligent conclusion as to whether the increase of consumption is due to a corresponding increase of population and output or not. On the other hand, it is impossible to determine whether the reduction of consumption shown in Table III. is due to a decrease of population and output or to improved plumbing. But, taking into consideration the industrial conditions which have prevailed during the past three years, I feel justified in the assumption that in New York City the population and output of most manufacturing establishments have increased since 1897; also that in establishments wherein a reduction is shown, such reduction is in excess of the natural increase, and where increase is shown, it has been sufficient to overcome the reduction which might have been shown had the population and output not increased during the period.

If the general correctness of this view be admitted, it may be concluded that the total decrease shown in Table III. represents practically the reduction reasonably possible in a total consumption represented by the 510 meters, and which may be attributed to greater care in the maintenance of the plumbing and house fixtures, such as has been presumably exercised by Mr. Bellis in all these cases. This total reduction is 19 per cent. of the entire original consumption, but it is reasonable to suppose that such a saving could not be depended upon throughout the entire number of meters amounting to over 36,000.

If the average reduction be assumed at 16 per cent., then the amount of waste accompanying the metered use for trade purposes would amount to 4 gallons per head (of the entire population) per day, making the actual trade consumption 20 gallons per head per day.

We have thus far accounted for 25 gallons actual use out of the 117 gallons of total consumption; the balance, 92 gallons per head per day, comprises the domestic consumption and the total waste.

It is obvious that this figure could not be materially increased without doing violence to reasonable assumptions, and also that if the foregoing reasoning is erroneous, and the metered trade consumption greater than we have taken it, the effect would be to diminish the figure of total waste. In other words, the 92 gallons per head per day represents the probable limit of combined domestic use and waste.

The next step will be taken in the endeavor to divide this quantity into its two elements.

III.

The Quantities of Water Used in Various Cities and the Reasonable Allowance for Actual and Necessary Use in New York.

Having separated the public and trade uses from the domestic use, comparison with figures obtained from the experience of other cities becomes easier.

In order to arrive at a reasonable estimate of the normal allowance of water for domestic purposes, recourse must be had to records of the few cities and towns, or districts, wherein, practically, the whole water supply is metered. Table V., which

I have compiled from a number of sources, gives all the available reliable data.

The table indicates a general approach to uniformity in different communities, as to the amount of domestic consumption, and also shows that a rate of domestic consumption of more than 30 gallons per head per day is only to be found in three cities out of the twenty-one enumerated, and that in the remaining cities, the rate averages less than 20 gallons per head per day. Taking into consideration the congested conditions of a large part of the Borough of Manhattan, it would seem to be demonstrated that the average actual domestic consumption in Manhattan and the Bronx does not exceed, or if it does, need not exceed, 30 gallons per head per day.

I am strengthened in this view by my own experience as a householder dependent upon a metered supply. Our household consists of six persons who use water freely. In the summer time little ice is used in the drinking water, because the supply is sufficiently cool if allowed to run a short time; this, of course, adding to the consumption. For the past two years the average consumption per head per day has been 23.28 gallons.

In 1883, Col. William Ludlow investigated the waste in Philadelphia, and gives the following results.* In all American cities examined, the waste varied from 25 to 75 per cent. of the total supply. In Philadelphia, he found 40 gallons were actually used, and 30 additional gallons wasted. His conclusion was that 40 gallons per head per day was an ample allowance for all purposes. Philadelphia is a great manufacturing city, but many establishments are located on the river fronts and are not entirely dependent upon the city supply, consequently the consumption for trade purposes is probably much smaller than in Manhattan.

In 1897, Mr. John C. Trautwine, Jr., then Chief of the Bureau of Water in Philadelphia,† caused meters to be placed in twenty residences in different parts of the city for observational purposes. Four of these residences averaged 149 gallons per head per day, and one of the four took as much as 181 gallons. The remaining 16 averaged only 33 gallons per head per day, but they paid for the wastefulness of their fellow-citizens.

* Annual Report of the Chief Engineer of the Philadelphia Water Department, 1883; p. 50.
† Annual Report of the Department of Public Works, Philadelphia, 1897; p. 67.

Certain limited areas of the distribution system were supplied through a 12-inch Venturi meter; at Chestnut Hill the consumption was thus found to average 160 gallons per head per day, and the Twenty-first Ward, similarly measured, showed 85.6 gallons per head per day. The Chestnut Hill district is a suburban residential section, while the Twenty-first Ward is a populous manufacturing centre; the latter, though well supplied with city water, is deficient in underground sewerage, without which there is usually less waste of water, for the reason that surface drainage is a nuisance which the community will not permit and neighborly considerations are very effective to check such waste, which would receive no attention if flowing unseen through the drain pipes to the sewers.*

In 1898, other meters were placed for observational purposes on a number of Philadelphia residences, some of which were occupied by prominent citizens. It is probable that no unnecessary waste is permitted in these dwellings, and the consumption was found to be only 34.4 gallons per capita per day. Certainly, if so small a quantity would suffice for all domestic needs and purposes where there was no restraint or inducement to economize, the same quantity should be ample in less pretentious dwellings, and the disparity shown can only be accounted for by the difference between careful use and extravagant waste.‡

The general conclusion reached as the result of these modern observations was that 40 gallons per head per day is an ample allowance for actual use for all purposes in Philadelphia, which is corroborative of Col. Ludlow's conclusions reached fifteen years earlier. And this conclusion was reached in face of the fact that the average daily consumption during the year 1898 was 196.2 gallons per head per day, an increase over the year 1897 of 10.4 gallons per head per day, and an increase over 1895 of 35.9 gallons per head per day.†

Reasonable Allowance for New York.

It is to be borne in mind that the figure of 30 gallons per day for domestic consumption does not apply to a parsimonious

* Annual Report of the Department of Public Works, Philadelphia, 1898; p. 135.
‡ Twelfth Annual Report of the Department of Public Works, Philadelphia, 1898; p. 133.
† Ibid, p. XXIII.

use, but to an abundant and free use. This is evident by a study of Table V., and by what has already been said. We may safely conclude that if all the New York supply was metered, there would be no inclination on the part of the citizens collectively to exceed 30 gallons per head per day, although, undoubtedly, there would be many individual cases exceeding the average.

We may, therefore, consider the following allowance sufficiently large to cover actual and necessary uses in New York:

Uses.	Gallons per Head per Day
Public	5
Trades	20
Domestic	30
Total	55

The above rate of 55 gallons per head per day applies to all the inhabitants supplied from the Croton.

Strictly considered, this gives somewhat too large a total, because the item of Trades Consumption actually covers a part of the domestic consumption, being that due to the comparatively small fixed resident population in the metered establishments devoted to trade. But on the other hand, there is an indeterminate factor of floating population covered up in the metered consumption, and the balance is too small to materially affect the result.

IV.

THE WASTE OF WATER IN NEW YORK IN COMPARISON WITH OTHER CITIES.

It was considered above that the quantity of 92 gallons per head per day covered the domestic consumption and the total waste. Subtracting the 30 gallons of domestic consumption, we have remaining 62 gallons per head per day, as the preventable waste out of a total delivery of 117 gallons, or 53 per cent., the incurable waste being concealed in the allowance for consumption in all cases.

Multiplying 62 by 1,947,000 we obtain the total theoretically preventable daily waste, amounting to 120,714,000 gallons, which is 53 per cent. of the average total daily consumption as gauged by Mr. Freeman.

It is important to compare this figure of waste with the results of experiments in other cities.

In comparing the results of other cities, it is to be borne in mind that waste is not necessarily proportional either to the total volume of supply or to the number of inhabitants. It may be several times greater than the actual amount used.

Bearing this in mind, we will first take up the case of the Shoreditch experiments, the results of which are concisely shown in Table VI.

These experiments were made in the highly successful endeavor to check waste in the district of Shoreditch, London, by means of examination with the Deacon meter and subsequent inspection and repairing of fixtures found defective. It will be seen that the waste per head per day was reduced from 35.4 gallons to 8.88 gallons, while the consumption per head per day decreased very slightly; and that the total daily supply to the district was reduced from 3,845,080 gallons to 1,479,382 gallons, making a total saving of 2,365,698 gallons per day, which amounts to 863,479,770 gallons per year.

In this case, the preventable waste was reduced 26.52 gallons per head per day.

Checking Waste.

One of the most instructive and valuable instances of the successful reduction of waste is that of Fall River, Mass., and attention is called to its remarkable similarity to the Shoreditch case. In Fall River 97 per cent. of the population is supplied through meters, and the officials have been enabled to bring about a very important reduction in the waste. In 1874, the average consumption per head per day was 84.53 gallons,* but about 1879 it had dropped to 35.8. The average for the next ten years was 34.088, and for the past ten years 33.285, the average for the twenty years being 33.686. Since 1889 the average has been remarkably uniform, the lowest being 28.49, in 1894, and the highest, 37.74, in 1896. In 1898 it was just below the aver-

* Twenty-sixth Annual Report Watuppa (Fall River) Water Board, Jan. 1, 1900.

age for the ten years. The percentage of waste has been persistently reduced through the intelligent efforts of the officials during the past three years.

The following quotation from the Twenty-fourth Annual Report of the Watuppa (Fall River) Water Board, January 1, 1898, p. 39, is interesting in the light of what has followed:

"A large percentage of water is unaccounted for in the quarters ending March 31 and December 31, which plainly shows the large waste of water caused by annual *rate-takers* allowing the water to run to prevent freezing. I would recommend the setting of meters in a number of places where such parties are connected with public sewers, in order to determine the amount of water passing through such pipes, *as the meter system has proved itself the best check known to prevent excessive waste.*"

The percentage unaccounted for in that year, 1897, was 41.1; in 1898 it had been reduced to 27.3, and in 1899 to 24.91, and it is claimed that the last figure would have been lowered still more had it not been that owing to the drought of that year there had been unauthorized use by outside parties.

As may be seen in Table VII., the waste was reduced from 15.47 gallons per head per day in 1897 to 9.01 gallons per head per day in 1900.

Mr. Trautwine's above described experiments with the Deacon meter in Philadelphia, in 1896, indicated that the quantity actually used in a certain district was only 65 gallons, whereas, the total consumption was 244 gallons, and the waste 179 gallons per head per day.* In the following year he continued the investigation by placing meters in 20 residences in different parts of the city. In 16 of those residences the consumption averaged 33 gallons per head per day. In the four others the average was 149 gallons per head per day; presumably much of the difference was preventable waste. In this connection, Mr. Trautwine's experiments to determine the rates at which faucets waste water are instructive. By actual measurement he found that one faucet leaking 60 drops per minute lost about 5 gallons per day, and one running full head lost 2,357 gallons per day.

* Tenth Annual Report, Bureau of Water, Philadelphia, 1896; p. 182.

The continuation in 1898 of the Philadelphia experiments showed an absolute waste ranging from 62 to 86 per cent. of the total consumption. A Deacon meter inspection that year in a district where the total consumption was 211 gallons per head per day, indicated that if the waste observed at night continued at the same rate during the remaining 19 hours out of the 24, it would equal 191 gallons per head per day, while the quantity actually used would only be 20 gallons per head per day.†

By way of summing up the Philadelphia experience, I quote the following verbatim from the Twelfth Annual Report of the Department of Public Works, Philadelphia, for 1898, p. 134:

"Our Deacon meter investigations show that between midnight and 6 A. M. only about 10 per cent. of the consumption during this period is actually used, and that the balance of it, 90 per cent., is wasted. In all these investigations the waste has been traced directly to the fixtures from which it was discharging; and, furthermore, it was found that the sum total of the leaks and discharges accounted approximately for the 90 per cent. of the water which was being wasted.

"If 10 per cent. be deducted from the above consumption during the hours from 12 P. M. to 6 A. M., the waste during that period would be 57,573,648 gallons, which, continued at the same rate during the balance of the 24 hours, would make a total of 230,254,592 gallons wasted, and leave out of the total day's supply 56,811,999 gallons actually used or approximately 40 gallons per capita.

"This estimate of water used and water wasted compares closely with the results obtained with the Deacon meter in local examinations, and it is not far from the true proportions of the quantities actually used and those wasted."

The total consumption is given as 215 gallons per head per day. Subtracting the 40 gallons as above, there remain *165 gallons of waste per head per day.*

In Boston, experiments to analyze waste have been carried on, but in answer to my inquiries I am informed that considerable difficulty has been experienced in obtaining some of the results, and for that reason they have not yet been made public. In his paper on Consumption and Waste of Water, above referred to, Mr. Dexter Brackett, M. Am. Soc. C. E., expresses the opinion based upon previous Boston experiments that in cities

† Twelfth Annual Report, Bureau of Water, Philadelphia, 1898; p. 133.

where water meters are not generally used, as in Manhattan and the Bronx, the quantity wasted would be from 20 to 100 gallons per capita, thus indicating a mean which my figure of 62 gallons closely approaches.

As to present conditions in Boston, I quote from the report of Mr. Frederick P. Stearns, M. Am. Soc. C. E., Chief Engineer to the Metropolitan Water Board,* concerning waste of water.

Mr. Stearns says: "The statistics already given with regard to the consumption of water since 1890 indicate there is a very large quantity wasted or misused (out of the total consumption, which is given as 103 gallons per head per day in the report.—F. C.). There is a legitimate increase in the consumption of water per inhabitant from year to year, occasioned by the greater wealth of the community, which enables a greater proportion of the population to have bath tubs, closets and other water fixtures which use water in large quantities. The amount of water used for manufacturing and mechanical purposes also increases much faster than the population, and there are other reasons for an increasing use of water per inhabitant.

"There is, however, an increasing waste and misuse of water, which might be stopped to a considerable extent by the application of meters, or by other measures which may be taken."

Tests of Waste in New York.

Efforts to determine the amount of waste in New York City have not been systematically carried on, but in 1882, when there were only 6,617 meters in use, Isaac Newton, then Chief Engineer of the New York Water Department, under the dirction of Hon. Hubert O. Thompson, Commissioner of Public Works, instituted a careful investigation into the amount of waste then occurring. The results are found in the Report of the Department of Public Works of the City of New York for 1882, and may be briefly summarized as follows:

The tests were made in two blocks of private residences between Fifth and Madison Avenues in Forty-seventh and Forty-ninth Streets, respectively. A 6-inch meter was first placed on the service main in each street to measure the aggregate quantity of water consumed. During the first ten days the average daily consumption in the 45 houses in the two blocks

* Fourth Annual Report, Metropolitan Water Board, Boston, 1899; p. 143.

was 26,130 gallons, or 82.68 gallons per head per day. Meters were then placed on the house connections, and the occupants of houses where water was found to be used excessively or absolutely wasted through leakage or by letting it run from the faucets over night, were notified to repair their plumbing and stop waste. The result was a gradual reduction to an average of 20,107 gallons per day, or 63.6 gallons per head per day, a reduction of 23 per cent.

An examination of sewers for waste of water in houses in various parts of the city, made in the last quarter of the year 1882, gave the following results:

Number of sewer connections found dry	2,399
Number where waste was less than 1 gallon per minute	63
Number where waste was from 1 to 5 gallons per minute	242
Number where waste was over 5 gallons per minute	2
Total number of house connections examined	2,706

The approximate average waste per head for the population represented during those hours was at the rate of about 2 gallons per hour, the examinations being made between 12 o'clock midnight and 6 A. M. If the same rate was maintained throughout the 24 hours, the waste would amount to 48 gallons per head per day. During the entire year the number of house connections examined was 9,268, with an average waste of about 72 gallons per head per day of the population represented on the above basis of computation.

It would have been interesting and desirable to have continued the experiments of 1882 by the permanent application of meters to the individual houses, which were grouped in the tests above given. That probably would have led to a considerable curtailment in the use of water and a still further visible reduction of waste. It is probable, in the light of the similar experiments in other cities, above described, that the consumption per head per day could thus have been reduced to an average of between 40 and 50 gallons, if *not* charged for at meter rates, and to a still lower quantity if so charged, for this has a potent effect upon suppression of waste.

The observations of night flow in house connections were continued until and including 1884, with an average estimated waste of 465 gallons per *house* per day in 28,436 houses.

V.

MEASUREMENT OF THE NEW YORK CONSUMPTION OF WATER BY GAUGINGS OF THE SEWAGE FLOW.

In 1888, Mr. Rudolph Hering, M. Am. Soc. C. E., made an extensive series of gaugings of sewage flow, extending over the entire year, in a district covering 221.72 acres with a resident population of 37,692.

Diagrams II. to V. show the character and extent of the gaugings graphically, and Table VIII gives the results in figures. The storm-water flow is excluded by using only the gaugings on such days when the sewage flow was unaffected by rain. These gaugings have never before been published, and are now kindly contributed by Mr. Hering.

A study of Table VIII will show that the daily average flow in the sewers for the entire year of 1888 was at the rate of 85.87 gallons per head per day for the total population of the district in question, which extends, roughly speaking, from Amity to Sixteenth street, and from Broadway and Union Square to Seventh avenue as shown on Diagram I.

It will be noted that this was not to a great extent at that time a manufacturing district, being occupied chiefly by residences and retail stores, and consequently the amount of water used locally for trade purposes was relatively very small. It is also probable that some of what was used for manufacturing went into the atmosphere in the form of steam, and did not enter the sewers directly.

Ground Water.

Ground-water is that portion of the rainfall which sinks into the ground and there remains until either extracted by capillary action or carried off by gravity through underground channels. The proportion of the rainfall which becomes ground-water varies greatly according to the character of the soil, the amount of vegetable growth therein, and also by those conditions which prevent some of the water from entering the ground at all.

In the case of sewers, a large proportion of the water that falls during a rainstorm falls on the roofs and the pavements and passes directly into the sewer, being termed storm-water. Mr. Hering's tabulations exclude this, the averages being made up from the comparatively regular flow of the sewers immediately preceding the storms. They include the ground-water, all of which must be assumed to eventually find its way into the sewers excepting that portion of it which is extracted by capillary action.

In order to arrive at the quantity of ground-water which enters the sewers, we must first exclude from our calculations the storm-water. Mr. Hering has computed that in this district there are 96.6 acres of roofs and 103.3 acres of pavements, leaving 21.8 acres of grass and pervious ground, which is only 10 per cent. of the entire area.

Outside of this district there may have been formerly a small remaining portion of the same drainage basin, amounting, however, to not over 20 acres, in which the unknown conditions of underground drainage may possibly cause a continuance of ground-water flow from outside territory to these sewers.

The above percentages would apply equally to this additional area, so that the amount of rain falling on grass and pervious ground could not exceed 11 per cent. of the rainfall in the district.

It is not probable that more than half of this becomes ground-water, but, assuming that it might under extreme conditions, we may say in round numbers that 6 per cent. of the total rainfall over this particular district under the above circumstances becomes ground-water.

Taking the annual rainfall at 44 inches, we shall find that the average daily quantity of ground-water for the district is 43,560 gallons, and dividing by the number of inhabitants in the district we obtain the ground-water per head per day, which is thus found to be 1.15 gallons.

We have thus the following statement of daily consumption:

TABLE IX.

MINETTA BROOK DRAINAGE DISTRICT,
NEW YORK CITY, 1888.

	Gallons per Head per Day.
Daily average sewage flow	85.90
Deduct ground-water	1.15
Balance: Consumption in district	84.75

This average is greater than that of the entire city for the year 1888, but the fact is readily accounted for when we consider that the Minetta Brook Drainage District was occupied as a residential quarter, and, in addition, had a large floating shopping population whose needs would increase the total consumption and, not being enumerated, would bring up the average.

In Diagram VI. the fluctuations of the sewage flow in 1888 and Mr. Freeman's observed fluctuations of surface in the Central Park reservoirs in 1899 are plotted to the same scale, and develop a remarkable similarity in their comparative relations, bearing in mind that, as suggested by Mr. Hering, the Central Park curve gives the flow several miles above the Minetta Brook gauge station, and that the two curves must, therefore, not be compared according to actual time, but with due allowance for the time required for the water to reach the lower end of the sewer from the reservoir.

VI.

Analysis of the Waste in New York: Conclusions Regarding Its Possible Prevention.

I have been furnished with a copy of the record of observations made under the direction of Mr. J. J. Croes, M. Am. Soc. C. E., for your committee in the present year, of twenty-five meters placed on residences in Manhattan for the purpose of determining average consumption.

If this record be studied with a view to arriving at the present average consumption, it shows a result of 84.8 gallons per head per day. Throwing out the five cases which bear unmistakable evidence of being abnormally high (their average being 200.6 gallons per head per day), the average of the remaining twenty cases is 55.84 gallons per head per day, this being domestic consumption.

But if we study the record with a view to getting the probable waste, we shall find that the average consumption in nine of the houses was only 42.8 gallons per head per day, while in the remaining 11 cases it was 66.43 gallons per head per day. As all were unrestricted, the fair conclusion is that the first set of households were more careful in their use of water than the second, and further that they might have gotten along with even less water than was used had they been obliged to pay for what they wasted.

But assuming that the 42.8 gallons combines only actual and necessary use with incurable waste, for the class of inhabitants which this group represents, a class living in small families in separate establishments with ample facilities for bathing, etc., and considering the far greater numbers of inhabitants who live in congested condition without adequate facilities or opportunities for bathing frequently, the conclusion is unavoidable that the figure is far too high for an average of all.

The average number of people, per residence, in the nine houses of lowest consumption, as above, is less than seven; while the average per building throughout Manhattan and the Bronx is nearly twice that.

Mr. Croes, in his report, has estimated the waste in these 25 houses at nearly 50 per cent. of the water which passes through them. The average of the 25 being 84.8, 50 per cent. would make the waste 42.4 gallons per head per day. Deducting from the 84.8 of consumption the 42.8 used in the 9 houses, on the average which I have assumed to be normal use, the waste as I make it is 42 gallons per head per day, agreeing almost exactly with Mr. Croes.

This element of the waste applies to the item of domestic use; there are likewise elements of waste in the items of trade and public uses. Taking the proportions I have assigned, viz., 30, 20 and 5, and assuming the elements of waste to be proportional thereto, then the total waste, both the preventable and the incurable, would be $\frac{55}{30} \times 42 = 77$ gallons per head per day.

Incurable Waste.

Subtracting the figure which we have taken for the preventable waste (62 gallons) we have 15 gallons per head per day for the present incurable waste.

Mr. Dexter Brackett, in the paper before quoted, expresses the opinion that it is not practicable to reduce the incurable waste below 15 gallons per head per day throughout a large city.

Assuming the total waste thus found to be constant through the 24 hours, and applying Mr. Freeman's gaugings as exhibited upon his diagram hereinbefore referred to, we find that the ratio of night consumption to day consumption is 36.6 per cent.:

	Per Head, Per Day.
Average Day Consumption (6 A. M. to 9 P. M.)..	125 Gals.
Average Night Consumption (2 A. M. to 4 A. M.)	96 "
Actual Night Use, 96—77=.................	19 "
Actual Day Use, 125—77=..................	48 "
Ratio of Night Use to Day Use, $\frac{19}{48}$ = 39.6 Per Cent.	"

Preventable Waste.

In conclusion, and in view of the array of facts presented, we are fully justified in the opinion that the present total theoretical preventable waste of that part of the New York water supply that is derived from the Croton system amounts to at least 120,000,000 gallons per day. Diagram VII. shows this graphically.

The above amount of waste is the combined result of leaks in the reservoirs, leaks in the mains and distribution system, and defective house fittings and plumbing.

I have made no attempt herein to separate the several elements.

It may be considered that the reservoir leakage is so small as to be practically negligible.

The experience of other communities which has been cited demonstrates very clearly that all the wastage might be attributed to defective plumbing, etc., without exceeding the reasonable probabilities, but there is probably considerable leakage in the mains and the distribution system also.

The amount of theoretically preventable waste, as has been stated above, is about 53 per cent. of the total quantity of water delivered at the present time. The extent to which the prevention can be carried depends upon other considerations than physical laws, and can only be estimated. Under the assumption that the entire consumption be metered, I should be inclined to estimate the possible saving as a very considerable part of the theoretical amount, dependent upon the thoroughness of official action and the proper education of the public, for every householder would thereupon become directly interested in the reduction of the waste, and the inherent trait of human nature which previously had led him to consider that the more water he used the more value he was getting back from his taxes, would not cause him to feel concerned lest he should suffer by being made to pay for water he did not use. That is the experience in other places where meters have been universally applied, and to a greater or less extent is to be counted upon.

Respectfully submitted,

FOSTER CROWELL,

Consulting Engineer.

April 11, 1900.

TABLE I.

AVERAGE DAILY METERED CONSUMPTION: MANHATTAN AND THE BRONX. IN GALLONS.

Year.	Total.	Domestic.	Per Cent.	Trade.	Per Cent.	Public.	Per Cent.	River-dale.	Per Cent.
1880..........	9,830,680	991,006	10.0	8,515,584	86.6	315,588	3.2	8,502	.09
1881..........	11,905,474	1,157,883	9.7	10,315,547	86.7	417,040	3.5	15,004	.13
1882..........	13,647,307	1,114,004	8.2	12,095,955	88.7	403,340	3.0	34,008	.20
1883..........	16,230,032	1,246,549	7.7	14,565,483	89.7	418,000	2.6	——	—
1884..........	19,988,152	1,354,410	6.8	18,172,773	90.9	410,989	2.0	49,980	.25
1885..........	22,197,544	1,419,684	6.4	20,371,818	91.8	406,042	1.8	——	—
1886..........	23,135,351	1,464,252	6.3	21,198,810	91.6	407,983	1.7	64,306	.20
1887..........	24,772,917	1,476,585	5.9	22,803,992	92.0	412,020	1.7	80,320	.30
1888..........	25,581,810	1,448,380	5.6	23,640,225	92.4	418,000	1.6	75,205	.30
1889..........	27,406,482	1,614,961	5.9	24,936,123	91.0	770,040	2.8	85,358	.30
1890..........	28,505,777	1,653,036	5.7	26,043,190	91.4	759,014	2.6	50,537	.18
1891..........	30,468,581	1,746,100	5.8	27,895,100	91.5	770,060	2.5	57,321	.19
1892..........	31,244,136	——	—	——	—	——	—	——	—
1893..........	33,137,815	——	—	——	—	——	—	——	—
1894..........	36,714,016	2,184,490	5.9	33,609,368	91.5	824,920	2.3	95,238	.25
1895..........	42,888,032	——	—	——	—	——	—	——	—
1896..........	46,657,200	——	—	——	—	——	—	——	—
1897..........	50,097,600	——	—	——	—	——	—	——	—
1898..........	50,002,848	——	—	——	—	——	—	——	—
1899..........	50,664,835	——	—	——	—	——	—	——	—

The average percentage of the metered supply used for Trade Purposes during ten years prior to 1894 is 91.65, and for Public Uses during six yeais is 2.55, slowly decreasing. Applying these percentages to the total metered consumption in 1899, we obtain the following approximate result:

Year.	Total.	Trade.	Per Head Per Day.	Public Uses.	Per Head Per Day.
1899	50,664,835	46,434,321	23.85	1,266,620	.65

The balance being considered as metered Domestic Consumption.

TABLE II.

TABLE SHOWING METERED CONSUMPTION IN 510 BUILDINGS.

Class.	No.	Gallons of Consumption.				Decrease Per-centage.
		1st R'dg.	2d R'dg.	Increase.	Decrease.	
Saloons	121	142,275	135,968	——	6,307	4.43
Dwellings	22	39,848	37,278	——	2,580	6.50
Office buildings.	23	67,957	60,297	——	7,660	11.30
Factories	57	122,636	110,513	——	12,123	9.90
Hotels	32	106,064	106,550	486	——	——
Stables	8	9,511	9,421	——	90	.95
Stores	247	233,722	223,190	——	10,532	4.50
Total	510	722,013	683,217	——	38,806	——
Average	——	1,416	1,340	——	76	5.30

Class.	Population.	Gallons of Consumption.	
		Per Head Per Day.	Per Service Per Day.
Saloons	1,778	76.5	1,124
Dwellings	651	57.3	1,694
Office buildings.................	1,224	49.3	2,621
Factories	3,395	32.6	1,939
Hotels	1,164	91.6	3,330
Stables	46	204.8	1,178
Stores	6,264	35.6	904
Total	14,522	——	——
Average	——	47.1	1,340

The figures of total decrease are entirely misleading, for the reason that nearly half of the entire number of meters included in above table showed an increase due probably to increased population and business. (See Tables III and IV.)

TABLE III.

TABLE SHOWING REDUCTION OF WASTE IN METERED CONSUMPTION ATTRIBUTED TO GREATER CARE IN KEEPING PLUMBING IN ORDER.

Classifications.	No.	Consumption.		Reduction.	Percentage of Reduction.
		1st R'dg. Gallons.	2d R'dg. Gallons.		
Saloons	61	80,923	52,486	28,437	35.14
Dwellings	13	28,366	20,592	7,774	27.40
Office buildings	14	55,884	43,577	12,307	22.02
Factories	33	91,155	69,100	22,055	24.20
Hotels	22	53,927	39,949	13,978	26.00
Stables	3	3,942	2,703	1,239	31.40
Stores	136	145,687	92,313	53,374	36.50
Total	282	459,884	320,720	139,164	
Average	—	1,631	1,137	494	30.27

	Population.	Gallons of Consumption.	
		Per Head Per Day.	Per Service Per Day.
Saloons	670	78.3	860
Dwellings	337	61.1	1,584
Office Buildings	924	47.1	3,112
Factories	1,792	38.5	2,094
Hotels	584	68.4	1,816
Stables	16	169.0	901
Stores	3,492	26.4	679
Total	7,815	—	—
Average		41.0	1,137

The decrease is attributed to better condition of plumbing, and is supposed to be the net reduction of waste, after allowing for an increase in consumption from 1897 to 1899, but the figures of population in 1897 were not taken.

TABLE IV.

TABLE SHOWING INCREASE IN METERED CONSUMPTION ATTRIBUTED TO INCREASE IN POPULATION AND OUTPUT.

Classifications.	No.	Consumption. 1st Reading. Gallons.	Consumption. 2d Reading. Gallons.	Increase.	Per centage of Increase.
Saloons	60	61,352	83,482	22,130	34.5
Dwellings	9	11,492	16,686	5,194	45.2
Office buildings	9	12,073	16,720	4,647	38.5
Factories	24	31,481	41,413	9,932	31.6
Hotels	10	52,137	66,601	14,464	27.9
Stables	5	5,569	6,718	1,149	20.6
Stores	111	88,035	130,877	42,842	48.7
Total	228	262,139	362,497	100,358	——
Average	——	1,149	1,590	441	38.3

	Population.	Gallons of Consumption. Per Head Per Day.	Gallons of Consumption. Per Service Per Day.
Saloons	1,108	75.34	1,391
Dwellings	314	53.14	1,854
Office buildings	300	55.73	1,858
Factories	1,603	25.83	1,725
Hotels	580	114.80	6,660
Stables	30	224.00	1,344
Stores	2,772	47.21	1,179
Total	6,707	——	——
Average	——	54.04	1,590

The increase is attributed to increased population, manufactures, etc., as is reasonable to suppose took place between 1897 and 1899, and which more than cancelled reduction of waste.

TABLE V.

DOMESTIC CONSUMPTION OF WATER PER HEAD PER DAY IN VARIOUS CITIES.

Cities.	Gallons per Head per Day.	
	Total Consumption.	Domestic.
Boston, Massachusetts	103 (Met. Dist.)	30. (a)
London, England	39.6 (i)	32. (b)
London (Shoreditch)		16.9 (c)
Fall River, Massachusetts	36.2 (d)	21.8 (d)
Yonkers, N. Y.	96. (e)	22. (e)
Woonsocket, R. I.	28.4 (f)	19. (f)
Zurich	56.7 (h)	30.5 (h)
Berlin		15.276 (h)
Cologne		30.6 (h)
Frankfort		28.3 (h)
Sheffield, England		17.0 (b)
Nottingham, England		16.2 (b)
Derby, England		15.6 (b)
Liverpool, England	36.0 (i)	18.0 (b)
Leicester, England		16.8 (b)
Manchester, England	34.0 (i)	15.6 (b)
Bradford, England	48.0 (i)	16.0 (i)
Bristol, England	26.4 (i)	
Glasgow, Scotland	60.0 (i)	
Edinburgh, Scotland	44.6 (i)	
Dublin, Ireland	46.0 (i)	

REFERENCES.

(a) Includes Stores, Markets, etc. See Brackett on "Consumption and Waste of Water," Trans. Am. Soc. C. E., Vol. XXXIV; p. 193. See, also, Fourth Annual Report Metropolitan Water Board, January 1, 1899.

(b) Expressed in American gallons. See Paper and Discussion on "Prevention and Detection of Waste of Water," by Ernest Collins, M. Inst. C. E., Proc. Inst. C. E., CXVII: p. 147 et seq.

(c) Shoreditch Observations, Ibid; p. 158.

(d) Annual Reports Watuppa (Fall River) Water Board, 1897, 1898, 1899.

(e) Twenty-seventh Annual Report Board of Water Commissioners of the City of Yonkers, December 1, 1899.

(f) Annual Reports of the Water Board of the City of Woonsocket for 1895, 1896, 1897, 1898.

(g) Preller on "Zurich Power Supply," Proc. Inst. C. E., Vol. CXII; p. 300.

(h) Transactions Am. Soc. C. E., Vol. XXXIV; p. 219.

(i) Watson on "The Rate of Water Supply," Proc. Inst. C. E., Vol. CXXXVIII; p. 465

TABLE VI.

SHOREDITCH EXPERIMENTS.

	1882.	1883.	1884.	1885.
Services	11,861	11,861	11,861	11,861
Population	86,988	86,988	86,988	86,988
Total daily supply*	3,845,080	2,848,704	1,728,020	1,479,382
Consumption per head per day	8.76	7.92	8.28	8.04
Waste per head per day	35.40	24.72	11.52	8.88
Supply per head per day	44.16	32.64	19.80	16.92
Reduction of waste per head per day	——	10.68	13.20	2.64
	——	——	10.68	23.88
	——	——	23.88	26.52

* Domestic purposes only. Reduced to U. S. Gallons.

TABLE VII.

FALL RIVER EXPERIENCE.

	1897.	1898.	1899.
Population supplied	97,500	94,267	98,931
Total daily supply*	3,669,640	3,136,049	3,580,895
Use per head per day	21.17	24.00	27.19
Waste per head per day	15.47	9.26	9.01
Supply per head per day	37.64	33.26	36.20
Reduction of waste per head per day	——	6.21	.25
			6.21
			6.46

* All purposes.

TABLE VIII.

DRY WEATHER FLOW OF SEWAGE AND GROUND WATER IN MINETTA BROOK DRAINAGE DISTRICT, NEW YORK.*

Area: 221.72 acres. Population: total, 37,692. Per acre, 170.

IN CUBIC FEET PER SECOND.

	Sund'y	Mon'y	Tues'y	Wed'y	Thurs.	Friday	Sat'y
	1st Quarter: Jan., Feb., March, 1888.						
Mean discharge	4.55	5.19	5.22	5.11	4.98	4.66	4.98
Maximum "	5.33	6.16	6.02	5.79	5.47	5.33	5.70
Minimum "	4.21	4.43	4.43	4.38	4.31	4.08	4.31
	2d Quarter: April, May, June, 1888.						
Mean discharge	3.96	4.41	4.31	4.33	4.66	4.45	4.24
Maximum "	4.39	5.33	4.97	5.15	5.33	5.19	5.06
Minimum "	3.61	3.68	3.54	3.54	3.91	3.61	3.25
	3d Quarter: July, Aug., Sept., 1888.						
Mean discharge	5.03	5.22	5.09	5.30	5.03	4.76	5.14
Maximum "	5.61	6.43	5.88	6.06	5.47	5.33	5.97
Minimum "	4.55	3.96	4.08	4.15	4.31	4.01	4.31
	4th Quarter: Oct., Nov., Dec., 1888.						
Mean discharge	5.58	5.64	5.58	5.55	5.41	5.83	5.91
Maximum "	6.23	6.62	6.43	6.54	6.32	6.73	6.70
Minimum "	4.68	4.76	4.74	4.55	4.57	4.84	5.03
	Averages for Year.						
Average mean	4.78	5.12	5.05	5.07	5.02	4.93	5.07
Average maximum	5.39	6.14	5.83	5.89	5.65	5.65	5.86
Average minimum	4.26	4.21	4.20	4.16	4.28	4.14	4.23

Means for the Year 1888.

	Cu. Ft. per Second.	Cu. Ft. per Head per Second.	Gallons per Head per Day.
Daily average	5.01	.00013	85.87
Daily average maximum	5.77	.00015	98.96
Daily average minimum	4.21	.00011	72.18

* From a Report made to Gen. John Newton, Commissioner, Department Public Works in 1889. By Rudolph Hering, M. Am. Soc. C. E., Consulting Engineer. Now published for the first time.

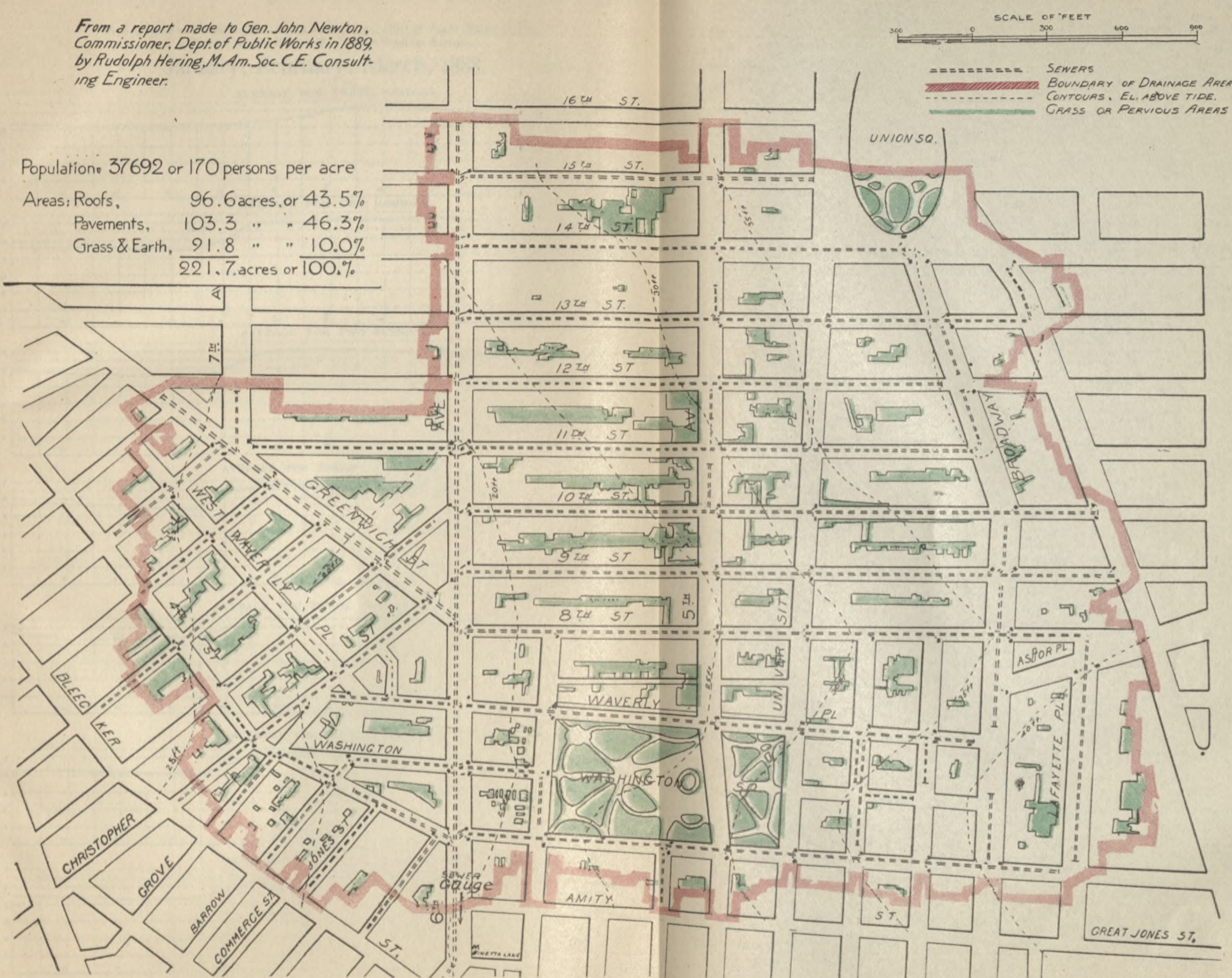
DIAGRAM 1.

MINETTA BROOK DRAINAGE AREA ABOVE 6TH AVE. SEWER GAUGE

From a report made to Gen. John Newton, Commissioner, Dept. of Public Works in 1889, by Rudolph Hering, M. Am. Soc. C.E. Consulting Engineer.

Population = 37692 or 170 persons per acre

Areas: Roofs,	96.6 acres,	or	43.5%
Pavements,	103.3 "	"	46.3%
Grass & Earth,	91.8 "	"	10.0%
	221.7 acres	or	100.%

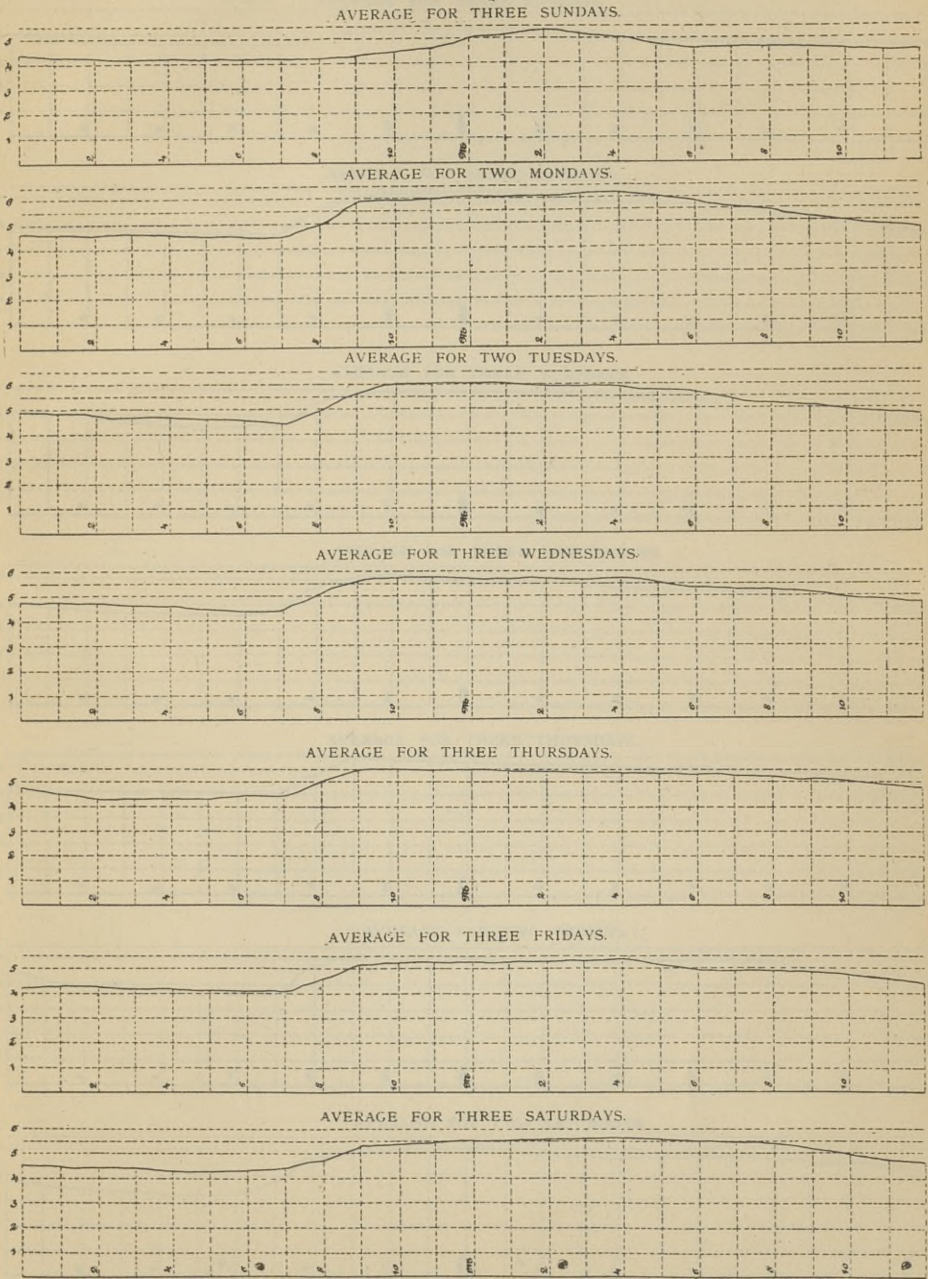


Average hourly discharge of dry weather sewage and ground water from Minetta Brook Drainage Area above Sixth Avenue Sewer Gauge, at Amity Street, New York.

From a report made to Gen. John Newton, Commissioner, Dept. of Public Works, in 1889, by Rudolph Hering, M. Am. Soc. C. E., Consulting Engineer.

January, February, March, 1888.

DIAGRAM II.



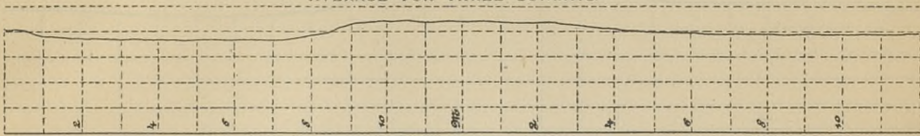
Average hourly discharge of dry weather sewage and ground water from Minetta Brook Drainage Area above Sixth Avenue Sewer Gauge, at Amity Street, New York.

From a report made to Gen. John Newton, Commissioner, Dept. of Public Works, in 1889, by Rudolph Hering, M. Am. Soc. C. E., Consulting Engineer.

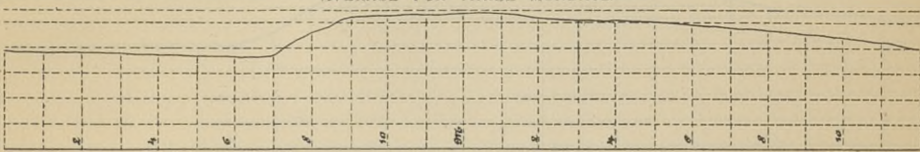
April, May, June, 1888.

DIAGRAM III.

AVERAGE FOR THREE SUNDAYS.



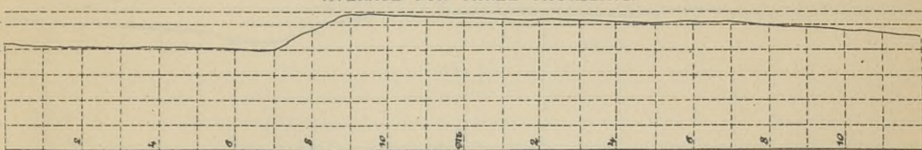
AVERAGE FOR THREE MONDAYS.



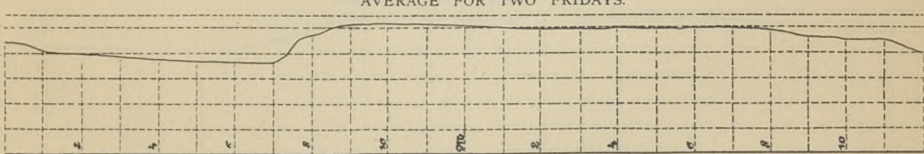
AVERAGE FOR THREE TUESDAYS.

AVERAGE FOR THREE WEDNESDAYS.

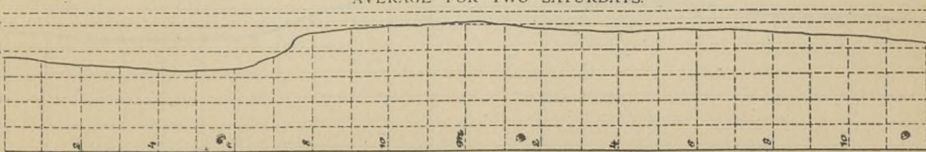
AVERAGE FOR THREE THURSDAYS.



AVERAGE FOR TWO FRIDAYS.



AVERAGE FOR TWO SATURDAYS.

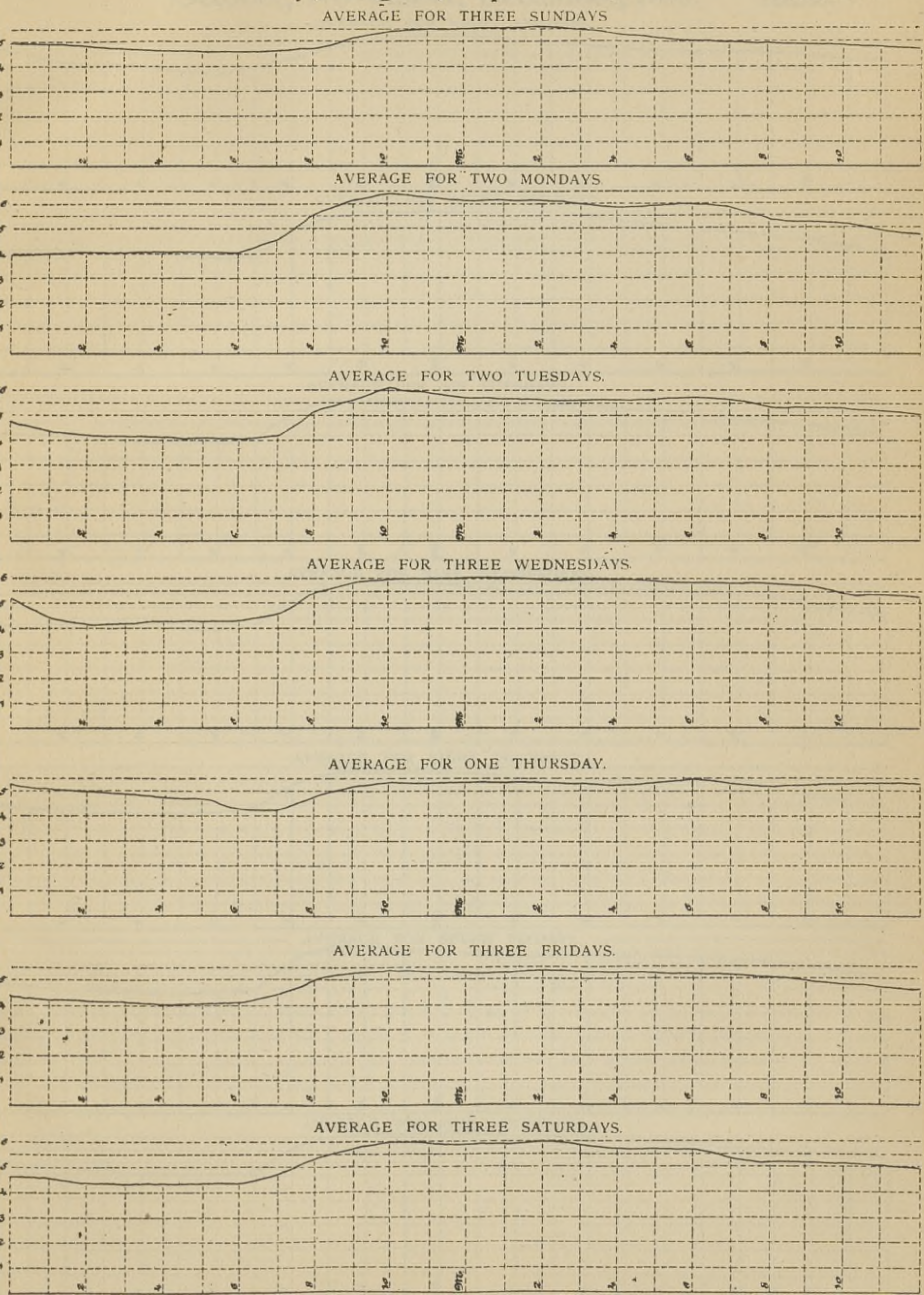


Average hourly discharge of dry weather sewage and ground water from Minetta Brook Drainage Area above Sixth Avenue Sewer Gauge, at Amity Street, New York.

From a report made to Gen. John Newton, Commissioner, Dept. of Public Works, in 1889, by Rudolph Hering, M. Am. Soc. C. E., Consulting Engineer.

July, August, September, 1888.

DIAGRAM IV.

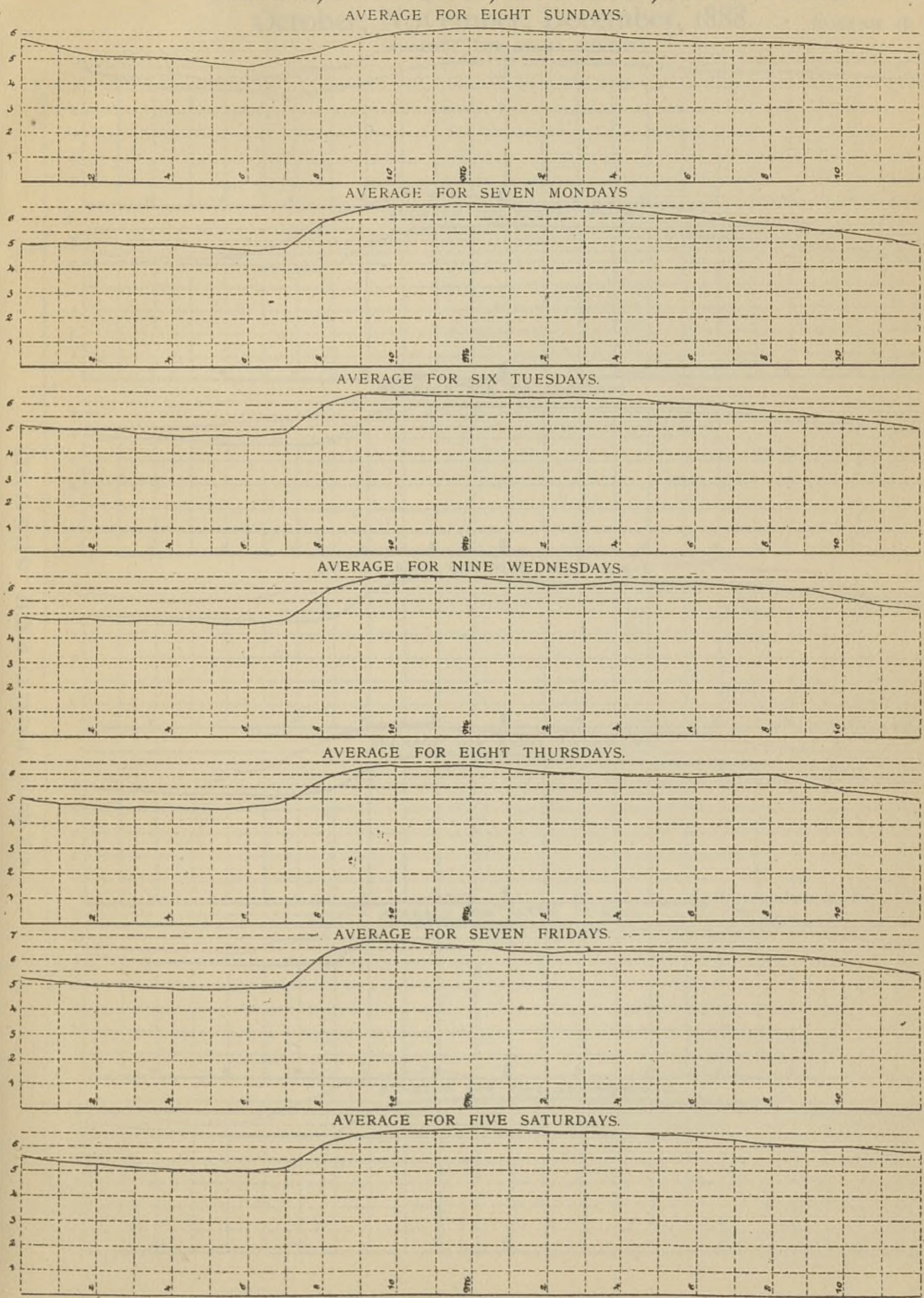


Average hourly discharge of dry weather sewage and ground water from Minetta Brook Drainage Area above Sixth Avenue, Sewer Gauge, at Amity Street, New York.

From a report made to Gen. John Newton, Commissioner, Dept. of Public Works, in 1889, by Rudolph Hering, M. Am. Soc. C. E., Consulting Engineer.

October, November, December, 1888.

DIAGRAM V.



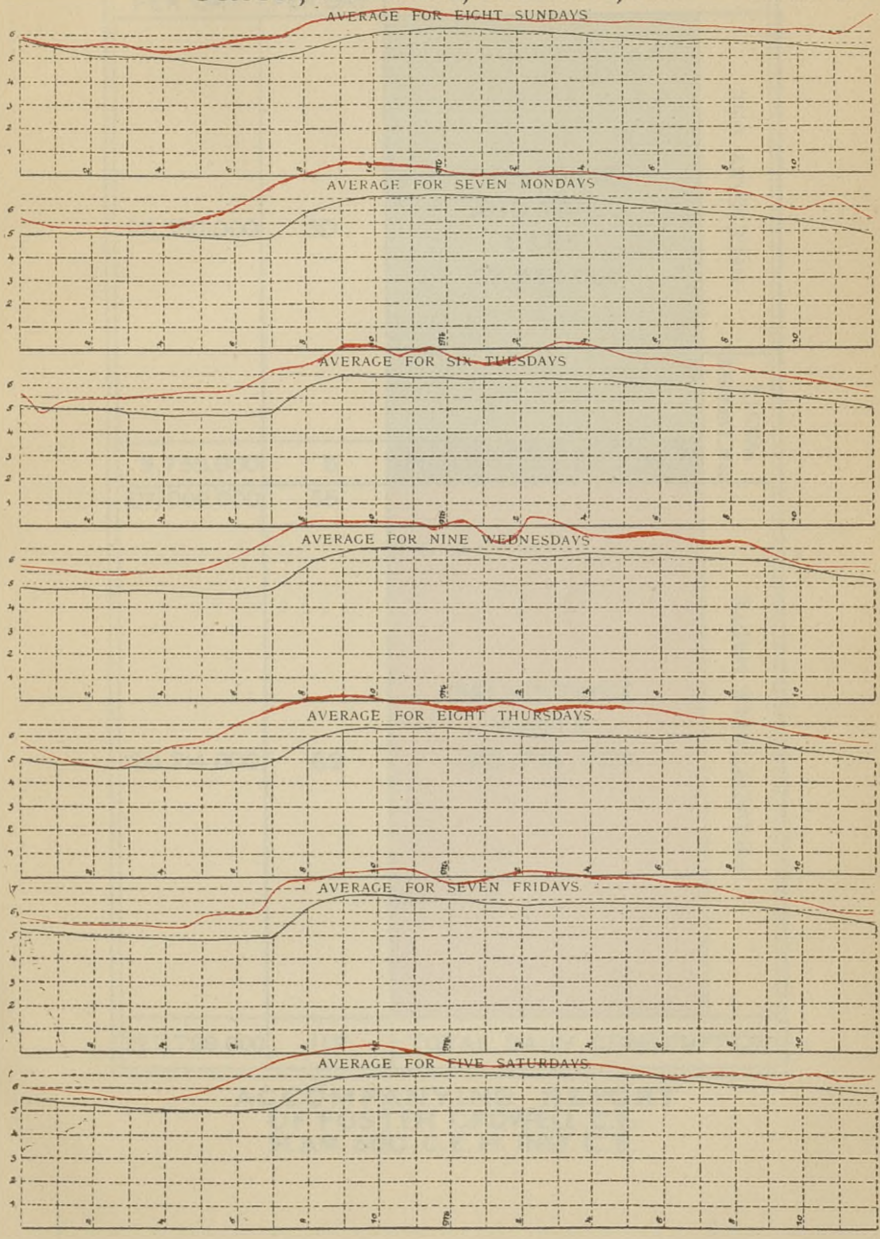
Average hourly discharge of dry weather sewage and ground water from Minetta Brook Drainage Area above Sixth Avenue Sewer Gauge, at Amity Street, New York.

The red lines show the gaugings, made by Mr John R. Freeman, C. E., at the reservoir in Central Park, of the actual consumption of water in lower Manhattan from December 8 to December 14, inclusive, 1899, after reduction to the population residing on the Minetta Brook District.

From a report made to Gen. John Newton, Commissioner, Dept. of Public Works, in 1889, by Rudolph Hering, M. Am. Soc. C. E., Consulting Engineer.

October, November, December, 1888.

DIAGRAM VI.



Average hourly discharge of dry weather sewage and ground water from Minetta Brook Drainage Area above Sixth Avenue Sewer Gauge, at Amity Street, New York.

[illegible]

October, November, December, 1888.

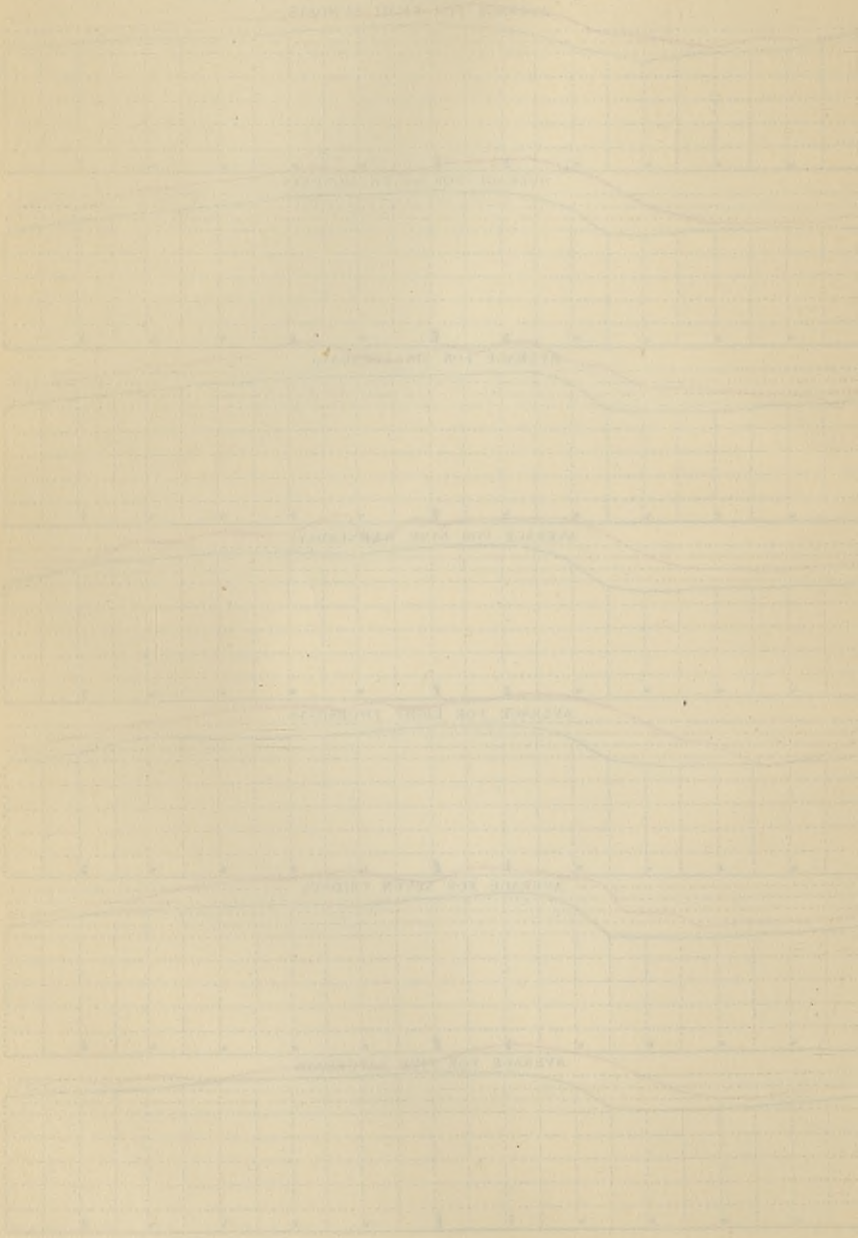
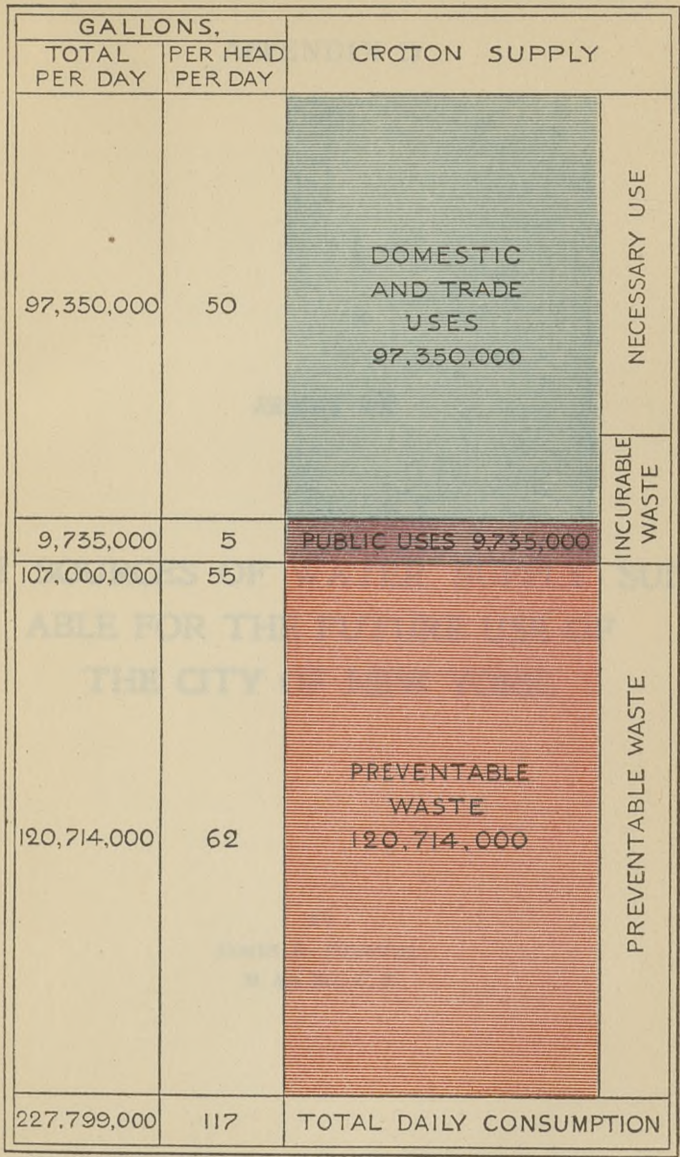


DIAGRAM
SHOWING WASTE OF WATER IN MANHATTAN AND THE BRONX



ACCOMPANYING REPORT
OF FOSTER CROWELL, C.E.
M. AM. SOC. C.E. M. INST. C.E.

APPENDIX D

REPORT ON

THE SOURCES OF WATER SUPPLY SUITABLE FOR THE FUTURE USE OF THE CITY OF NEW YORK.

BY
JAMES H. FUERTES,
M. Am. Soc. C. E.

CONTENTS OF APPENDIX D.

LIST OF PLATES.

THE SOURCES OF WATER SUPPLY SUITABLE FOR THE FUTURE USE OF NEW YORK CITY.

By James H. Fuertes, C. E.

To the Engineering Committee of the New York Merchants' Association, Thomas C. Clarke, Past President Am. Soc. C. E., Chairman:

Gentlemen:

On the 16th of December, 1899, instructions were given me by your committee to make the investigations necessary to ascertain from what sources, at what pressure and at what cost, water, as pure as the present Croton water in its best condition, could be obtained for a future supply for the City of New York.

In response to these instructions, I have now the honor, after nearly four months of work, of presenting the results of these investigations.

The work accomplished has been, in brief, the careful investigation of all the possible sources of water supply which could be economically developed by New York City. This has required the location of several hundred miles of aqueduct lines, the selection of sites for filter plants, settling basins, distributing reservoirs, storage reservoirs and their accessory works; the making of surveys of the valleys of the Catskill, Schoharie and Esopus creeks and Wallkill River; the reconnaissance for aqueduct lines in country for which no maps were available; the examination of all stream crossings and other critical points, and the study of the geology of the State with reference to its effect on the cost of the proposed structures. The most exacting part of the work has been the preparation of the detailed estimates of cost of construction and operation of each project, abstracts of which only are presented with this report.

Record maps, on a scale of 500 feet to the inch, have been prepared from the field notes of all the surveyed creek valleys, reservoir sites and filter sites, and preliminary designs were made for all the filter plants, aqueduct sections and special structures, as a basis for the various estimates of cost. The estimates have been made in as much detail as was desirable, applying prices for materials and labor in the same manner as if the work were to be let by contract. In the estimates of annual cost of operation, your committee instructed me to use a rate of 3 per cent. for interest charges, and to leave out of consideration any charge for a sinking fund. My office force has prepared not only the finished maps published with my own report, but also the maps and diagrams submitted with the reports of Messrs. Croes and Crowell. The work has been carried on by a permanent force of six men, with additional assistants, as circumstances occasionally required. I have been particularly fortunate in having the uninterrupted services of William B. Fuller, M. Am. Soc. C. E., late resident engineer in charge of the construction of the Albany filter plant, to whom was assigned the supervision of the calculations regarding the movement of salt water in Hudson River, and the estimate of the present value of the New York water-works plant.

The other members of the engineering force were Messrs. Albert J. Himes, M. Am. Soc. C. E.; William P. Boright, C.E.; R. H. Anderson, C.E.; J. F. K. O'Connor, M.E.; A. A. Aguirre and R. H. Cable. The quantity and quality of the work accomplished bear witness to the faithfulness and devotion of the corps.

At this point I wish to express my thorough appreciation of the many courtesies extended me by the members of the Engineering Committee and of the Association.

I.

Preliminary Considerations.

As a basis of work the Engineering Committee specified two quantities of water for the securing of which it was desirable to provide plans and estimates of cost: 250,000,000 gallons daily, and double this amount, 500,000,000 gallons daily. Instructions were also given me to leave out of consideration all streams flowing into other states, and all waters in the Adirondack Mountains. The investigations recounted in this report are therefore confined to the Hudson River and its tributaries south of the Mohawk River.

A preliminary study of the region north of New York City, on both sides of the Hudson, indicated that waters which could be economically brought to New York by gravity could be delivered at an elevation of 310 feet above sea level; and that the additional quantity which could be delivered at a lower level was quite small. All the gravity projects provide, therefore, for delivering the water 310 feet above sea level at the City line, an elevation sufficient to allow of the distribution of the water to any part of New York, Brooklyn or Staten Island, without pumping.

The watershed areas, for estimating stream flows, have been taken from the topographic maps of the U. S. Geological Survey, from Julius Bien's atlas of the State of New York, and from county maps secured especially for the purpose.

As a basis for calculating the yield of the different streams investigated, it has been assumed that the conditions affecting losses of water by evaporation and seepage on their watersheds are about the same as on the watersheds of the New York and Boston water supply works. It has also been assumed that the dry-year yields of the streams, per square mile of watershed, with different amounts of storage, would be about the same as has been determined for the streams in the Boston, Mass., Croton, N. Y., Perkiomen, Tohickon and Neshaminy, Pa., watersheds, the records of which are the most complete and reliable to be had in the eastern part of the United States. These assumptions are conservative, because the normal annual rainfall on the watersheds under consideration is somewhat greater than on the Boston watersheds. Another compensating factor in the Catskill watersheds is that the valleys through which the creeks flow are filled with gravel and other permeable materials, which will make the available considerably in excess of the visible storage.

In the absence of continuous records of the gaugings of the streams, the assumptions are sufficiently near the truth for the purposes of this study.

The yields obtained under these assumptions will err on the safe side by giving too small rather than too large quantities.

This view is strengthened by Mr. Rafter's estimates of the yield of Schroon reservoir, which are based on gaugings of the rivers in neighboring territory, using Rochester evaporation data. From these he concludes that the reservoir can easily furnish 500,000,000 gallons a day. The yield, according to the data which I have used, would be about 433,000,000 gallons per day.

The absolute minimum yield of a stream during a series of dry years is exceedingly difficult to estimate with accuracy, even when complete rainfall records have been kept for a great many years in the territory in question. The yield depends, naturally, upon the meteorological conditions and the geological structure of the country, as these affect the natural losses of water, including absorption by plant life, evaporation from surfaces and seepage into the soil.

Evaporation data, including all the above losses, have been collected for some years at several points in this country, and in making calculations for the yields of streams, data from one of these places are generally used, often regardless of whether or not the modifying conditions are similar to those at the point where the data were obtained. As the influence of evaporation is very great, errors in its amount will seriously affect the yield deduced from its use.

It has always appeared to me, therefore, that to use carefully collected information regarding stream flow from places in about the same latitude, where annual rainfall and temperature conditions are not very different, would give results as nearly correct as it would be possible to approximate in view of the many complex and not easily differentiated conditions.

In order to ascertain the amount of water which could be stored in some of the creeks, it was necessary to survey and prepare contour maps of their valleys, the needed information not being available in published form. These surveys, though hastily made with the aid of many labor-saving devices, covered Esopus and Schoharie creeks, parts of Catskill Creek and the upper thirty miles of Wallkill River, together with the tributaries of each. Although not more than approximate accuracy was desired, various checks were employed whereby errors were kept within definite limits. In addition to surveying the valleys of the principal streams, the various sites for filter beds, pumping stations, settling basins, reservoirs and other works were also surveyed and mapped.

The alignments and profiles of the aqueduct lines were established, in the main, from the United States Geological Survey sheets; the courses of the lines for about one hundred miles, through country for which no maps were available, being located in the field by inspection.

The crossings of the aqueducts over the different streams and valleys have all been inspected and carefully studied on the ground, and the geological structure of the country traversed or occupied by the works has been carefully observed and made a subject of special study.

The aqueducts have been located with the view of securing the shortest lines between the given points consistent with economic construction.

II.

THE BASIN OF THE LOWER HUDSON.

The main branches of the lower Hudson, on the west side, are:

Murderers' Creek,	emptying	into	the	Hudson	near	Cornwall.
Wallkill River,	"	"	"	"	"	Kingston.
Esopus Creek,	"	"	"	"	"	Saugerties.
Catskill Creek,	"	"	"	"	"	Catskill.
Schoharie Creek,	"	"	"	Mohawk	"	Amsterdam.
Hannacrois Kill,	"	"	"	Hudson	"	Coeymans.
Normans Kill,	"	"	"		"	below Albany.

And several smaller creeks, such as Vlaumans Kill, Coeymans Creek, Plaaterskill Creek and Kaaterskill Creek.

On the east side of the river, above the present Croton watershed, are:

Peekskill Creek,	emptying	into	the Hudson	near	Peekskill.
Fishkill Creek,	"	"	"	"	Fishkill.
Wappinger Creek,	"	"	"	"	New Hamburg.
Sawkill Creek,	"	"	"	"	Red Hook.
Roeliff Jansens Kill,	"	"	"	"	N. Germantown.
Claverack Creek,	"	"	"	"	Hudson.
Kinderhook Creek,	"	"	"	"	Hudson.
Wyant Kill,	"	"	"	"	Troy.
Poesten Kill,	"	"	"	"	Troy.
Hoosic River,	"	"	"		above Mechanicsville.

Among these streams are some which could not be used because they do not lie at sufficiently high elevations; are already appropriated by other municipalities; do not possess satisfactory storage reservoir sites, or would not yield pure enough water on account of pollution by sewage. The creeks that would be ruled out entirely by one or more of these considerations are: Fishkill Creek and tributaries, Crum Elbow Creek, Landmans Kill, Sawkill, Roeliff Jansens Kill, Claverack Creek, Moordener Kill, Wyant Kill, Poesten Kill, Tomhannock Creek, Batten Kill, Murderers' Creek and several other small creeks.

On the east side of the lower Hudson River there are no other available watersheds from which large quantities of water could be obtained, excepting certain ones, the diversion of the waters of which, by New York, would involve questions of interstate rights.

About 6,000,000 gallons per day could be obtained from Peekskill Creek; 5,000,000 from Clove Creek and about 15,000,000 gallons from Wappinger Creek. The headwaters of Kinderhook Creek would probably yield about 50,000,000 gallons daily, and the south branch of the Hoosic about 30,000,000. Fifty million gallons additional per day might be brought into the city at a lower elvation than 300 feet. These waters, however, are scattered over such a wide expanse of country that they would hardly pay for collection. Further detailed study of the streams of this region might indicate greater possibilities for storage than I was able to find in the limited time available. Thus, from all the small watersheds it would probably not be possible to secure much over 150,000,000 gallons daily, and to obtain this quantity it would be necessary to build an aqueduct about 150 miles in length. Furthermore, in view of the possibility of securing other waters in larger quantities and from districts lying closer to the city, no necessity exists for pursuing further the study of the creeks on the east side of the Hudson River.

On the west side of the Hudson are two distinct highland districts, surrounded by rolling lands and elevated plains. These are the Catskill Mountains, and the mountains in Northern New Jersey and Southeastern New York comprising the Shawangunk, Bear Port, Ramapo and other ranges at the eastern termination of the Blue Mountains. The Delaware River, Rondout, Esopus, Schoharie and Catskill creeks are the principal streams receiving the surface waters from the Catskills, while to the Wallkill, Ramapo, Hackensack and Passaic rivers flow the waters of the other district.

A small amount of water could be secured from reservoirs on Rondout Creek; but these would be so far distant from other available waters in the Catskills as to render this territory, at present at least, unfavorable for development.

The only streams, therefore, in the lower Hudson watershed, not involving questions of the diversion of water flowing into other states, which offer opportunities for the storage of water in sufficiently large quantities to warrant development for the future water supply of Greater New York are: The Hudson River above the influence of salt water; Catskill Creek; Schoharie Creek, Esopus Creek and the Wallkill River.

III.

SUPPLY FROM THE ADIRONDACK MOUNTAINS.

The plan proposed by Mr. Geo. W. Rafter, and described in his report, for securing 500,000,000 gallons of water daily from Schroon River, in the Adirondack Mountains, contemplates, briefly, the raising of the level of Schroon and Brant lakes by means of a dam at Tumblehead Falls.

In my estimates of cost, I have included Mr. Rafter's estimates of the cost of storage, water-rights, damages, etc., as well as the cost of the aqueduct from the dam at Tumblehead Falls to New York, and the new reservoir near the city line. The most serious objection to this project lies in the destruction of the water powers on Schroon River, a protective measure necessary in order to safeguard the purity of the water.

A plan that would meet this objection would be to build a diversion weir across the Hudson River at Hadley, construct certain storage reservoirs in the upper Hudson watershed, for which numerous favorable sites exist, for the purpose of securing the desired yield, and after filtering the water, to take it to New York in an aqueduct. This aqueduct would be about 25 miles shorter than the one from Tumblehead Falls, and the saving in cost on this item, in addition to the reduction in cost of damages to water-rights and properties, would about equal the cost of filters and accessory works; the estimates of cost of construction, presented further on, may therefore be taken as representative of either project.

The cost of the water under the Hadley project, however, would be about $3 more per million gallons than under the Schroon Lake project, this amount representing the cost of filtration.

In view of our present knowledge regarding the effects of stream pollution on public health, I should not regard it as safe to use the water of Hudson River at Hadley as a domestic supply for New York City without previously filtering it properly, unless the water were first passed through an enormous reservoir, where sufficient time would be allowed for the complete dispersion, nitrification or sedimentation of the polluting matter.

IV.

Quantity of Water that May Be Secured in the Catskill Mountains.

The lowest elevations considered in seeking storage reservoir sites in the Catskills were: On Catskill and Esopus creeks, 500 feet, and on the Schoharie, 1,100 feet, above sea level; lower elevations will not economically permit of the delivery of water at New York 300 feet above sea level.

Catskill and Esopus creeks flow in a southeasterly direction, nearly parallel, and about 25 miles apart; Catskill on the northern side and Esopus on the southern side of the main mountains. Both creeks empty into Hudson River, Catskill at the Village of Catskill and Esopus at Saugerties. Schoharie Creek lies between Catskill and Esopus and flows in the opposite direction, bending around toward the north after leaving the highlands and emptying into Mohawk River near Amsterdam. The sources of the Schoharie are over 2,000 feet above sea level, and not more than ten miles from Hudson River.

The waters of Catskill and Esopus creeks can be delivered to New York through conduit lines leading direct from the reservoirs. The waters of the Schoharie, however, can only be brought to the City by the construction of a tunnel from the lowest reservoir on the Schoharie to the nearest point in the valley of the Esopus, at a suitable elevation.

Topographically, Catskill and Esopus creeks are similar in general characteristics. In the areas under consideration the tributaries of the streams have, as a rule, very steep beds, offering no sites for large storage reservoirs, while, on the contrary, the main streams are much flatter and afford fairly good sites for the construction of dams.

The Schoharie has three large tributaries, the Batavia Kill, West Kill and East Kill, on each of which good storage may be secured. For this reason the Schoharie will yield a greater amount of water per square mile of watershed than either Esopus or Catskill creeks.

All these streams are more or less flashy, rising quickly during heavy rains and discharging their flood waters very rapidly after the storms have passed.

Esopus Creek.

The lowest dam site chosen on Esopus Creek is a short distance above the falls at the village of Olive. At this point the creek runs through rather a narrow gorge in the shale rock, affording an opportunity for the construction of a masonry dam, 60 feet high and about 600 feet long.

The area of the watershed above this dam is 245 square miles. The proposed reservoirs have an available combined storage capacity of about 27,000,000,000 gallons, and can yield in dryest years about 150,000,000 gallons daily. This corresponds to an average yield of about 625,000 gallons of water per square mile of land surface per day.

The proposed dams would be located as follows: At Olive; Cold Brook station; Lake Hill; one mile above Mt. Pleasant station; one-half mile above Phoenicia; one mile and one-half above Phoenicia; one mile above Shandaken, and one-half mile below Big Indian. The dam at Shandaken could be omitted by increasing the height of the Big Indian dam. Such an expedient, however, would render more difficult the relocation of the Ulster and Delaware Railroad.

All the dams on the Esopus, excepting the one at Olive, will, of necessity, be of earth, or rock-fill construction, with spillways cut in the solid rock sides of the valley.

The Ulster and Delaware Railroad enters the Esopus Valley about half a mile above the Olive dam, and follows the creek from Brodheads station to above the highest reservoir site. The building of the proposed storage reservoirs would require a relocation of this railroad for its entire length.

The construction of the reservoirs would also require the relocation of the villages of Brodheads, Beechford, Riseleys, Big Indian and part of South Allaben. These villages contain from six to fifteen houses each, with no industrial institutions, excepting the village of Brodheads, where a stone planer plant is located. The villages of Olive, Shokan, West Shokan, Boiceville, The Corner, Mt. Pleasant, Long Year, Phoenicia, Chichester, Allaben, Shandaken Center and Shandaken are not interfered with. As they lie above and between the various reservoirs, however, the cost of providing them with sewers and sewage purification works has been included in the estimates.

There are a few water powers on the main stream which would be destroyed by the erection of the proposed dams, the principal ones being located at Olive, Boiceville, Allaben and Big Indian. None of these powers is developed by storage reservoirs, the mill owners depending upon the natural flow of the stream, the head being secured by the erection of small in-take dams, or diversion weirs a few feet in height. The power at Olive drives grist mills, and the low-water flow of the stream could not be depended on to give more than 100 horse-power with the head available. The power at Boiceville is used for running a sawmill, and can develop about 80 horse-power at low-water flow. The power at Allaben drives a mill, not more than 25 horse-power being available at that point in dry weather. At Big Indian a small sawmill uses about 15 horse-power. Several of these plants have turbine capacity above that required to develop the minimum flow of the stream. There are, aggregating about 93 horse-power, three unused powers which might be developed cheaply.

Inasmuch as these powers would be completely destroyed and the industries which they now serve would be seriously crippled if obliged to use steam instead of water for power, liberal provision has been made in the estimates for the purchase of the various plants. This method has been adopted in the estimates of cost, not necessarily as an indication of what would be best in the premises, but in order that these estimates may be based upon a plan that would give a total cost larger, rather than smaller, than the true amount.

Where routes of travel would be interfered with or intercepted by the construction of reservoirs and accessory works, provisions have been made for the construction of new highways or bridges or such other structures as would be required.

Catskill Creek.

The main valley of Catskill Creek is very much narrower than that of Esopus, and consequently affords more favorable dam sites. The lowest dam has been located near the village of East Durham. The area of the watershed above this dam site is about 192 square miles. It is proposed to construct dams at the following points: East Durham; about two miles above East Durham; about one-half mile below Oak Hill; just above the village of Preston Hollow, and on Basic Creek near the village of Greenville.

These reservoirs will provide an available storage capacity of nearly 19 billion gallons and would yield about 110,000,000 gallons per day.

All the dams, excepting that at East Durham, would be of earth with masonry cores, or of rock-fill construction, with spill-ways cut in the rock walls of the valley. The East Durham dam would be of masonry, with the spill-way over its crest.

The construction of the Oak Hill reservoir would require the complete removal of the village of Oak Hill, which consists of some 90 buildings, including churches, stores and dwellings. With the exception of the small hamlet of Greenville, consisting of eight or ten houses and a small store, no other towns are interfered with by the system of reservoirs proposed.

Sewage purification works have been provided for in the estimates of cost for the towns of East Durham, Durham, Potter Hollow, Cooksburg, Preston Hollow, Livingstonville and Franklinton.

In order to develop the territory as highly as possible, Thorp Creek, which naturally empties below East Durham, is to be intercepted by an artificial channel, thereby diverting its waters into East Durham reservoir.

The developed water powers on Catskill Creek above East

Durham are of little importance. In that portion of the watershed occupied by the reservoirs is one mill which lies within the flow line of the reservoir, thus necessitating the acquisition of the property and power.

On the lower creek the most important power is at Leeds, where there are falls in the stream. The head here is sufficient to develop, with low-water flow, about 500 horse-power. About a mile out of Catskill is another small dam located on the brink of some rapids. The water is diverted to turbines running a sawmill, and the power available at this point is about 100 horse-power.

Schoharie Creek.

The area of the Schoharie watershed above Gilboa is about 305 square miles. This is as much of the area as could be economically developed for the supply of the City of New York, because the proposed Gilboa dam raises the water level to elevation 1,100 feet above tide water, which is just sufficient to permit of the discharge of the Schoharie waters into the Esopus Valley through a tunnel ending near Shandaken.

The dams proposed for the Schoharie reservoirs vary from 50 to 110 feet in height, and from 700 to 1,840 feet in length, and would be located at the following points: Gilboa; about one mile north of Prattville; about the same distance north of Lexington and at Kaaterskill Junction; on Batavia Kill: just north of the towns of Ashland and Windham, and south of the town of Big Hollow; and on the East Kill, below East Jewett. These reservoirs would afford about 40,000,000,000 gallons of available storage, and would yield in dryest years very nearly 200,000,000 gallons of water daily.

The dam at Gilboa would be of masonry; all the others would be of earth with masonry cores, or of rock-fill construction, with spill-ways cut in the rock sides of the valleys.

The water powers on the Schoharie and its tributaries above Prattville are insignificant, consisting of but two or three very small sawmills. The lower reaches of the stream have been developed, however, more fully than above Prattville, and the question of damages to water-rights which would be caused by the abstraction of the water requires careful consideration.

An unused power of 200 to 300 horse-power could be developed at Devasego Falls.

At Gilboa, a small dam above the falls in the stream gives an available head of about 15 feet, and the low-water flow of the stream will develop about 150 horse-power.

At the Borst mill, one mile below Middleburg, is situated a dam having a head of about 7 feet, which furnishes power for a grist mill. Probably a maximum of about 70 horse-power is available at low-water.

Another dam, about two and one-half miles below Middleburg, at Frisbie's grist mill, has a head of about 7 feet, and the low-water flow of the stream will give about 70 horse-power.

At Auriesville, about five miles from the mouth of the Schoharie, the Empire State Water Company has begun the construction of a plant. The head secured is about 40 feet, and the resulting maximum power available is claimed to be 350 horse-power.

The abstraction of the water from the Schoharie would affect all these powers as well also as the powers on Mohawk River below the mouth of the Schoharie.

At the lower Mohawk aqueduct, which carries the Erie Canal across the river near Crescent, from 1,000 to 1,100 horse-power is available. The most extensive powers, however, are owned by the Cohoes Water Power Company, and it is estimated that they are capable of producing 12,000 horse-power.

There is another power on the Mohawk at Rexford Flats, at the upper canal aqueduct, four miles below Schenectady. The head available is 11 feet, which would produce at low-water flow about 740 horse-power.

All the above-mentioned powers are stated on the basis of continuous operation for 24 hours per day. Several of the plants, however, have considerable storage which might permit their running at double the above rates for ten hours per day.

The proposed development of Schoharie Creek will abstract practically the entire flow of the stream in dryest years. This would, of course, obliterate the water-powers on the stream. It would also reduce the flow of the Mohawk River by a slight amount, and thereby also damage the existing water-powers to some extent.

Basing the calculations on the power actually developed at

Cohoes, in relation to the low-water flow of stream, the effect of the abstraction of the Schoharie water at the different points would be about as follows:

Loss of power at	Cohoes	1,200 H. P.
" "	Rexford Flats (State dam)	180 H. P.
" "	Dunsbach Ferry	40 H. P.
" "	Crescent (not in use)	300 H. P.

In the various estimates of cost, these damages to water powers have been liberally compensated for in money.

The specific information regarding the several reservoirs proposed in the Catskill Mountains is summarized in Tables I., II. and III.

To obtain a daily supply, in dryest years, of 250,000,000 gallons from the Catskill Mountains would require the development of Esopus Creek above Olive, and Catskill Creek above East Durham.

The Schoharie, with the reservoirs proposed, would yield about 200,000,000, and the combined yields of all the streams would reach about 460,000,000 gallons daily.

Careful and extended surveys and borings would be necessary to determine the best sites for the various dams. There are several sites besides those named above, and possibly a readjustment of locations would be desirable in order to secure proper foundations. Such a readjustment would not materially change the cost of the works as given in the estimates.

I have no hesitancy in asserting that the yield of these water sheds as deduced above, averaging about 630,000 gallons per square mile per day, could be sustained with the reservoirs proposed. I should not consider it advisable, however, to attempt a higher development than this.

TABLE I.

PROPOSED STORAGE RESERVOIRS IN CATSKILL MOUNTAINS.

ESOPUS CREEK.

Name of Reservoir.	Area of Watershed. Sq. Miles.	Approx. Elevation of High Water in Feet Above Sea Level.	Approx. Elevation of Low Water in Feet Above Sea Level.	Height of Dam. Feet.	Length of Dam. Feet.	Area of Reservoir, Full. Sq. Miles.	Available Storage. Millions of Gallons.	Yield per Sq. Mile of Land Surfaces. Thousand Gallons per Day.	Total Yield. Gallons per Day.
Olive	49	510	485	60	620	.78	2,750	415	20,000,000
Cold Brook	31	690	655	85	1,150	1.03	5,050	730	22,100,000
Lake Hill	18.6	1,080	1,055	70	500	.72	2,790	705	12,700,000
Mt. Pleasant	34.9	790	755	80	1,670	.89	4,820	685	23,500,000
Lower Phœnicia	22.3	910	885	90	900	.25	1,040	375	8,300,000
Upper Phœnicia	40.8	985	940	95	1,170	1.01	6,740	735	29,400,000
Shandaken }	48.9	1,180	1,150	80	1,420	.37	1,740 }	580	27,900,000
Big Indian }		1,240	1,210	70	1,630	.51	2,280 }		——
Total	245.5	——	——	——	——	5.56	27,210	595 Av'g	143,900,000
If operated in series	——	——	——	——	——	——	——	625	151,000,000

TABLE II.

SCHOHARIE CREEK.

Name of Reservoir.	Area of Watershed. Sq. Miles.	Approx. Elevation of High Water in Feet Above Sea Level.	Approx. Elevation of Low Water in Feet Above Sea Level.	Height of Dam. Feet.	Length of Dam. Feet.	Area of Reservoir, Full. Sq. Miies.	Available Storage. Millions of Gallons.	Yield per Sq. Mile of Land Surfaces. Thousand Gallons per Day.	Total Yield. Gallons per Day.
Kaaterskill Junction.	33.4	1,740	1,700	90	1,700	.47	2,830	540	17,800,000
East Jewett..........	20.6	1,830	1,800	95	1,550	.74	3,390	730	14,700,000
Big Hollow..........	13.6	1,720	1,675	90	1,340	.29	2,050	705	9,400,000
Windham	15.5	1,560	1,540	65	860	.28	860	410	6,300,000
Lexington	42.2	1,430	1,380	100	1,250	.83	6,150	700	29,100,000
Ashland	22.9	1,480	1,455	50	710	.49	1,960	540	12,100,000
Prattville	76.9	1,280	1,225	105	1,840	1.64	14,110	765	57,900,000
Gilboa	80.3	1,100	1,050	110	780	1.01	8,108	600	47,800,000
Total..............	305.4	—	—	—	—	5.75	39,530	650 Av'g	195,100,000
If operated in series..	—	—	—	—	—	—	—	662	199,400,000

TABLE III.

CATSKILL CREEK.

Name of Reservoir.	Area of Watershed. Sq. Miles.	Approx. Elevation of High Water in Feet Above Sea Level.	Approx. Elevation of Low Water in Feet Above Sea Level.	Height of Dam. Feet.	Length of Dam. Feet.	Area of Reservoir, Full. Sq. Miles.	Available Storage. Millions of Gallons.	Yield per Sq. Mile of Land Surfaces. Thousand Gallons per Day.	Total Yield. Gallons per Day.
Greenville	30.4	680	650	85	730	.45	1,950	450	13,500,000
Lower East Durham	21.8	540	500	60	620	.33	1,900	545	11,700,000
Upper East Durham.	43.3	620	580	100	700	.89	5,020	635	27,100,000
Oak Hill...........	52.4	720	680	90	1,600	.97	5,750	620	32,000,000
Preston Hollow......	44.1	960	900	100	1,500	.44	3,930	550	24,000,000
Total..............	192.0	—	—	—	—	3.08	18,550	570 Av'g	108,300,000
If operated in series..	—	—	—	—	—	—	—	580	110,000,000

V.

The Hudson River, Above the Influence of Salt Water, as a Source of Supply.

The minimum fresh-water flow of Hudson River at Poughkeepsie, based on the lowest recorded flow at Albany, is about 1,500,000,000 gallons per day. The river is affected by the tides as far up as the dam at Troy, and consequently it becomes important to know what effect the abstraction of so large a quantity of water as 500,000,000 gallons daily at Poughkeepsie would have upon the saltness of the water at that point.

As the water must be brought to New York in expensive aqueducts, it is desirable, from the standpoints of cost of con-

TABLE IV.

Year.	Remarks.
1876	Brackish water in Fall. Dryest year for 40 years Long, steady south winds.
1879	Slight saltness from November 1 to December 23.
1880	Slight saltness in Fall, due to dry Summer.
1881	Saltness began August 10, continued to December 10. Greatest intensity September 20.
1882	Slight brackishness from August 17 to end of the year.
1883	Saltness began August 17 and continued to end of the year. Appreciably manifest September 1 to December 1.
1884	Saltness appeared about the 1st of August, and disappeared about the middle of November. Not very manifest.
1885	No brackishness.
1886	Presence of sea water slightly manifest August 17.
1888	No saltness, but slight indications of presence of sea water.
1891	Sea water indicated by increased chlorine, October 6 to December 10.
1892	Slight increase in chlorine in October and November.
1893 to 1899	No mention of salt water.

struction and operation, to have these as short as possible. The taking out of a considerable portion of the minimum flow of the river will undoubtedly tend to draw the salt water toward the point of abstraction, and it becomes necessary, therefore, to find the nearest point to New York City where the water may safely be taken from the river.

Study of the Hudson water at various points has shown that it is always salty at Sing Sing and always fresh at Rhinecliff; between these points the limits of saltness change with local conditions. Table IV., compiled from the Public Water Works Reports of Poughkeepsie, shows that at that city, which derives its water supply from the river, brackish water has quite frequently been encountered during periods of very low fresh water flow in the river.

From 1879 to 1884 is the period during which all the streams in this part of the country gave the lowest recorded flow, on account of the occurrence of several consecutive years of low rainfall. Since 1884 the saltness has been manifest at Poughkeepsie only by a slight rise in the chlorine. It is evident, therefore, that if at the present time Poughkeepsie is likely to get salt water occasionally, the abstraction of half a billion gallons of water from the river daily would undoubtedly increase both the frequency and duration of these salt periods, and the City of New York, should it locate its intake above Poughkeepsie, would be in danger of ruining the Poughkeepsie supply, while if the intake were located below Poughkeepsie the City would occasionally get water too salty for use.

The solution of this difficulty is entirely feasible, and in a manner that should meet with support, rather than opposition, from all the various interests along the river. By reference to Mr. George W. Rafter's report it will be seen that it is possible to construct at a comparatively small expense a series of storage reservoirs in the Adirondack Mountains that will impound and hold the flood waters of the spring and winter months until dry weather approaches; by then letting these waters out of the reservoir into the river channel the low-water flow may be kept up to a quantity several times that which now obtains. The present low-water flow at Albany is about 1,000,000,000 gallons a day, while the additional quantity that can be added, during the dryest years, by this means, is about 2,600,000,000 gallons. The practical result of the addition of this large volume of fresh water in dry-weather flow would be to raise the river level, increase the depth for navigation, increase the available power at the mills along the river, facilitate the running of logs in the upland streams, and also hold the salt water further down the stream, and make the quality of the water much better in summer by greater dilution of the polluting matter contained in it.

It is not possible to state, without further examination of the relative specific gravities of the water at different depths and points, how far this additional fresh water would actually force the salt water down stream, but theoretical considerations indicate that as this added water would raise the river level about two feet, it is not probable that salt water would get within from 15 or 20 miles of Poughkeepsie, even when more than half a billion gallons of water was being abstracted from the river daily, in the dryest years, for water-supply purposes.

TABLE V.

AVERAGE ANALYSES OF HUDSON RIVER WATER, AT POUGHKEEPSIE, N. Y., JUNE, 1893, BY DR. THOMAS M. DROWN.

	Parts per 100,000.					
	Albumenoid Ammonia.	Free Ammonia.	Nitrogen as Nitrates	Nitrogen as Nitrites	Oxygen Consumed.	Chlorine.
At intake of Poughkeepsie Water Works. Average of 9 samples taken from 5 to 8 feet below surface.........	.0144	.0031	.0007	.0108	.5197	.110
At one-third distance from east shore. Average of 19 samples taken at surface, 30 feet, and 50 feet below surface	.0137	.0032	.0006	.0106	.5159	.107
At two-thirds distance from east shore. Average of 21 samples taken at surface, 30 feet, and 48 feet below surface	.0149	.0034	.0006	.0110	.5389	.109
Seven miles above Poughkeepsie. Average of 6 samples across river 30 feet below surface..............	.0143	.0034	.0006	.0095	.4606	.113

Sentimental considerations would dictate that the water should be taken from the river above Poughkeepsie, and some distance from the shore; but, judging by Professor Drown's analyses and special report on that subject, it actually matters little where the intake is located. The volume of flow of the river is so large in comparison with the amount of sewage discharged into it at Poughkeepsie that the latter is lost, even to delicate chemical tests, a few feet distant from the sewer outfalls.

In the plans for which estimates have been made, however, the intakes have been located above the town, more in order to have these estimates large enough to cover all possible contingencies than because the facts in the case require such an arrangement.

The plans proposed are to build storage reservoirs in the upper Hudson Valley, take the water from the river several miles above Poughkeepsie, pump it up to the filter beds located on high land, and after purification to let it run to new covered reservoirs at New York. The plans proposed contemplate two plants of 250,000,000 gallons daily capacity each, one delivering the water, at the City line, 260 feet above sea level, and the other, 131.5 feet, which is the elevation of Jerome Park reservoir.

VI.

WALLKILL RIVER AS A SOURCE OF SUPPLY.

Wallkill River rises in the northern part of the State of New Jersey, a few miles south of the town of Sparta. Its general course is in a northeasterly direction, and it enters the State of New York about half way between the villages of Liberty Corner and Unionville. Flowing then through the Counties of Orange and Ulster, it joins Rondout Creek which empties into Hudson River at Kingston.

Just before reaching the State line the stream enters a broad, flat valley reaching to Phillipsburg, and varying from one to five miles in width. The floor of this valley is practically flat, both longitudinally and transversely, and its slope in the direction of the river flow is so slight that the valley is practically a lake during the spring rains. Several hills and ridges of small extent rise up from the floor of the valley, and are, in local parlance, called islands. During dry weather the waters drain off the flats through the river and through several artificial drainage ditches.

The valley walls consist of high hills with steep sides. The hills on the west and north sides of the valley are of slate rock, with a thin covering of soil, while the hills on the easterly side are of granite, marble and limestone. The bottom of the valley is underlaid with a calciferous sandstone, cropping out in certain places, but generally covered with a few feet of black soil on top of the detritus with which the valley is filled. From the geological structure of the region it is to be inferred that all the rain falling on the watershed above Phillipsburg passes through the open river bed at that point with very little underground flow.

The valley floor is now nearly clear of timber, only from 20 to 30 per cent. being wooded. The cleared portions are used partly for raising grass and partly for corn and onions. These crops are not reliable, however, a rainy season often causing great loss to the farmers.

The valley is crossed by several roads built with State or town aid to afford cross communication at ordinary seasons. At the time of my first visit to the valley the water stood over the greater part of the road from Gardnerville to Pine Island about two feet deep, and had the water not been covered several inches in thickness with ice, the road would have been impassable.

The water of the reservoir as proposed would be as soft and as colorless as the Croton water. This conclusion is based on a knowledge of the local conditions, on a set of carefully made experiments and analyses, and on a study of the ground and surface flows of the streams. As the slope of the river is very slight, a rainy season will pile the water up in the flats more rapidly than the head thus acquired can force it out through the gap at Phillipsburg. These waters, however, drain off when the stream flow is small and the weather is dry.

It is proposed to erect a dam at Phillipsburg which will impound the waters of the river and flood these drowned lands from 20 to 30 feet in depth. The general elevation of the valley is about 390 feet above sea level. A dam which would raise the water level to elevation 410 would provide sufficient storage to make possible a daily draught of 250,000,000 gallons by drawing the water in the reservoir down five feet. This would leave 15 feet of water over the bottoms at the lowest level to which it is drawn. The area of the watershed above Phillipsburg is 465 sq. miles. The area of the land submerged at elevation of 405 is 48.9 square miles, and at 410 it is 51.4 square miles, showing that only about 5 per cent. of the area is exposed by drawing down the reservoir enough to give a yield of 250,000,000 gallons daily. The amount of water impounded behind this dam would be, approximately, 200,000,000,000 gallons, of which 53,000,000,000 gallons would be available. This amount of storage would assure a daily yield of 615,000 gallons of water per square mile of land surface per day, or 254,000,000 gallons per day.

In view of the large area of the reservoir, and the possibility of algæ and lily growths in the shallow places around the edges, it is proposed to filter the water before conducting it to New York.

The land which would be submerged is very sparsely populated, and with the exception of Florida, Hamburg and Deckertown, there are no villages of any importance near the valley. The sewage of Goshen and Middletown, which now enters streams flowing into the Wallkill above the point where the dam would be located, would be taken below the dam by means of sewers. The sewage of Florida, Deckertown and Hamburg would have to be purified before its discharge into the streams tributary to the lake. The other small hamlets, consisting of from three to a dozen houses, could easily be taken care of by purchase or otherwise, and there would be therefore nothing left to injuriously affect the purity of the water.

Since it is proposed to filter the water, it will not be necessary to remove the top soil of the submerged portions except in a few places, ample protection being afforded by simply clearing the land, grubbing out the roots, burning the grass and débris and then giving the area a general cleaning. The estimates of cost provide for a purchase of 70 square miles of country, which includes a strip of land around the edge of the lake wide enough to afford sufficient protection from contamination.

Of the land that it is proposed to submerge, not over 20 per cent. is at present, or has been in the past, under cultivation, or of value for crops of any kind. The rest is now covered with water and rank growths of coarse grass, reeds and underbrush. Many drainage ditches intersect the flat areas, nearly all of which have been cleared to facilitate their drainage.

The hills surrounding the valley are dotted with dairy farms, and the Lehigh & New England Railroad and Pine Island Branch of the Erie Railroad collect the milk and convey it to the markets. These railroads would have to be re-located along the edge of the proposed lake, with crossings, embankments and bridges where required. It would also be necessary to build cross-roads over the lake, with bridges, and roads along the margins. The expenses of all these items have been included in the estimates of cost.

The most expensive damages that will be incurred on account of land will be in the Village of Florida; about half of the village will have to be moved further up the hill.

There are several dams on Wallkill River, below the drowned lands, at which power is used for operating mills and factories.

At Phillipsburg, a low dam gives about 60 H. P. at low-water flow. Considerably less than this amount is now in use there.

Just below Montgomery Bridge there is a dam that will furnish about 100 H. P., and half a mile further down is another, from which about 120 H. P. can be obtained. Both powers are in use.

The principal developed power on the river, however, is at Walden, which is engaged in the manufacture of cutlery and similar wares. The population of the village is from 2,500 to 3,000 people, and its prosperity depends upon the water power that has been developed by two dams and which amounts, altogether, to about 500 H. P. at minimum low-water flow. At ordinary times the power available would be double this. The crippling of this power would seriously affect the community dependent on it. In the estimates, therefore, very liberal figures have been used and are thought to be sufficiently high to cover any method of compensation that might be adopted.

At Wallkill about 70 H. P. is available, at low water flow, but the considerable amount of storage in this pond would allow a higher power development than that given; the power is not at present in use.

The last dam is on Rondout Creek below the junction of

Wallkill River, at New Salem. This belongs to the Delaware and Hudson Canal Company, and was built to create slack-water navigation in the river; it is not used for power.

The total power actually in use does not much exceed 1,000 H. P., although in some instances the plants have a capacity somewhat in excess of that needed for the minimum flow of the stream.

Some distance below the proposed dam at Phillipsburg, there is a suitable piece of ground on which the filter beds can be built. The plan proposed provides for the construction of covered filter beds, similar to those described for the Poughkeepsie projects, with all the necessary appurtenances, and an aqueduct leading from the filters to a new covered reservoir at New York 310 feet above sea level.

The water flows from the reservoir to the filters, then to the aqueduct, and thence to New York, by gravity, without the intervention of pumping machinery. No steam power will be required in connection with the works, as the power necessary to pump the water under pressure for the sand washers, and to provide for electric lighting, is to be generated by turbine wheels interposed between the dam and the filters, and operated by the water before filtration.

The filter beds have a reserve area of 20 per cent. to permit proper operation, and are designed to filter the water at the rate of 3,000,000 gallons per acre per day. For filtering 250,000,000 gallons daily, 133 beds, and for filtering 460,000,000 gallons daily, 245 beds are provided. They are each three-quarters of an acre in area and have the requisite sand runs, regulating chambers on inlets and outlets, sand washers, and equipment necessary for economical service.

The estimates of cost are for the work complete, ready for service, with all needed appurtenances the best of their respective kinds.

The aqueduct from the filters to New York will be expensive, as it has very little "cut and cover" work, being nearly all either in tunnel or of pipe lines. It is not, however, a very difficult tunnel line to build, as shafts can be sunk at almost any desired point, and only in a distance of about three miles will they be excessively deep. The estimates of cost take into account these difficulties and they are thought to be amply large to cover any probable method of construction.

By increasing the height of the Phillipsburg dam, thereby raising the water surface to 422 feet above sea level, the flooded area will be 58 square miles, and the available storage capacity of the reservoir, when drawn down to elevation 402, will be 219,000,-000,000 gallons; with this available storage the minimum yield in dry years will be about 417,000,000 gallons daily. When the reservoir is full the total amount of water impounded will be 387,000,000,000 gallons, and when drawn down to its lowest level to yield 417,000,000 gallons daily the water will stand twelve feet deep over the entire flat portion of the valley.

This reservoir would be the largest artificial reservoir in the world, and would take, after closing the gates, about 500 days to fill.

By diverting the waters of Shawangunk Creek into the reservoir through a tunnel 18 feet in diameter, leading from Bloomingburg to Mechanicstown, a distance of a little over six miles, 47 sq. miles may be added to the watershed and the Wallkill reservoir may be made to yield about 460,000,000 gallons daily in dryest years, and over 500,000,000 gallons in ordinary years.

In developing this Wallkill project to its full capacity, it is assumed that the filter plants, aqueduct lines and distributing reservoirs at New York are duplicated. It will then also become necessary to purify the sewage of Goshen and Middletown, as the entire flow of the stream will be diverted to maintain the daily draught of 460,000,000 gallons, and the discharge of sewage into the open dry channel of the river would soon create offense. The costs of these works are all included in the estimates.

It may be said, against this project, that the construction of the Phillipsburg dam will cause the flooding of lands in New Jersey, and that objections might be raised in that State. It may be answered, however, that the Wallkill, although rising in New Jersey, flows into New York State, and that New York is entitled to the flow of the river, in the same manner that New Jersey claims the right to the waters of the Ramapo, Mahwah and other streams rising in New York, but flowing into New Jersey. It would seem, in view of the importance of the streams in the Ramapo Mountains as possible future water supplies for the metropolitan district of New Jersey, that an amicable agreement could be reached between the two States that would make it possible for each to avail itself of the needed watersheds in the other State, instead of both being deprived of these benefits by reason of inability to exercise the right of eminent domain in the acquisition and holding of property for reservoir sites.

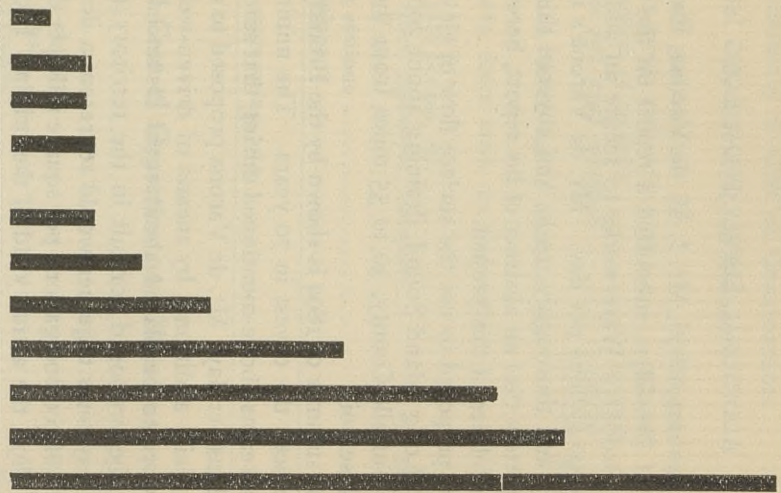
In such a transfer of rights, New Jersey would certainly not be the loser, as the lands desired for the Wallkill reservoir are now largely valueless for farming purposes.

The reservoir would be a lake varying from one to five miles in width, having an area of nearly 60 square miles, dotted with numerous small islands. The shores would be steep and it could be surrounded by fine, level roads, the length, around the water's edge, being about 70 miles. The lake would be surrounded on all sides by high hills, and could, at slight expense, be made a beautiful metropolitan park district.

A concrete idea of the enormous size of this reservoir, a reservoir which could be created by the construction of one small dam, may be gained by a study of the following table, which exhibits, by the lengths of the lines opposite the names of the reservoirs, their relative capacities. The largest existing reservoir in the world is the Periyar, in India, used for storing water for the purposes of irrigation. Its total capacity is only about one-fourth the total capacity of the proposed Wallkill reservoir:

TABLE VI.

Name of Reservoir.	Comparative Size.
Combined reservoirs of the Metropolitan Water Works, Boston..............	
San Mateo, Cal. San Francisco........	
New Croton, New York..................	
Nira, India. Irrigation reservoir.......	
Combined reservoirs of present New York City Works..................	
Wachusett, Boston.....................	
Periyar, India. Irrigation reservoir......	
Schroon Lake, reported by G. W. Rafter,	
Tonto, Arizona, reported by T. C. Clarke,	
River Nile, Assuan, Egypt. Now building,	
Wallkill................	



VII.

ADDITIONAL SUPPLY FROM LONG ISLAND.

In January, 1896, Mr. I. M. de Varona, Engineer of Water Supply of Brooklyn, submitted a report on the extension of the present Brooklyn Waterworks to secure an additional supply of 100,000,000 gallons per day. Mr. de Varona's investigation was carefully and thoroughly made, and covered this field of inquiry so completely that an abstract of his report, here given, will show the possibilities of this project.

It is proposed to use the surface flow of eleven streams flowing into Long Island Sound, draining about 200 square miles of land in Suffolk County, 30 to 55 miles from the present Ridgewood Reservoir.

The summer of 1894 is shown by the Brooklyn rainfall record to have been the dryest in 70 years. The minimum yield of the eleven streams above-mentioned during that summer was 80,000,000 gallons per day. Mr. de Varona proposed to obtain 20,000,000 gallons daily additional by means of driven-well plants, four of which were to be placed about equal distances apart along the line of the proposed conduit in the territory to be developed. The two systems together would represent a development of the territory of 500,000 gallons per square mile per day.

In 1894, the actual yield of the original Brooklyn watershed was 730,000 gallons per square mile per day. Mr. de Varona's assumption of a possible draught of 500,000 gallons per square mile per day would, therefore, seem to be not excessive.

Judging by the published gauging of the streams in the original watersheds, it seems to me that to get 500,000 gallons per square mile per day it might be necessary to develop the ground water supplies more highly than was proposed.

Mr. de Varona's plan is to allow the water to flow by gravity conduits to the nearest one of three pumping stations, located at Babylon, Connetquot and Connecticut, respectively. At each of these stations the water is to be pumped to tanks placed on the tops of high trestles, whereby it may flow by gravity through riveted steel pipes to Ridgewood reservoir. From Babylon to Ridgewood is 30.4 miles, and the water is to be conveyed between these points in two 81-inch steel pipes.

Estimate of Cost of Construction.

By Mr. I. M. de Varona.

Land for conduits and stations	$660,000	
Land for supply ponds and water rights	320,000	
Land for protection of streams	1,770,000	
Special damages and legal expenses	1,250,000	
		$4,000,000
Special structures, force main, Babylon to Ridgewood		500,000
Special structures, force main, to Connecticut River		800,000
Supply ponds, gate houses, etc.		2,000,000
Conduits, pipe lines, pipes, etc., complete		13,520,000
Steel towers and tanks		180,000
Three pumping stations		1,080,000
Driven well stations		320,000
		$22,400,000
Contingencies, engineering, etc.		2,100,000
		$24,500,000

Annual Cost of Operation and Maintenance.

Interest at 3½%	$857,500.00
Sinking fund	215,726.27
Pumping station expenses	290,880.00
Driven well expenses	22,636.00
Maintenance and repairs	38,000.00
	$1,424,742.27

The above estimates are based on 1895 prices, and on actual costs of similar works in the Brooklyn system.

A reserve boiler and pump power of more than 50 per cent. was provided for in the estimates, and, based on these considerations, the price of the water per million gallons would be $39.03.

The estimates do not include the cost of a new distributing reservoir.

If it should be found necessary to develop the ground-water supply more highly than supposed, the cost of construction would thereby be considerably increased.

In this connection a few notes with regard to the extension of the present ground-water plants will be pertinent.

As an ultimate source for a large supply, there are certain considerations to be urged against the extension of the present ground-water supply of Brooklyn. These considerations are, chiefly: The legal difficulties which may arise, and which have been foreshadowed by several suits for injunctions within a few years past, and the danger of the pollution of the water when the territory becomes more highly populated. In addition to these considerations, it is also possible to show that such a supply as a finality would not be as desirable from the point of view of cost as certain other gravity projects. While a ground-water supply would cost more per million gallons than water from certain other sources, special conditions might arise in the near future which would make it expedient to develop such a supply to tide over the period of time required to build more extensive works elsewhere.

The lines upon which a development would have to be made would be, briefly, to extend the collecting conduit eastward, and at points a mile apart, more or less, along its length, erect stations for securing this ground-water. It is not necessary just here to go into a detailed description of the geological structure of Long Island in relation to the water-bearing strata, as this information is already largely in print. One point, however, worth mentioning, brought out by Mr. John R. Freeman, C. E., in his report to the Comptroller, is that there is no warrant for the extension of the system of deep wells on account of the complexity of the convolutions of the strata of sand and clay lying 150 feet and more below the surface, making it impossible to predict the yield that may be secured.

The extension of the ground-water stations, as above outlined, would provide means for securing perhaps three or four million gallons of water daily from each mile of length of the extension; the water would then have to be pumped to the reservoirs in the city. It would be possible, by a plant of this kind, to secure from 100,000,000 to 150,000,000 gallons of water per day, in addition to the present supply, at a cost per million gallons, including interest, depreciation and repairs on the conduit line connecting the wells with the Brooklyn reservoir, of from about $30 to $35, or, including a charge for sinking fund, from $36 to $41.

VIII.

The Staten Island Supply.

The situation on Staten Island for the development of a large ground-water supply is less favorable than on Long Island, in view of the fact that the heart of the island is formed of rock, and the water-bearing strata surround this in a belt of varying width. There is, consequently, not a very large amount of ground storage along the north and east sides of the island. When the island becomes thickly populated, as it promises to do in a comparatively short time, the ground-water will have to be abandoned as a source of supply, particularly the present sources, because all the polluting matter from the entire watershed will percolate to this narrow belt of water-bearing stratum, and the water will gradually become unfit for domestic consumption.

Water from a source outside the island can be delivered into the local reservoirs at no greater expense per million gallons than the cost of the present water.

The connecting conduit, from the proposed Brooklyn system to the Staten Island reservoir, should cross the harbor from a point near Bay Ridge to Stapleton, as along this line the water is not so deep as to prevent the pipes being laid by divers in a manner similar to those recently laid for the Boston Water Works. The estimates of cost for these conduits provide for independent lines as a safeguard against the interruption of the supply in case of accident to one of the lines.

A suitable site for a large storage reservoir on Staten Island exists on the hill just back of Stapleton.

IX.

Basis of Estimates.

For unskilled labor I have been instructed to use a rate of $2.00 per day of eight hours on the works in New York City, and outside of the city the rates of wages prevailing in the respective sections. Two sets of estimates of cost are given, therefore; one based on New York City prices, and the other on conditions which would prevail on ordinary contract work.

A liberal allowance has been made to provide for expensive sections of work, where ground-water would make pumping and timber foundations necessary. In the estimates the assumption is made in each case that approximately 33 1-3 per cent. of the length of the aqueduct will be "wet," this being about the proportion usually found on such works.

Provision is made in the estimates for timbering 50 per cent. of the soft rock tunnels and 5 per cent. of those in hard rock. All tunnel sections in soft rock are to be lined with brick, and those in hard rock with concrete. Concrete and mortar are, in all cases, to be made with Portland cement. For wearing surfaces, and where strength rather than weight is required, concrete is to be mixed in the proportion of one part cement to two and one-half parts sand and four parts of broken stone. All other concrete is to be made of one part of cement to three of sand and six of broken stone.

The aqueduct sections have been designed to deliver the required quantities when running three-quarters full; and a low coefficient has been used in the calculations to compensate for the gradual reduction of capacity during use.

All inverts are to be lined with vitrified brick laid in cement mortar. All sections in cut and cover and in embankment are to have the sides lined with one course of brick from the invert to the springing line of the arch.

The interior surfaces of the aqueducts are to be given a wash of Portland cement plaster.

The estimates provide for the dressing and seeding of the banks, erection of stone walls along the right of way in country districts and iron fences through the cities, and the establishment of telephone lines, keepers' houses, etc.

Where the aqueducts cross over streams they are carried on stone arch bridges in all cases, excepting at Kingston where the Rondout is to be crossed on a steel trestle. Where aqueducts cross under streams the crossing is made in an inverted siphon in one or more lines of pipes, according to the head which the pipes sustain. For low heads an eleven-foot riveted steel pipe, lined inside and backed outside with concrete, is used; and as the heads increase the pipes are reduced in diameter and increased in number.

Substantially constructed gatehouses with gates and movable stop-planks are provided at each end of every pipe line. Air valves, blowoffs and manholes are located wherever necessary.

An extra allowance has been made in the estimates of cost for the crossings of railroads, highways, etc., and for the acquisition of lands, at tunnel headings and shafts, for dumping grounds for the excavated materials.

The quantities of excavation and refilling, and the extra allowances to determine the fixed lines of the sections were deduced from the percentages found on the new Croton aqueduct. In the estimates it is assumed that the excavation is to be paid for to these fixed lines, while the refilling masonry outside of these fixed lines is to be paid for at one-half price, for the given class of work.

The crossing of Hudson River on the Adirondack line is in a tunnel, under a head of 370 feet. This tunnel is lined with cast iron, of full thickness to resist the pressure, with a 10-inch ring of concrete on the inside, and a solid packing of concrete between the tunnel walls and the cast-iron lining.

Pipe lines over 6 feet 4 inches in diameter are of riveted steel, coated with asphalt, lined inside and backed outside with concrete.

For the filtered supplies covered reservoirs, and for the unfiltered supplies open reservoirs, have been provided for in the estimates. These reservoirs have, in each case, a capacity equivalent to one day's supply.

The estimates include the cost of all damages to properties, water powers and other interests affected, as well as the cost of all sanitary and protective measures necessary for safeguarding the purity of the waters.

The filtration plants have been designed to filter three million gallons of water per acre per day, with an additional reserve area of 20 per cent., to allow the beds to be properly cleaned, refilled and rested. The filter beds are roofed with concrete vaulting covered with sodded earth; the beds, grounds and buildings are provided with electric lights, and the estimates include the cost of the requisite drains, sand washers, pumping machinery, tramways, wharfs, coal-handling machinery, screens, coal sheds, machine shops, dwellings for officials and laborers, bacteriological laboratories, store rooms, shelters, lunch rooms and conveniences, and all other accessories necessary on works of such magnitude.

Unit Prices.

The unit prices used in making the estimates of cost of the various projects are given in the following table:

TABLE VII.

Grubbing and clearing, per acre	$100.00
Rock excavation, granite, in tunnel, per cubic yard	5.00
Rock excavation, shale and limestone, in tunnel, per cubic yard	4.00
Rock excavation, and refilling, open cut, per cubic yard	1.20
Shaft excavation, per vertical foot	100.00
Earth excavation, including refilling, per cubic yard	.30
Earth embankment, including rolling, per cubic yard	.25
Dry rock filling over tunnel arch, per cubic yard	2.00
Rubble masonry in tunnel, per cubic yard	5.00
Brick masonry in tunnel, per cubic yard	12.00
Brick masonry in trench, per cubic yard	12.00
Timbering in tunnel, per lineal foot	20.00
Portland cement concrete in tunnel, 1 : 2½ : 4, per cubic yard	9.00
Portland cement concrete in trench, 1 : 2½ : 4, per cubic yard	8.00
Portland cement concrete in trench, 1 : 3 : 6, per cubic yard	6.30
Portland cement plastering on arch, per lineal foot	.25
Portland cement wash, invert and sides, per lineal foot	.08
Dressing and seeding banks, per square yard	.08
Fencing, stone wall on two sides, per lineal foot	.40
Fencing, iron fence on two sides, per lineal foot	2.00
Telephone line, per mile	600.00
Railroad crossings over aqueduct, each	2,000.00
Railroad crossings under aqueduct, each	25,000.00
Culverts under aqueducts, each	10,000.00
Gate-houses, each ... $35,000.00 to	60,000.00
Manholes, each	15.00
Blow-offs, each ... $500.00 to	1,000.00
Air-valves, each	200.00
Riveted steel pipes, coated and erected, per pound	.06

Cost of Pumping Water.

Cost per million gallons raised one hundred feet high, including labor, coal, oil, waste and supplies, and ordinary repairs; but excluding interest and depreciation.......................... $3.75

Cost of Filtration.

Cost per million gallons of filtered water, including labor, cost of wash and waste water, lost sand, sanitary analyses of water, ordinary repairs, superintendence, wages of watchmen, and all incidental expenses; but excluding interest, depreciation and cost of pumping water to filters:

Hudson River water.. $4.00
Wallkill Reservoir water.................................... 3.00

Interest and Depreciation.

Interest on cost of works has been computed at the rate of 3 per cent. per annum.

Depreciation of works has been assumed as follows:

TABLE VIII.

Structures, Apparatus, etc.	Life in Years.	Annuity on One Dollar.
Masonry conduits.........................	Permanent	——
Covered masonry filter beds................	"	——
Covered reservoirs.........................	"	——
Permanent buildings.......................	100	.00165
Cast-iron pipe............................	80	.00311
Vitrified pipe............................	80	.00311
Railroad sidetracks........................	80	.00311
Gate-houses	65	.00515
Steel pipe................................	35	.01654
Air-valves, blow-offs and gates on pipe lines	35	.01654
Engines and pumps........................	30	.02102
Boilers	20	.03722
Electric light plants......................	20	.03722
Tramways and equipment..................	20	.03722
Iron fences	20	.03722
Telephone lines...........................	10	.08724
Sand-washer apparatus, etc.................	10	.08724
Regulating apparatus for filters.............	10	.08724

Detailed estimates of cost have been made, and are presented herewith in abstract, of five projects for supplying 250 million gallons of water daily, two for supplying 460 million gallons daily, and two for supplying 500 million gallons of water daily.

X.

ESTIMATES OF COST OF CONSTRUCTION, OPERATION AND MAINTENANCE.

A.—250,000,000 Gallons Daily from the Adirondack Mountains.

It is proposed to dam Schroon River at Tumblehead Falls, thus raising the levels of Schroon and Brant Lakes. A description of the storage project, together with estimates of its cost, will be found in Mr. Geo. W. Rafter's report. The water is to be brought to New York through a 13-foot aqueduct and delivered to a new 250,000,000-gallon reservoir just above the city line, 310 feet above sea level.

The aqueduct follows Schroon River from the dam to Hudson River, passing through Warrensburg, and under Hudson River just above the highway bridge at Thurman Station. It follows Hudson River on the west bank from Thurman to Hadley, where it leaves the Hudson Valley and follows for a few miles the general direction of the Adirondack Railroad, heading for the Mohawk River, which is crossed about four miles west of Schenectady. Thence the course of the aqueduct is nearly straight to Cairo Round Top, which it pierces. It then skirts the base of the Catskill Mountains to a point about three miles from Kingston, where three lines of 8-foot 4-inch steel pipe, lined and backed with concrete, are laid across the valleys of Esopus and Rondout Creeks. The line then follows the range of hills on the west bank of the Hudson to just above Roseton, where it crosses the river in a cast-iron and concrete-lined tunnel to Low Point Station, on the N. Y. C. & H. R. R. R., about ten miles below Poughkeepsie.

From Low Point the line crosses the rolling land between the river and Fishkill Mountains, going through the latter in tunnel and entering the valley of Clove Creek. For the remainder of its course the aqueduct is a succession of tunnels and pipe lines. Crossing Peekskill Creek half a mile below Putnam Valley, and the Croton River just below the Cornell dam site, it passes then under the villages of Claremont and Spring Valley, and about half a mile to the east of Grassy Sprain Reservoir, terminating in a new distributing reservoir about two and a half miles north of the present Jerome Park reservoir.

It is the intention to take the water from the proposed dam at Tumblehead Falls and to compensate by purchase or otherwise for all the water powers which would be destroyed by the abstraction of the water. While it would be desirable, as pointed out by Mr. Rafter, to preserve these water rights, the question of the pollution of the water in the open channel and mill flumes in case the power were preserved, should have very careful consideration. In the estimate of cost of this project, therefore, the sum of $2,000,000 has been included to cover the value of these rights, and of the undeveloped powers on the Schroon. The damages to water powers on the Hudson, below Hadley, by the abstraction of 250,000,000 gallons per day has been estimated, following the line of argument suggested by Mr. Rafter, at $2,600,000, which sum is also included in the estimate.

The locations of the aqueduct line and Schroon River reservoir are shown on Plate IX.

Cost of Construction.

For a daily supply of 250,000,000 gallons from the Adirondack Mountains, to be taken from Schroon River at Tumblehead Falls, and delivered into a new reservoir at New York 310 feet above sea level.

	Labor $2.00 per Day.	Labor $1 35 per Day.
Storage Reservoir	$7,800,000	$7,800,000
Aqueduct	92,399,000	62,340,000
Distributing Reservoir	2,268,000	1,587,000
Total	$102,467,000	$71,727,000

Annual Cost of Operation and Maintenance.

Interest	$3,074,010	$2,151,810
Depreciation of plant	469,580	469,580
Sanitary inspection	8,448	8,448
Ordinary repairs	18,593	18,593
Keepers' wages	20,290	20,290
Sanitary analyses of water	13,000	13,000
General accounts	45,625	45,625
Total	$3,649,546	$2,727,346
Say	3,650,000	2,727,000
Cost per million gallons for the water delivered into the reservoir at New York	$40.00	$30.00

B.—250,000,000 Gallons Daily from Catskill Mountains.

This project contemplates taking 100,000,000 gallons of water daily from Catskill Creek and 150,000,000 gallons daily from Esopus Creek.

The distributing reservoir at New York and the aqueduct line from Kingston to New York are the same as described for Project "A." At a point about three miles north of Kingston and about eighty miles from New York, the aqueduct divides, one branch, 8.65 miles long, going to Olive to collect the waters of Esopus, and the other, 38 miles long, going to East Durham to collect the waters of Catskill Creek. The estimates include in all cases the cost of sewerage and sewage disposal for the various towns, and an allowance for water rights destroyed by the reservoirs.

The most important water powers that would be interfered with in this region are at Leeds, on the Catskill, and at Olive, on the Esopus. Both creeks have considerable fall, and afford storage facilities, in their lower reaches, which could be developed cheaply for power. These would, of course, be affected by the abstraction of so large a portion of the waters of the streams, and the damages that might be claimed for such abstraction would be difficult to estimate. I have assumed the total amount of these damages, provisionally, at $1,500,000, or about $350 per horse-power for 4,300 horse-power, the approximate power available between the lowest reservoirs and the Hudson River at low-water flow.

The alignment of the aqueduct and the locations of the reservoirs are shown on Plate IX.

Cost of Construction.

For a daily supply of 250,000,000 gallons from the Catskill Mountains, to be derived from the Esopus and Catskill Creeks, and delivered into a new reservoir at New York 310 feet above sea level.

	Labor $2.00 per Day.	Labor $1.35 per Day.
Storage Reservoirs, Esopus Creek........	$11,891,000	$8,324,000
Storage Reservoirs, Catskill Creek........	9,064,000	6,344,000
Aqueduct and connecting conduits........	55,216,000	38,652,000
Total	$76,171,000	$53,320,000

Annual Cost of Operation and Maintenance.

Interest	$2,285,133	$1,599,600
Depreciation of plant	313,073	313,073
Sanitary inspection.......................	5,530	5,530
Ordinary repairs..........................	11,430	11,430
Keepers' wages............................	11,800	11,800
Sanitary analyses of water................	13,000	13,000
General accounts..........................	45,625	45,625
Total	$2,685,591	$2,000,058
Say	2,686,000	2,000,000
Cost per million gallons for the water delivered into the reservoir at New York...	$29.44	$21.90

C.—250,000,000 Gallons Daily from Hudson River Above Poughkeepsie.

This project contemplates taking 250,000,000 gallons daily from Hudson River above Poughkeepsie, filtering the water and conducting it through an aqueduct 63 miles long to a new covered reservoir of 250,000,000 gallons capacity, adjoining the Jerome Park reservoir.

The water is to be taken from the river about two miles above the city into a forebay, from which high-duty pumps will lift it to a settling basin of 250,000,000 gallons capacity, located about a mile and a half northeast of Poughkeepsie. From the settling basin the water will pass through the filters by gravity, and thence into the aqueduct leading to New York.

The pumping machinery is to be in large units, with ample reserve capacity, and of the highest class of workmanship.

The filter beds, of which there are 136, as designed, are in groups, each bed having an area of about $\frac{3}{4}$ of an acre. The groups of beds are separated by roads in which the pipes and conduits are laid, and on which are tramways for handling the sand that is removed from the filters or replaced upon them after it has been washed.

Each bed is provided with the necessary regulating apparatus and gate houses. A sufficient number of sand washers are provided to permit washing all the sand during the warm months, thus avoiding winter work.

The locations of the aqueducts, filters, covered reservoir at New York and storage reservoirs are shown on Plate X.

Cost of Construction.

For a daily supply of 250,000,000 gallons from the Hudson River, to be taken from the river above Poughkeepsie, filtered and delivered to an aqueduct discharging into a new covered reservoir at Jerome Park, 131.5 feet above sea level.

	Labor $2.00 per Day.	Labor $1.35 per Day.
Storage reservoirs in Adirondacks..........	$4,230,000	$4,230,000
Filters, including sedimentation basin......	11,758,000	8,094,000
Pumping plant, force mains, etc...........	5,750,000	5,502,000
Aqueduct	25,831,000	17,221,000
Covered reservoir, capacity 250,000,000 gals.	2,750,000	1,833,000
Total	$50,319,000	$36,880,000

Annual Cost of Operation and Maintenance.

Interest	$1,509,581	$1,106,400
Depreciation of plant......................	171,179	171,179
Cost of pumping...........................	855,469	855,469
Cost of filtering water....................	365,000	365,000
Ordinary repairs..........................	19,168	19,168
Keepers' wages, etc........................	22,335	22,335
General accounts..........................	45,625	45,625
Total	$2,988,357	$2,585,176
Say	2,990,000	2,585,000
Cost per million gallons for the water filtered and delivered into the new reservoir at New York..............................	$32.77	$28.33

D.—250,000,000 Gallons Daily from Hudson River Above Poughkeepsie.

The project is similar in character to "C," except that the water is delivered at New York at an elevation of 260 feet above tide, instead of at the Jerome Park level.

Near the town of New Hamburgh, lying in a line toward the Fishkill Mountains, are several round-topped hills, the summits of which are about 300 feet above tide-water. It is proposed to locate the high-level filter beds, of which there are 133, on the tops of these hills and allow the water, after being filtered, to flow through an aqueduct to the city by gravity.

The intake for the water from the river has been located about a mile above Poughkeepsie, and it is proposed to build a tunnel some distance back from the river shore and at about river level from the intake to the mouth of Caspar Creek, where it is proposed to dredge out the valley to form a large settling basin. On the banks of this basin will be located the pumping station, with the necessary side-tracks, storerooms, coal sheds, machine shops, residences and all other accessories.

The water is to be pumped to the filters through four 6-foot riveted steel pipes. The general features of the plant are similar to those described under project "C."

Cost of Construction.

For a daily supply of 250,000,000 gallons from the Hudson River, to be taken from the river above Poughkeepsie, filtered and delivered into a new covered reservoir at New York, at an elevation of 260 feet above sea level.

	Labor $2.00 per Day.	Labor $1.35 per Day.
Storage in Adirondack Mountains........	$4,230,000	$4,230,000
Filters, including sedimentation basin......	10,324,000	7,271,000
Pumping plant, intake tunnel, mains, etc...	14,233,000	11,690,000
Aqueduct	20,732,000	14,693,000
250,000,000 gallon covered reservoir........	2,761,000	1,841,000
Total	$52,280,000	$39,725,000

Cost of Operation and Maintenance.

Interest	$1,568,401	$1,191,750
Depreciation of plant.....................	247,608	247,608
Cost of pumping..........................	1,197,656	1,197,656
Cost of filtering water....................	365,000	365,000
Ordinary repairs..........................	18,798	18,798
Keepers' wages, etc. on aqueduct and storage reservoirs.......................	21,595	21,595
General accounts.........................	45,625	45,625
Total	$3,464,683	$3,088,032
Say	3,470,000	3,088,000
Cost per million gallons of the water filtered and delivered into the reservoir at New York..........................	$38.03	$33.88

E.—250,000,000 Gallons Daily from the Wallkill River.

This project contemplates the building of a dam across Wallkill River near Phillipsburg, thereby flooding the extensive drowned lands lying to the south and securing sufficient storage to yield 250,000,000 gallons of water daily. The water so collected is to be filtered through slow sand filters, and brought to New York in an aqueduct 48 miles long, terminating in a new covered reservoir just north of the city line, 310 feet above sea level.

The aqueduct line is largely in tunnel. It crosses Hudson River just north of the New York-New Jersey line, to Hastings. The maximum depth of the river at this point is about 50 feet, and it is proposed to take the water across the river in cast-iron pipes, laid by divers, instead of in tunnel as contemplated for the Adirondack and Catskill aqueducts.

On account of the large area of this reservoir, the value of the land required is difficult to estimate closely. It may be said, however, that an addition of as large a sum as $4,000,000 to the cost of construction, as given in the estimates, will increase the cost of the water only $1.31 per million gallons.

For the extinguishment of water rights and the purchase outright of the present industries which would be affected by the abstraction of the water, the provisional sum of $2,000,000 has been included in the estimates of cost. The present utilized power on the river does not exceed 1,000 horse-power.

The alignment of the aqueduct and the location of the filters and the reservoir are shown on Plate XI.

Cost of Construction.

For a daily supply of 250,000,000 gallons from the Wallkill River, the water to be filtered and delivered into a new covered reservoir at New York, 310 feet above sea level.

	Labor $2.00 per Day.	Labor $1.35 per Day.
Storage reservoir	$7,405,000	$6,405,000
Filter plant	8,000,000	6,333,000
Aqueduct	24,255,000	17,248,000
250,000,000 gallon covered reservoir	2,761,000	1,841,000
Total	$42,421,000	$31,827,000

Annual Cost of Operation and Maintenance.

Interest	$1,272,644	$954,810
Depreciation of plant	180,551	180,551
Sanitary inspection	5,000	5,000
Ordinary repairs	37,400	37,400
Keepers' wages, Aqueduct line	4,800	4,800
Cost of filtering water	273,750	273,750
General accounts	45,625	45,625
Total	$1,819,770	$1,501,936
Cost per million gallons for the water filtered and delivered into the reservoir at New York	$19.94	$16.46

F.—500,000,000 Gallons Daily from the Schroon River.

This project differs from the one for supplying 250,000,000 gallons daily from Schroon Lake in the provision for the construction of a second 13-foot aqueduct, to bring to New York the additional 250,000,000 gallons daily, and the duplication of the distributing reservoir at the City Line. Two lines of equeduct have been estimated upon, instead of one, because it is probable that if the works were built by the city it would probably first undertake their construction with capacity to deliver 250,000,000 gallons daily, and extend them later, when there was need for more water.

It is also better policy, when such long and large aqueducts are to be built, to have two lines to depend upon instead of one; two lines will give greater security against accidental interruption of the supply, and will also permit the cleaning of one of the aqueducts without entirely stopping the supply.

The damages to the water rights on Schroon River and on Hudson River are also much increased by reason of the diversion of the entire flow of Schroon River at Tumblehead Falls. (See report of Mr. Rafter.)

ERRATUM.

Page 269. Second column, first table, column caption sho
read, "Labor $1.35 per day," not $3.15.

Cost of Construction.

For a daily supply of 500,000,000 gallons from the Adirondack Mountains, to be taken from Schroon River at Tumblehead Falls and delivered into a new covered reservoir at New York, 310 feet above sea level.

	Labor $2.00 per Day.	Labor $3.15 per Day.
Storage reservoir	$9,961,000	$7,621,000
Aqueducts	184,799,000	129,359,000
Distributing reservoirs	4,535,000	3,175,000
Total	$199,295,000	$140,155,000

Annual Cost of Operation and Maintenance.

Interest	$5,978,855	$4,204,650
Depreciation of plant	939,160	939,160
Sanitary inspection	8,448	8,448
Ordinary repairs	28,738	28,738
Keepers' wages	40,580	40,580
Sanitary analyses of water	25,000	25,000
General accounts	91,250	91,250
Total	$7,112,031	$5,337,826
Cost per million gallons of the water delivered into the reservoirs at New York	$38.97	$29.25

G.—460,000,000 Gallons Daily from the Catskill Mountains.

This project consists of the addition of 210,000,000 gallons of water daily to the 250,000,000 gallons obtained from Catskill and Esopus Creeks under project "B."

Two lines of aqueduct run from Olive on Esopus to New York, and the water from Schoharie Creek is turned into Esopus at Shandaken by means of a tunnel 19 miles long under the mountains separating the valleys. The shafts on this tunnel, with the exception of one section at the summit about three miles long, will not be over 500 feet deep.

In addition to the compensation for the destruction of water rights on Esopus and Catskill Creeks, mentioned in Project "B," the sum of $1,034,000 has been added to the estimates of cost as the value of the loss of power on Schoharie Creek and Mohawk River, occasioned by the diversion of the waters of these streams. Some of the powers would be destroyed completely, while others would be reduced by so small a proportion of their normal amounts as to render compensation entirely feasible.

Cost of Construction.

For a daily supply of 460,000,000 gallons from the Catskill Mountains, to be derived from the Catskill, Schoharie and Esopus Creeks, and delivered into a new reservoir at New York, 310 feet above sea level.

	Labor $2.00 per Day.	Labor $1.35 per Day.
Storage reservoirs	$32,160,000	$21,440,000
Aqueducts	120,253,000	84,177,000
Distributing reservoirs	4,535,000	3,024,000
Total	$156,948,000	$108,641,000

Annual Cost of Operation and Maintenance.

Interest	$4,708,457	$3,259,230
Depreciation of plant	584,533	584,533
Sanitary inspection	9,210	9,210
Ordinary repairs	20,460	20,460
Keepers' wages	22,500	22,500
Sanitary analyses of water	25,000	25,000
General accounts	83,950	83,950
Total	$5,454,110	$4,004,883
Cost per million gallons of the water delivered into the reservoir at New York	$32.48	$23.85

H.—500,000,000 Gallons Daily from the Hudson River above Poughkeepsie.

To supply 500,000,000 gallons daily from Hudson River above Poughkeepsie it is proposed to build the two filtration plants, and their respective aqueducts, mentioned above under "C" and "D."

Of these plants, the one delivering the water at elevation 260 feet above sea level at the City Line, would probably be built first, to be followed, when necessity demanded, by the construction of the low-level plant delivering the water at the proposed new Jerome Park covered reservoir. The estimated cost of construction of this project does not, therefore, truly represent the actual cost of the works to the city, because about half of the capital expenditure called for would be deferred for a great many years. There is also another modifying element tending to make the actual cost less than that exhibited by the estimates. A large part of the cost of the works is in pumping machinery and filter beds, which would not have to be built until needed, thus saving the outlay of capital until actually required.

Cost of Construction.

For a daily supply of 500,000,000 gallons from the Hudson River, taken from the river above Poughkeepsie, filtered and pumped into aqueducts discharging into two new reservoirs at New York, 131.5 and 260 feet above tide, respectively:

	Labor \$2.00 per Lay.	Labor \$1,35 per Day.
Storage reservoirs in Adirondack Mountains	\$4,230,000	\$4,230,000
Filters, including pumping plant	42,065,000	32,557,000
Aqueducts	46,563,000	31,913,000
500,000,000-gallon covered reservoir	5,511,000	3,674,000
Total	\$98,369,000	\$72,374,000

Annual Cost of Operation and Maintenance,

Interest	\$2,951,082	\$2,171,220
Depreciation of plant	418,787	418,787
Cost of pumping	2,053,125	2,053,125
Cost of filtering water	730,000	730,000
Ordinary repairs	37,966	37,966
Keepers' wages, etc., on aqueduct and storage reservoirs	43,930	43,930
General accounts	91,250	91,250
Total	\$6,326,140	\$5,546,278
Say	6,326,000	5,546,000
Cost per million gallons of the water filtered and delivered into new reservoirs at New York	\$34.66	\$30.39

J.—460,000,000 Gallons Daily from the Wallkill River.

By making the dam on the Walkill at Phillipsburg 12 feet higher than in project "E," and by turning the flood waters of Shawangunk Creek into the Wallkill reservoir by means of a tunnel, about 460,000,000 gallons of water daily may be obtained. The estimates include the cost of this work, and also the cost of additional filter beds, another aqueduct line to New York, and an additional covered reservoir for the filtered water.

The estimates for this project are based on two independent aqueducts of 250,000,000 gallons daily capacity each. If, instead of constructing the two aqueducts, one were built with a daily capacity of 460,000,000 gallons, the cost of the works complete, on the basis of $1.35 per day for common labor, would be $43,-037,000; the annual cost of operation and maintenance would be $2,193,000, and the cost of the water per million gallons $13.06.

If the water were not filtered, but the reservoir site were more thoroughly stripped, as a precautionary measure for preventing the deterioration of the quality of the water, the cost of construction on the $1.35 per day basis would be reduced to $37,637,000; the annual cost of operation and maintenance to $1,567,000, and the cost of the water per million gallons to $9.33.

On account of the large area of this reservoir, the value of the land required is difficult to estimate closely. Should so large a sum as $4,000,000 be added to the cost of construction, as given in the estimates, it would increase the cost of the water only 72 cents per million gallons.

The unfiltered water of the Wallkill, so far as danger from pollution by pathogenic germ life is concerned, would, in my opinion, be better than the present Croton water. In view of the cheapness of the supply, however, even when filtered and delivered in two independent aqueducts, it would seem wise to filter it at the start, keeping in view the fact that the standard of quality of water supplies for populous districts is higher than it was a few years ago, and is at present lower than it will be a few years hence, when popular agitation shall have taught an indifferent public the economic value of pure water.

Cost of Construction.

For a daily supply of 460,000,000 gallons from the Wallkill River, the water to be filtered and delivered into new covered reservoirs at New York, 310 feet above sea level.

	Labor $2.00 per Day.	Labor $1.35 per Day.
Storage reservoirs and accessory works...	$11,471,000	$9,115,000
Filters	15,360,000	10,240,000
Aqueducts	48,511,000	34,497,000
500,000,000 gallon covered reservoir........	5,522,000	3,682,000
Total	$80,864,000	$57,534,000

Annual Cost of Operation and Maintenance.

Interest	$2,425,926	$1,726,020
Depreciation of plant....................	361,102	361,102
Sanitary inspection......................	5,000	5,000
Ordinary repairs..........................	42,400	42,400
Keepers' wages, Aqueduct line	7,000	7,000
Cost of filtering water....................	402,700	402,700
General accounts..........................	83,950	83,950
Total	$3,328,078	$2,628,172
Say	3,328,000	2,628,000
Cost per million gallons of the water filtered and delivered into the reservoirs at New York..........................	$19.82	$15.65

XI.

Discussion of Estimates of Cost.

The cost of construction of the four aqueduct lines, with labor at $2.00 per day, is given in some detail in the following tables:

TABLE IX.

Aqueduct to Adirondack Mountains.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	90.65	$28,705,658	$59.97	$316,664
Tunnel	67.45	32,049,272	90.00	475,155
Pipe lines	44.80	31,644,226	133.77	706,343
			Average.	Average.
Total	202.90	$92,399,156	$86.25	$455,392

Poughkeepsie High-Level Aqueduct.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	14.65	$4,918,136	$63.58	$335,709
Tunnel	26.25	12,017,880	86.71	457,828
Pipe lines	6.60	3,796,143	108.93	575,173
			Average.	Average.
Total	47.50	$20,732,159	$82.66	$437,467

Poughkeepsie Low-Level Aqueduct.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	25.30	$7,993,648	$59.84	$315,955
Tunnel	37.10	16,901,522	86.28	455,569
Pipe lines	1.25	935,829	141.79	748,663
			Average.	Average.
Total	63.65	$25,830,999	$76.86	$405,829

Wallkill Aqueduct.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	8.65	$3,139,796	$68.75	$362,982
Tunnel	21.10	9,900,673	88.87	469,226
Pipe lines	18.10	11,214,702	117.35	619,597
			Average.	Average.
Total	47.85	$24,255,171	$96.00	$506,900

With labor at the average rate of $1.35 per day, the costs would be as given below:

TABLE X.

Aqueduct to Adirondack Mountains.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	90.65	$17,200,000	$35.93	$189,741
Tunnel	67.45	21,366,000	60.00	316,768
Pipe lines...............	44.80	23,774,000	100.50	530,670
			Average.	Average.
Total	202.90	$62,340,000	$58.19	$307,245

Poughkeepsie High Level Aqueduct.

	Length. Miles.	Total Cost.	Cost per foot.	Cost per Mile.
Aqueduct	14.65	$3,456,000	$44.68	$235,905
Tunnel	26.25	8,200,000	59.16	312,380
Pipe lines...............	6.60	3,037,000	87.15	460,151
			Average.	Average.
Total	47.50	$14,693,000	$58.58	$309,327

Poughkeepsie Low Level Aqueduct.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	25.30	$5,304,000	$39.70	$209,644
Tunnel	37.10	11,168,000	57.01	301,024
Pipe lines...............	1.25	749,000	113.50	599,200
			Average.	Average.
Total	63.65	$17,221,000	$51.24	$270,557

Wallkill Aqueduct.

	Length. Miles.	Total Cost.	Cost per Foot.	Cost per Mile.
Aqueduct	8.65	$2,093,000	$45.83	$241,966
Tunnel	21.10	6,700,000	60.14	317,536
Pipe lines...............	18.10	8,455,000	88.47	467,127
			Average.	Average.
Total	47.85	$17,248,000	$68.27	$360,459

For the purpose of comparison the foregoing have been rearranged in Table XI., with the costs of the New Croton Aqueduct, the Wachusett Aqueduct and certain estimates published in September, 1899, in the report on the Improvement and Extension of the Philadelphia Water Supply, by Messrs. Rudolph Hering, Joseph M. Wilson and Samuel M. Gray.

TABLE XI.

Comparative Costs of Various Aqueducts.

	Diameter. Feet.	Cost per Foot.	Notes.
New Croton	14.00	$104.24	Average cost of horse-shoe section, excluding land, supervision, etc.
Wachusett	11.33	32.00	Contractor said to have lost money on tunnels; very favorable, easy work; inexpensive labor; no pipe lines; about one-third in tunnel.
Philadelphia Estimates: Point Pleasant to Philadelphia	14.00	65.80	Including: Land, Fencing, Telephone Lines and Supervision. Labor, $1.75 per day.
Portland to Point Pleasant	14.00	72.90	
Aquanchicola Creek to Treichlersville	12.00	60.62	
Perkiomen Low Level	12.00	53.80	
Perkiomen High Level	12.00	64.00	

New York Estimates.

	Diameter. Feet.	Cost per Foot		
Adirondack	13.00	86.25 58.19*	About one-fifth pipe-lines under high heads; about one-third in tunnel.	Including: Land, Telephone Lines, Fencing and Supervision. Labor $2.00 per day.
Poughkeepsie High Level.	13.00	82.66 58.58*	One-eighth pipe-lines; over one-half in tunnel.	
Poughkeepsie Low Level.	13.00	76.86 51.24*	Very little pipe; over one-half in tunnel.	
Wallkill	13.00	96.00 68.27*	One-third pipe lines under high heads; about one-half in tunnel, with deep shafts.	

* Labor at average rate of $1.35 per day.

It will be noted that the estimates of costs of the aqueduct lines are higher than those for the reported Philadelphia works, but lower than the actual cost of the New Croton Aqueduct, in which the expenses of land and supervision are not included.

The cost of the Wachusett aqueduct is exceedingly low; the structure could not be duplicated to-day at the same cost.

On the proposed aqueducts for New York the prices of materials will probably be higher than on the Boston work; the hours of work may be shorter; real estate will be much more expensive; the character of the work much more difficult; the geological structure of the country less favorable; access to the work from railroads more difficult; the average haul on materials much longer; the crossings of streams much more expensive; the pipe lines will be under greater heads, and therefore much more costly; in fact, almost every item of expense will be much higher than it would be for such work in the vicinity of Boston.

The estimates presented are higher than any of those given in the list, except the New Croton aqueduct, because, in addition to the above considerations, they are based on the most thorough and expensive construction, in order to lessen the annual cost by decreasing the items of depreciation and repairs. An inspection of the detailed estimates of the cost of the aqueducts will show the effect of the high cost per foot of the pipe lines in raising the average cost per foot of the aqueducts. These pipe lines are all of riveted steel, coated with asphalt, and lined on the inside and backed on the outside with Portland cement concrete, to prevent the distortion of the section by settlement and to protect the steel from corrosion and tuberculation. This adds greatly to the cost of construction, but makes a direct gain in the annual charges, owing to the longer life of the structure, and the prevention of the reduction of capacity by distortion of section and incrustation.

The costs per million gallons of available capacity of the various storage reservoirs proposed are given in Table XII.; and for the purposes of comparison the costs of certain existing reservoirs, or of carefully-made estimates on projected works, are given in another column. These costs have been calculated by modifying the actual costs to make them accord with the assumed conditions as to stripping, cost of land, etc. These prices are per million gallons of available, not total, capacity.

TABLE XII.

Cost of Storage Reservoirs per Million Gallons of Available Capacity.

The costs include land, fencing, clearing and grubbing and stripping of 20 per cent. of the reservoir areas; but exclude damage to mill properties and water power.

(1) Reservoir.	(2) Estimated cost per million gallons of available capacity of reservoir named in Column No. 1.	(3) Name of existing or proposed reservoir most nearly like in elements of cost reservoir on same line in Column No. 1.	(4) Actual or estimated cost per million gallons of available capacity of reservoir named in column No. 3 on same line, making allowances for items named in heading above.
Olive	$240	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	$260 270 240
Cold Brook	255	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Lake Hill	235	Carmel (Croton) 8 and 9 (Phila. ests)	220 240
Mt. Pleasant	245	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Lower Phoenicia	460	No. 3 (Boston) No. 12 (Phila. ests.)	530 450
Upper Phoenicia	250	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Shandaken	360	Titicus (Croton) No. 5 (Boston) 3 and 11 (Phila. ests.)	320 350 340
Big Indian	295	Titicus (Croton) 4 and 10 (Phila. ests.)	320 265
Greenville	240	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Lower E. Durham	255	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Upper E. Durham	245	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Oak Hill	250	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240
Preston Hollow	245	Sodom (Croton) Croton (") 8 and 9 (Phila. ests.)	260 270 240

TABLE XII—(Continued).

Cost of Storage Reservoirs Per Million Gallons of Available Capacity.

(1)	(2)	(3)	
Gilboa	$220	Carmel (Croton) 8 and 9 (Phila. ests.)	$220 240
Prattville	240	Sodom (Croton) Croton (Croton) 8 and 9 (Phila. ests.)	260 270 240
Ashland	250	Sodom (Croton) Croton (Croton) 8 and 9 (Phila. ests.)	260 270 240
Lexington	255	Sodom (Croton) Croton (Croton) 8 and 9 (Phila. ests.)	260 270 240
Windham	365	No. 5 (Boston) Titicus (Croton) 3 and 11 (Phila. ests.)	350 320 340
Big Hollow	320	Titicus (Croton)	320
East Jewett	265	Sodom (Croton) Croton (Croton) 4, 13 and 10 (Phila. ests.)	260 270 265
Kaaterskill Junction	305	Titicus (Croton)	320

The estimates of cost of construction and of annual cost of operation and maintenance for the several projects are for convenience summarized in Table XIII.*

TABLE XIII.

Summary of Estimates of Cost.

Source of Supply.	Daily Supply. Million Gallons.	Cost of Reservoirs, Aqueducts, etc.	Cost of Filters and Pumping Machinery.	Total Cost.
Schroon River at Tumblehead Falls.......	250	$71,727,000 102,467,000	....	$71,727,000 102,467,000
100,000,000 gallons daily from Catskill Creek and 150,000,000 gallons daily from Esopus Creek .	250	53,320,000 76,171,000	....	53,320,000 76,171,000
Hudson River; water to be taken above Poughkeepsie and filtered.............	250	23,284,000 32,811,000	$13,596,000 17,508,000	36,880,000 50,319,000
Hudson River; water to be taken above Poughkeepsie and filtered.............	250	20,764,000 27,723,000	18,961,000 24,557,000	39,725,000 52,280,000
Wallkill River; water to be filtered........	250	25,494,000 34,421,000	6,333,000 8,000,000	31,827,000 42,421,000
Schroon River at Tumblehead Falls.......	500	140,155,000 199,295,000	....	140,155,000 199,295,000
110,000,000 gallons daily from Catskill Creek, 150,000,000 gallons daily from Esopus Creek, and 200,000,000 gallons daily from Schoharie Creek..............	460	108,641,000 156,948,000	....	108,641,000 156,948,000
Hudson River; water to be taken above Poughkeepsie and filtered.............	500	39,817,000 56,304,000	32,557,000 42,065,000	72,374,000 98,369,000
Wallkill River; water to be filtered........	460	47,294,000 65,504,000	10,240,000 15,360,000	57,534,000 80,864,000

* The upper figures given are for labor at the average rate of $1.35 per day; the lower figures are for labor at $2.00 per day.

TABLE XIII.

Summary Continued.

Source of Supply.	Annual cost of Operation and Maintenance.	Cost of Water per Million Gallons.	Elevation at which water is delivered at City Line.
Schroon River at Tumblehead Falls	$2,727,000 3,650,000	$30.00 40.00	310
100,000,000 gallons daily from Catskill Creek and 150,000,000 gallons daily from Esopus Creek	2,000,000 2,686,000	21.90 29.44	310
Hudson River; water to be taken above Poughkeepsie and filtered	2,585,000 2,990,000	28.33 32.77	131.5
Hudson River; water to be taken above Poughkeepsie and filtered	3,088,000 3,470,000	33.88 38.03	260
Wallkill River; water to be filtered	1,502,000 1,819,770	16.46 19.94	310
Schroon River at Tumblehead Falls	5,338,000 7,112,000	29.25 38.97	310
110,000,000 gallons daily from Catskill Creek, 150,000,000 gallons daily from Esopus Creek, and 200,000,000 gallons daily from Schoharie Creek	4,005,000 5,454,000	23.85 32.48	310
Hudson River; water to be taken above Poughkeepsie and filtered	5,546,000 6,326,000	30.39 34.66	Half at 131.5 " " 260
Wallkill River; water to be filtered	2,628,000 3,328,000	15.65 19.82	310

The relative advantages and disadvantages in point of cost of the various projects are apparent. The Adirondack region, as a source of supply, would be much the most expensive in first cost, and also in annual cost of operation, while the Wallkill would be by far the least expensive in both these regards. In point of quality, the filtered mountain water of the Wallkill would also be the superior.

The water from the Wallkill can be delivered by gravity to any part of Greater New York without pumping. This, in the case of the Brooklyn and Staten Island supplies, is of considerable importance, as the expense of pumping in these boroughs forms a large part of the annual cost of operation.

The Wallkill water, filtered and delivered into the proposed reservoirs at New York, will cost, with very expensive construction, not over $20 per million gallons for a supply of either 250,000,000 or 460,000,000 per day. If delivered also into the reservoirs of Brooklyn and Staten Island the cost would be not over $23 per million gallons, on the basis of 250,000,000 gallons per day, and $21.50 on the basis of a 500,000,000-gallon supply. With labor at rates prevailing on well-managed contract work these prices might be materially reduced.

The present cost of the Brooklyn water, excluding the cost of distribution, varies from $33 to $39 per million gallons, and the cost of pumping the Staten Island ground-water supplies is not far from $25. It would, therefore, be possible to supply all the boroughs of New York with filtered mountain water at a pressure sufficient to reach the highest districts without resorting to pumping, and at a cost well below the present cost of water in the respective boroughs.

Respectfully submitted,

JAMES H. FUERTES.

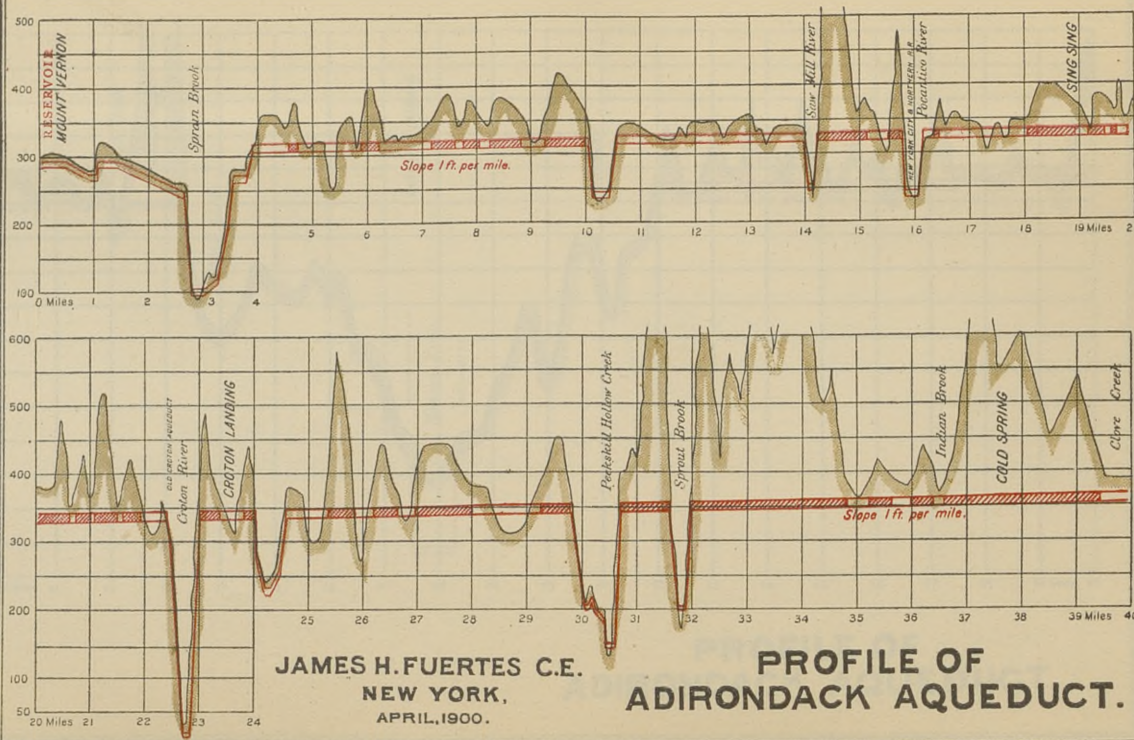
NEW YORK, April 14, 1900.


AVAILABLE SOURCES
OF
FUTURE WATER SUPPLY
FOR
THE CITY OF NEW YORK
SHOWING WATERSHEDS RESERVOIR SITES
and
AQUEDUCT LINES.
JAMES H. FUERTES C.E.
NEW YORK.
April 1900.
0 1 2 3 4 5 10 15 20 25
ATLANTIC OCEAN
LONG ISLAND SOUND
STATEN ISLAND
NEWARK
JERSEY CITY
NEW YORK
BROOKLYN
NEWBURG
POUGHKEEPSIE
KINGSTON
CATSKILL
HUDSON
ALBANY
TROY
COHOES
SCHENECTADY
AMSTERDAM
SARATOGA
BALLSTON SPA
HOOSIC FALLS
MIDDLETOWN
GOSHEN
PEEKSKILL
FISHKILL
SING SING
ESOPUS
SCHOHARIE
CATSKILL
SCHROON
ULSTER
ORANGE
ROCKLAND
DUTCHESS
COLUMBIA
RENSSELAER
SARATOGA
WARREN
ESSEX
HAMILTON
FULTON
WESTCHESTER
WASHINGTON
UPPER HUDSON
LAKE GEORGE
Yield 500,000,000 gallons daily
HUDSON RIVER


AVAILABLE SOURCES
OF
FUTURE WATER SUPPLY
FOR
THE CITY OF NEW YORK
SHOWING WATERSHEDS RESERVOIR SITES
and
AQUEDUCT LINES.
JAMES H. FUERTES C.E.
NEW YORK.
April 1900.
0 1 2 3 4 5 10 15 20 25
N.
ATLANTIC OCEAN
LONG ISLAND SOUND
STATEN ISLAND
NEWARK
JERSEY CITY
NEW YORK
BROOKLYN
NEWBURG
KINGSTON
POUGHKEEPSIE
CATSKILL
HUDSON
ALBANY
TROY
COHOES
WATERFORD
SCHENECTADY
AMSTERDAM
SARATOGA
BALLSTON SPA
MIDDLETOWN
GOSHEN
HOOSIC FALLS
ULSTER
GREENE
ALBANY
SCHOHARIE
ORANGE
DUTCHESS
COLUMBIA
WESTCHESTER
WARREN
ESSEX
HAMILTON
FULTON
SARATOGA
LAKE GEORGE
CHAMPLAIN

PLATE XI

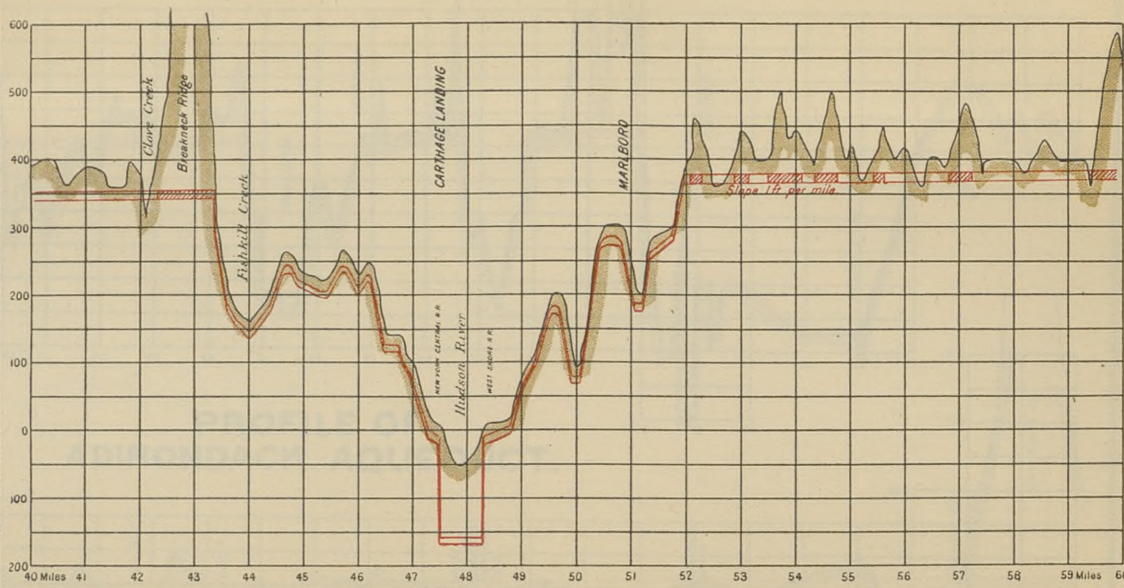
AVAILABLE SOURCES
OF
FUTURE WATER SUPPLY
FOR
THE CITY OF NEW YORK
SHOWING WATERSHEDS RESERVOIR SITES
and
AQUEDUCT LINES.
JAMES H. FUERTES C.E.
NEW YORK,
April 1900.
ATLANTIC OCEAN
LONG ISLAND SOUND
STATEN ISLAND
NEWARK
JERSEY CITY
NEW YORK
BROOKLYN
NEWBURG
KINGSTON
POUGHKEEPSIE
CATSKILL
HUDSON
ALBANY
TROY
COHOES
SCHENECTADY
AMSTERDAM
SARATOGA
BALLSTON SPA
MIDDLETOWN
GOSHEN
HOOSIC FALLS
ULSTER
GREENE
SCHOHARIE
ALBANY
DUTCHESS
COLUMBIA
RENSSELAER
WASHINGTON
WARREN
HAMILTON
FULTON
ESSEX
WESTCHESTER
TEN MILE RIVER
LAKE GEORGE
CHAMPLAIN



JAMES H. FUERTES C.E.
NEW YORK,
APRIL, 1900.

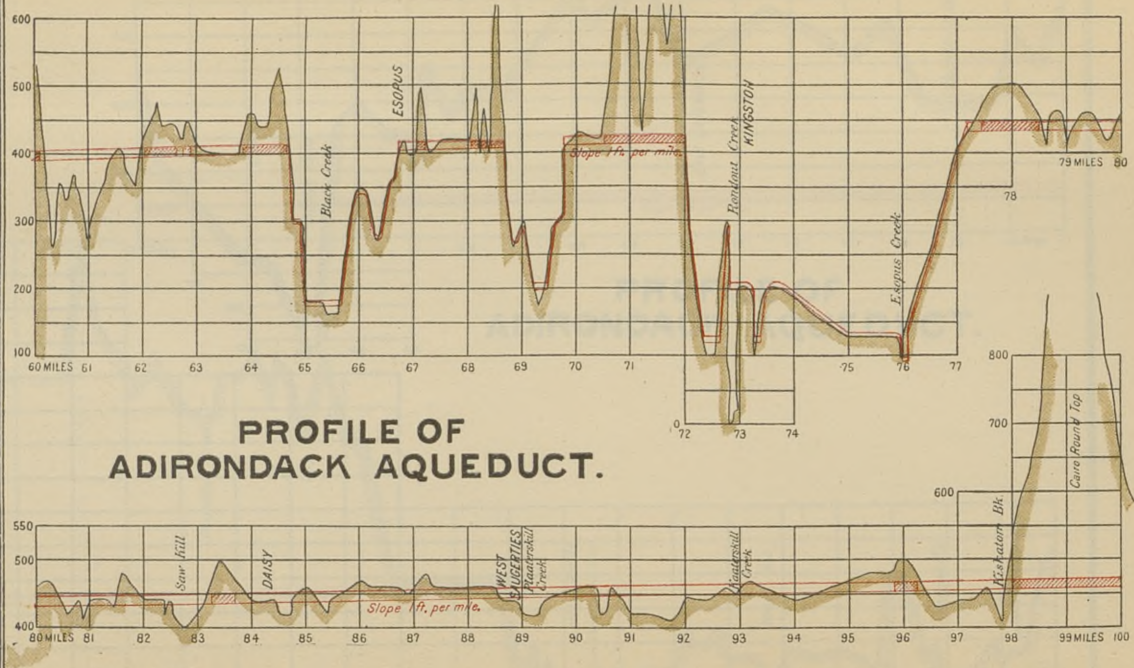
PROFILE OF ADIRONDACK AQUEDUCT.

PLATE XIII



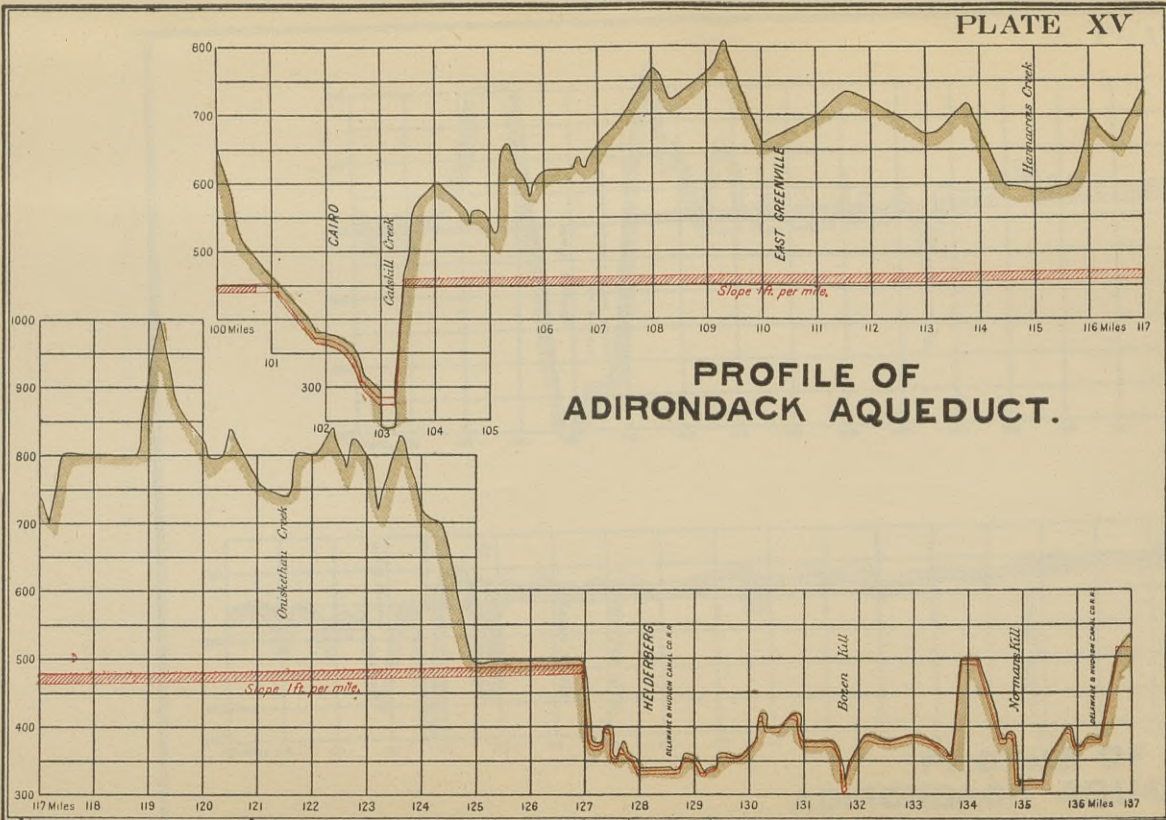
PROFILE OF ADIRONDACK AQUEDUCT.

PLATE XIV

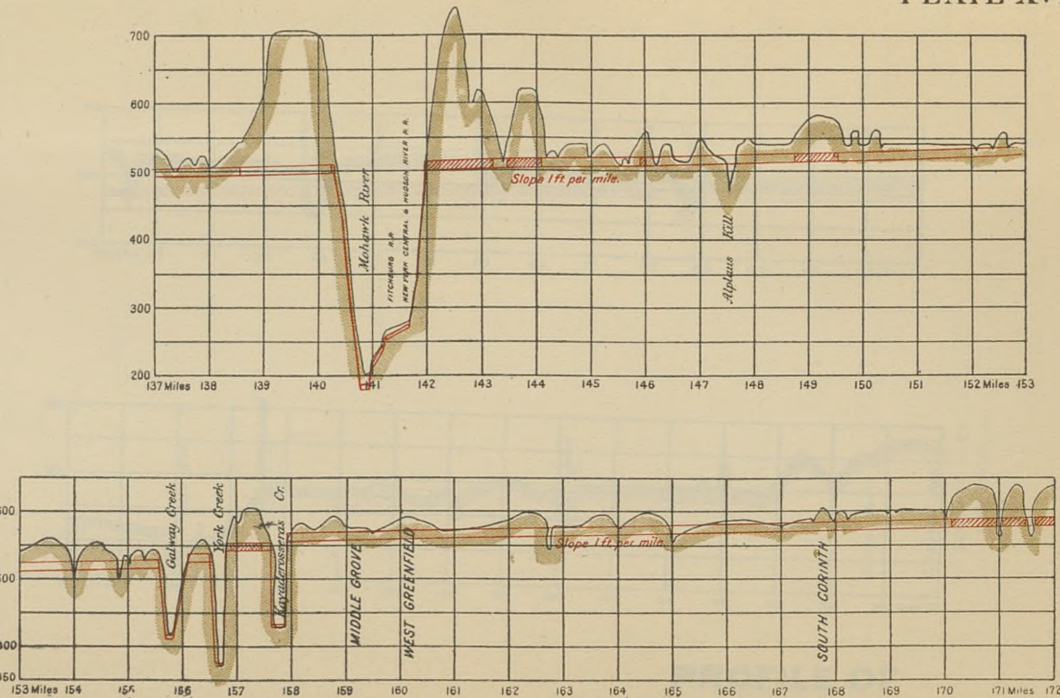


PROFILE OF ADIRONDACK AQUEDUCT.

PLATE XV

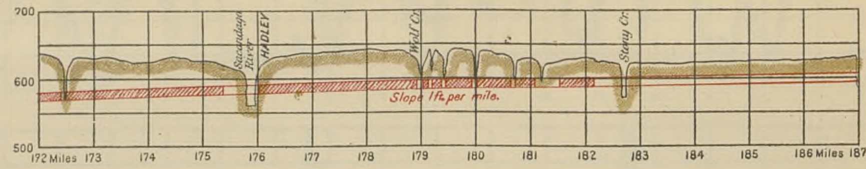


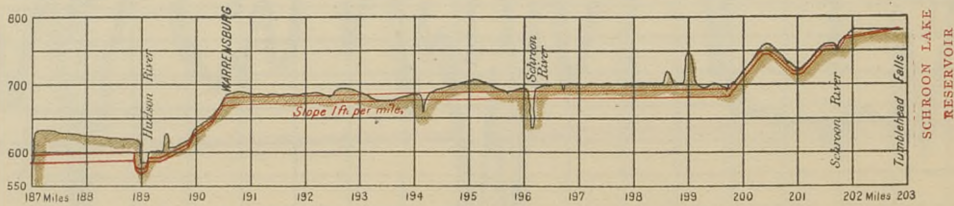
PROFILE OF
ADIRONDACK AQUEDUCT.
CAIRO
Catskill Creek
EAST GREENVILLE
Hannacrois Creek
Slope 1ft. per mile.
Oniskethau Creek
HELDERBERG
DELAWARE & HUDSON CANAL CO. R.R.
Bozen Kill
Normans Kill
100 Miles
116 Miles
117 Miles
136 Miles



PROFILE OF
ADIRONDACK AQUEDUCT.

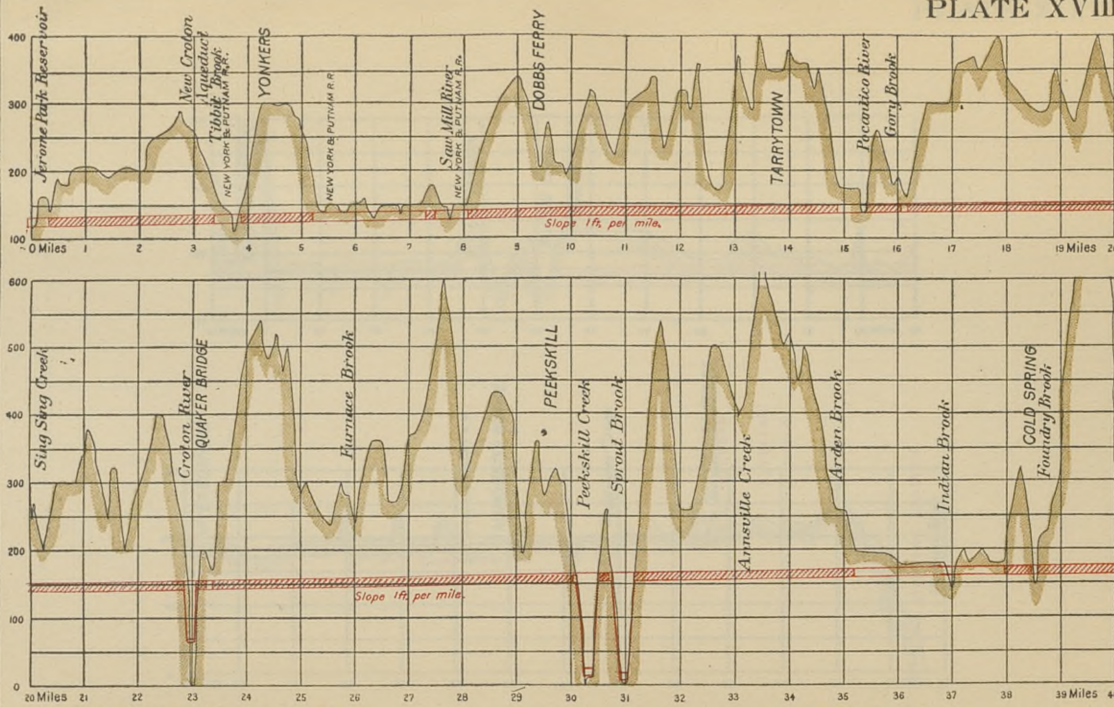
PLATE XVII





PROFILE OF ADIRONDACK AQUEDUCT.

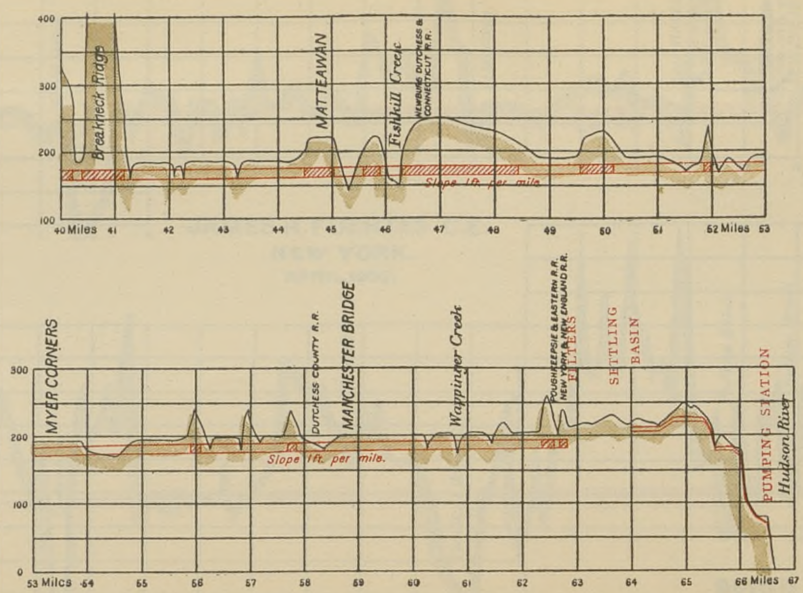
PLATE XVIII



JAMES H. FUERTES C.E.
NEW YORK,
APRIL, 1900.

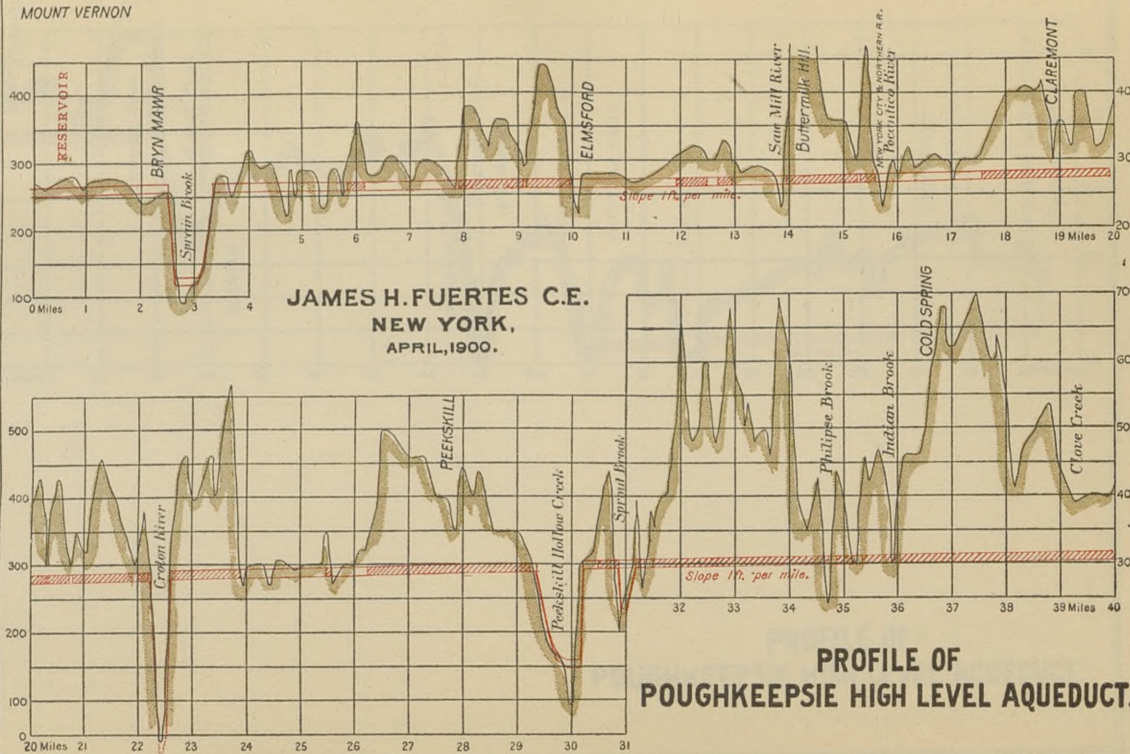
PROFILE OF
POUGHKEEPSIE LOW LEVEL AQUEDUCT.

PLATE XIX



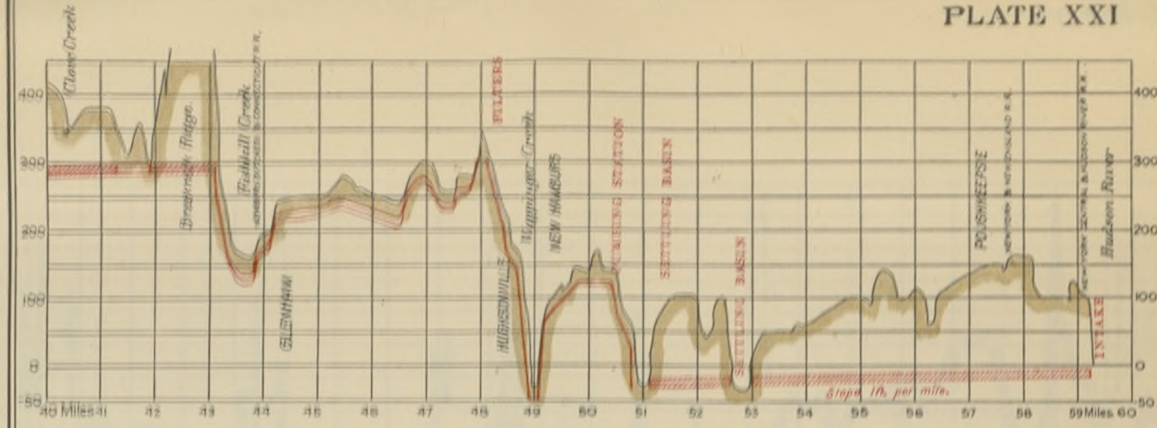
PROFILE OF
POUGHKEEPSIE LOW LEVEL AQUEDUCT.

PLATE XX



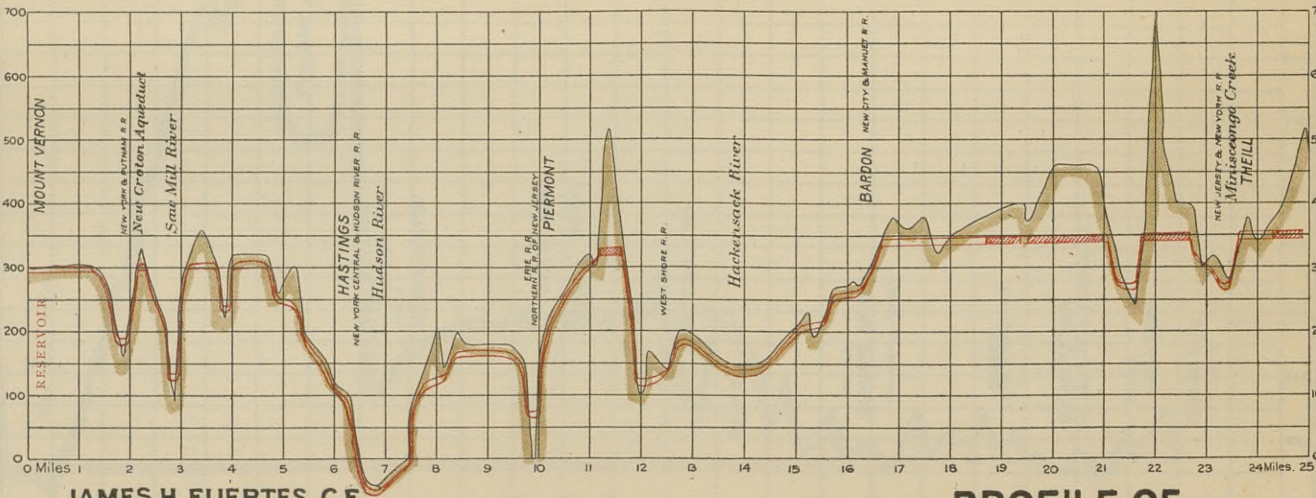
PROFILE OF
POUGHKEEPSIE HIGH LEVEL AQUEDUCT.

PLATE XXI



PROFILE OF
POUGHKEEPSIE HIGH LEVEL AQUEDUCT.

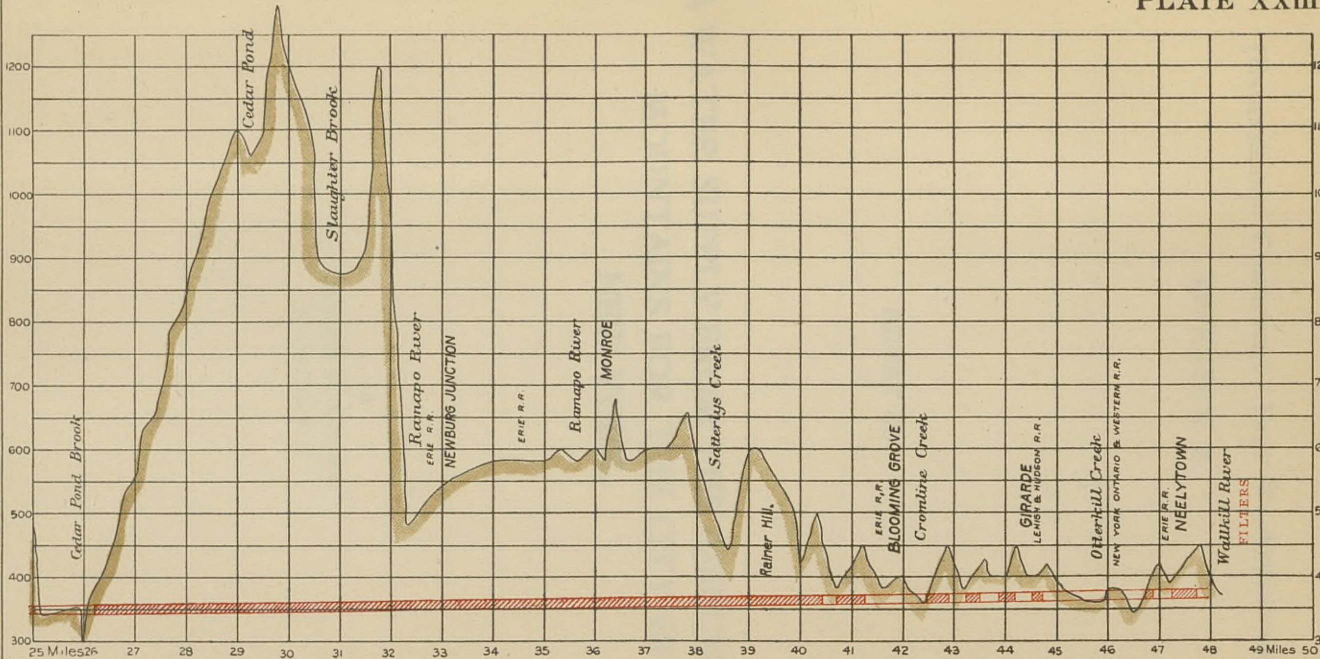
PLATE XXII



JAMES H. FUERTES C.E.
NEW YORK,
APRIL, 1900.

PROFILE OF WALLKILL AQUEDUCT

PLATE XXIII



PROFILE OF
WALLKILL AQUEDUCT.

APPENDIX E.

REPORT ON

A WATER SUPPLY FROM THE ADIRONDACK MOUNTAINS FOR THE CITY OF NEW YORK.

BY
GEORGE W. RAFTER,
M. Am. Soc. C. E.

CONTENTS OF APPENDIX B.

TABLES.

A WATER SUPPLY FROM THE ADIRONDACK MOUNTAINS FOR THE CITY OF NEW YORK.

By George W. Rafter, C. E.

To the Engineering Committee of the Merchants' Association of New York, Thomas C. Clarke, Past Prest. Am. Soc. C. E., Chairman:

Gentlemen:

In accordance with instructions of January 3 and January 29, 1900, I herewith present a report on an additional water supply for Greater New York, from the Adirondack mountains.

The scope of this report is as follows:

(1) The discussion of a project for supplying five hundred million (500,000,000) gallons daily (775 cubic feet per second) of pure water from a single large reservoir to be located on Schroon River.

(2) The supplying of the same quantity from Lake George and Schroon River.

(3) In addition to the storage reservoirs, from which the city supply of pure water will be drawn, these two projects further include compensating reservoirs large enough to compensate for amount of water abstracted for supply of Greater New York.

(4) The discussion of a project for supplying a large quantity of stored water to Hudson River, in order to hold the point of upward flow of salt water through tidal action as far down stream as practicable.

Aside from some extensions herewith given, the data on which the various conclusions of this report have been founded may be mostly found in my reports on Upper Hudson

Storage, and other papers and reports.* Space will not be taken, therefore, to present extended extracts from these several sources of information, to which your committee are referred for full detail. Only enough will be given here for convenient ready reference, or to easily illustrate the discussion.

The following tables, which are in the way of extensions of data given in the several reports and papers, may be briefly described.

Table No. 1 gives flow of Hudson River at Mechanicville for the water years, 1888 to 1899, inclusive, in cubic feet per second. Description of these gagings and methods of computations used may be found in First Report on Upper Hudson Storage Surveys, for the year 1895, at page 104. Also, in Report on Water Resources of the State of New York, Part I., page 79.

The catchment area is given at 4,500 square miles, as per original determination made in 1895. A more careful recomputation, in 1899, gave 4,507 square miles. As the error is only a small fraction of one per cent. the original figure is allowed to stand.

Table No. 2 presents the same data as Table No. 1 in inches on the tributary catchment area.

Extensive studies of flow over dams made by the author recently lead to the conclusion that probably the actual flow at Mechanicville is somewhat greater than indicated by the figures of Tables Nos. 1 and 2. The large amount of labor involved has thus far precluded a recomputation, and for the present the

* The following reports and papers may be referred to:

(1) Two reports on Upper Hudson Storage Surveys. Appendices to An. Rept. State Eng. and Sur., for 1895 and 1896.

(2) Water Supply and Irrigation Papers of the United States Geological Survey, Nos. 24 and 25—Water Resources of the State of New York, Parts I and II.

(3) Paper on Stream Flow in Relation to Forests. In Proc. Am. Forestry Assn., Vol. XII (1897). Also, reprinted in Second An. Rept. of Fisheries, Game and Forest Commission of New York (1896), published in 1898.

(4) Paper on Natural and Artificial Reservoirs of the State of New York. In Third An. Rept. of Fisheries, Game and Forest Commission of New York (1897), published in 1899.

(5) Paper on the Application of the Principles of Forestry and Water Storage to the Mill Streams of the State of New York. In Proc. of 22d An. Meeting of Am. Pulp and Paper Assn. (1899).

(6) Paper on the Indian River Dam. By Geo. W. Rafter, Wallace Greenalch and Robert E. Horton. In Engineering News for May 18, 1899.

figures are allowed to stand, the more especially since any deductions as to storage, based upon their present values, will from this point of view be certainly realized.

Table No. 3 presents the data of Tables Nos. 1 and 2 in cubic feet per second per square mile of catchment area.

Table No. 4 gives the precipitation data of the Northern Plateau for the water years, 1891 to 1899, inclusive, as derived from monthly publications of State Weather Bureau. It is considered that precipitation of the whole Northern Plateau best represents precipitation on Upper Hudson catchment area.

In Table No. 5 we have run-off of Schroon River, at Warrensburg, both in cubic feet per second and in inches on the tributary catchment area of 562.5 square miles for the water years, 1896 to 1899, inclusive. This table also gives the mean of the four years, in inches on the catchment area at Warrensburg, in comparison with the contemporaneous quantities at Mechanicville.

The comparison indicates that run-off of Schroon River is about 11 per cent. greater than that of Hudson River at Mechanicville, the difference occurring mostly in the storage period. This is probably true, although since some uncertainty attaches to the gagings at Warrensburg, it has been considered best to base available storage in Schroon Valley on the 12-year Mechanicville record, rather than on the shorter Warrensburg record.

As regards the comparison of these two contemporaneous records, for the growing and replenishing periods, it may be remarked that the natural flow of Schroon River is considerably modified by the temporary storage of Schroon Lake, which has a low water area of about 9.10 square miles. There is a dam at Starbuckville, controlled by Schroon River Pulp Company, at whose power dam near Warrensburg, the gagings recorded in Table No. 5 have been made. The Starbuckville dam stores from 4 to 5 feet in depth over the Schroon Lake area, which is let down as required for use during summer months. This fact explains why Schroon River area apparently yields proportionally more water in growing period than entire Hudson area, and less in replenishing period.

There are no rainfall stations in the Schroon area, and we are accordingly compelled to depend for such statistics upon the general data of the Northern Plateau, the same as for entire Hudson area.

In Table No. 6 we have evaporation from a water surface, as observed at Mount Hope Reservoir of Rochester Water Works, for the indicated months and years. It is considered that this record fairly applies to average inland conditions in the State of New York. It has, therefore, been made the basis of the computation of evaporation loss in the accompanying tables, showing state of storage in proposed Schroon River Reservoir from year to year.

Schroon Valley Reservoir.

With the foregoing data at hand, we may now consider possibilities of supplying from Hudson River, at some point near Hadley, 500,000,000 gallons of water per 24 hours, which shall have a quality equal to the best mountain waters. The elevation of crest of dam of George West's paper mill, at Hadley, is about 570.+ tidewater at New York, which is sufficient to ensure easy delivery into city reservoirs placed at elevations of from 300 to 350 feet above tide.

Schroon River flows into Hudson River just above Thurman Bridge, about 15 miles north of Hadley. This stream, which has a catchment area at its mouth of 570 square miles, issues from a sparsely settled region. The prevailing rocks are granite, with large areas of fine sand. There are only limited swamp areas.

In order to show the approximate relative proportions of virgin forest culled area from which merchantable softwood timber has been removed, together with the cleared and water areas of Schroon River catchment basin, the following data have been compiled from several of the U.S. Geological Survey's topographical sheets, including territory either wholly or partly within Schroon River catchment:

Topographic Sheet.	Virgin Forest. Square Miles.	Culled Area. Square Miles.	Cleared Area. Square Miles.	Water Area. Square Miles.	Total Area. Square Miles.
Bolton	——	153.00	43.55	19.85	216.4
Paradox Lake...	——	171.55	38.60	5.35	215.5
Schroon Lake...	1.10	182.10	35.80	6.50	215.5
Totals	1.10	506.65	117.95	31.70	647.4

The large water area of Bolton sheet is due to the fact that this sheet includes a considerable portion of Lake George. Aside from this, the Bolton, Paradox Lake and Schroon Lake sheets, covering a total area of 647.4 square miles, are considered to be—as regards forestation—fairly illustrative of Schroon River catchment area. The figures show that the cleared area is only about 18 per cent. of the whole. The northern part of Schroon River catchment area, which is included in Mount Marcy and Elizabethtown sheets, is substantially all in timber, and for the entire catchment area probably the cleared surface does not exceed about 15 per cent.

According to the U. S. Census of 1890, the population of several townships in Schroon River catchment area was as follows: Warrensburg, 1,725; Chester, 2,247; Schroon, 1,731; Horicon, 1,633, and North Hudson, 693. These townships are not wholly included in Schroon River area, although their approximate area is 570 square miles, or about the same as the catchment area of the stream. The figures show a permanent population of about 14 per square mile in 1890. Probably the permanent population is no greater in 1900. The decrease of lumbering and abandonment of farms has, on the whole, tended to a decrease. On the other hand, because of the growth of summer camps and hotels throughout the region, there has probably been a small increase in the summer population.

The topography of Schroon River catchment area is rugged. The low water surface elevation of Schroon Lake is 807 + tidewater, and the extreme northern tributaries issue from the base of the highest mountains of the State.

The foregoing brief statements in regard to physical characteristics of Schroon River catchment area show that it is an ideal region from whence to draw a municipal water supply. The forest-covered granitic rocks and interspersed sand areas insure a water of extreme purity, and when we further take into account the economy of reservoir construction which can here be attained, we have a combination of favorable conditions existing, so far as the author knows, nowhere else in the United States.

Referring to the author's report on Upper Hudson Storage Surveys of date December 31, 1895, in Annual Report of State Engineer and Surveyor for 1895, there is found, on page 173, reference to a large reservoir on Schroon River at Tumblehead Falls, a map of which is also shown by Plate VIII., accompanying that report.* Additional reference to this project may be found in Second Report on Upper Hudson Storage Surveys, in Annual Report of State Engineer and Surveyor for 1896.

An approximate estimate made in 1895, before all the conditions were known, placed the cost of Schroon Valley reservoir—when developed up to a storage of 13.5 inches on the catchment area—at $840,000. This was for a water storage reservoir purely, and did not include clearing and stripping of margins any further than that cutting and burning of standing timber was provided for. Investigations made by the author in 1896 indicated more expense for foundation of dam at Tumblehead Falls than assumed in 1895. Moreover, for a storage reservoir for regulation of stream flow purely, nothing was allowed for sanitary protection of watershed or for removal of buildings along or near new margins.

The estimates herewith submitted take into account all these several items, as well as an allowance for present labor conditions and price of materials in State of New York.

In the first report on Upper Hudson Surveys (1895), I have discussed, extensively, the question of proper height of flow line for Upper Hudson River reservoir system, reaching the conclusion that for stream regulation 13.5 inches in depth on the catchment area was the approximate figure. As an

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* The catchment area above Tumblehead Falls is stated in Report of 1895 at 502 square miles. This was derived from the best maps available in 1895, but a re-computation based upon Biens' Atlas and published sheets of Topographical Survey, gives 518 square miles at Tumblehead Falls. This figure has been used in present study, as have the following corrections at other points of Schroon River area, as follows:

	Square miles.
Area, as originally used for whole basin above Thurman....	550.0
Amended area, used in present study..........................	570.0
Difference..	20.0
Area, as originally used for portion of basin above Schroon River Pulp Company's dam..........................	545.0
Amended area, used in present study..........................	562.5
Difference..	17.5

So far as necessary all data have been re-computed to make them agree with the new determination of catchment areas.

additional reason for adopting this figure, it may be mentioned that this is about as large a storage as can be ponded at several Upper Hudson sites. At Tumblehead Falls, however, there is apparently no reason why the development may not be carried higher, and the present study for a pure water reservoir has accordingly been based upon a development of storage up to 18 inches in depth on the tributary catchment area of 518 square miles. Such development gives a total storage of 21,662,000,000 cubic feet (162,248,380,000 gallons) and will utilize, during a series of years, substantially the entire flow of the stream.

To accomplish this result, the uniform outflow from the reservoir has been taken at 500,000,000 gallons in 24 hours; or, for even figures, at 775 cubic feet per second. It is quite easy, on this basis, to furnish the quantity fixed upon by your Committee, from a single reservoir.

In order to show the effect of drawing 775 cubic feet per second, continuously, from such a reservoir in Schroon Valley, Table No. 7 has been prepared. The data are (1) the runoffs off Hudson River for the 12 years from 1888 to 1899, inclusive, as exhibited in detail in Tables Nos. 1, 2 and 3; and (2) evaporation at Rochester, as per Table No. 6. The computation has been made by years, beginning with an assumed depth of 4 inches on the catchment area in reservoir at the end of November, 1887,* and is carried along through each water year, to end in November, 1899. The first page of Table No. 7 is a summary covering the entire period tabulated; the balance of the table includes the detailed computation for each year.

These computations are so self-explanatory as to render extended explanation unnecessary.

Table No. 8 presents the summary of a similar computation for a reservoir in Schroon Valley storing 13.5 inches and with uniform outflow of 650 cubic feet per second (421,000,000 gallons in 24 hours).

These computations show that for a storage of 18 inches on the catchment area and a uniform outflow of 775 cubic feet per second, the total waste in the 12-year period from 1888 to 1899, inclusive, would have been only 13.81 inches; while for a storage

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* The water year for 1888 is taken to begin December 1, 1887, and so on through the whole series.

of 13.5 inches and uniform outflow of 650 cubic feet per second, the waste would have been 55.36 inches, amounting to a mean waste per year of 4.61 inches.

The distance from Hadley to proposed site of Schroon Valley barrage at Tumblehead Falls—measured along thread of Hudson and Schroon Valleys—is about 29 miles. Of this, about 14 miles is in Schroon Valley. The village of Warrensburg, with a population of 748 in 1890, lies on Schroon River, three miles above its mouth. At and in the vicinity of this place, water power to the extent of 1,627 net horse-power (2,167 gross horse-power) has been developed on Schroon River. The largest block of power at a single point is at dam of Schroon River Pulp Company, one and one-half miles below Warrensburg, where 1,086 net horse-power are in use. Owing to the equalizing effect of Schroon Lake storage, these powers are all fairly permanent except at the pulp mill, which is sometimes short of water in late summer and fall months. A glance at the mean monthly flows, as per the first part of Table No. 5, will show about what may be expected on this stream. The minimum will, of course, be less for short periods than the means there indicated.

The water surface elevation of Schroon River at its mouth, near Thurman, is approximately 620 + tide water. At Tumblehead Falls the elevation is about 780 + tide water. There is, therefore, a total fall of say 160 feet between Tumblehead Falls and mouth of stream. Of this, 39 feet is included in the dams at Warrensburg village and the Schroon River Pulp Company's power, leaving, say, 121 feet still undeveloped. It seems to me very desirable, in case Schroon Valley reservoir is constructed, that the water power possibilities of the stream be preserved. A uniform outflow of 775 cubic feet per second would yield, on 121 feet fall, 10,639 gross horse-power.

As to the proper policy to be pursued in acquiring riparian rights and developing water power on Schroon River, it may be remarked that extended discussion on that line would be foreign to the purposes of this report. In the present discussion, therefore, merely future possibilities are indicated, leaving to others the development of the proper policy to be pursued.

In order to preserve present water powers and ultimately utilize the undeveloped fall, it would be necessary to let the water discharged from the reservoir dam at Tumblehead Falls flow down present channel of Schroon River to a diversion weir, to be located just above the mouth, at which point a conduit of 775 cubic feet per second capacity would begin. This diversion weir would be 16 miles above Hadley, but the author considers that the additional cost of extending the conduit this distance would be compensated for by the keeping of pure Schroon River water entirely separate from balance of Hudson River water.

In proposing such separation, it is not intended to imply that Hudson River water at Hadley is not suited for a public supply. In any case, Upper Hudson water is very pure, but due to relatively somewhat more extensive swamp areas to north of mouth of Schroon River, Hudson River water at Hadley, as a whole, is hardly equal to that from Schroon River. The purifying effect of wind and sunlight on the extended water areas of Schroon, Brant and Paradox lakes is taken into account in reaching this conclusion.

Another important reason for extending conduit to diversion weir just above mouth of Schroon River may be found in considering that much the cheapest way to reimburse water power owners on Hudson River for diversion of 775 cubic feet per second, will be by constructing compensation reservoirs. Some of these would be located on Sacundaga River, which flows into Hudson River at Hadley, but nevertheless several would be on main North River above Thurman. If proposed additional water supply of Greater New York were taken at Hadley, then all compensating reservoirs should be thoroughly cleared and stripped, the same as is proposed for Schroon Valley reservoir. Even after completion of such expensive work, the conditions at several reservoir sites to north of Thurman are not such as to yield an ideal water without filtration. There are extensive muck areas which now discolor the water and taint it with an offensive odor. Filtration would, of course, make any of these waters ideal, and probably for a thorough study of the project in all of its phases, estimates should be worked out showing approximate cost of taking 775 cubic feet per second at Hadley, with all stripping of reservoirs omitted, but including the cost of a filtration plant capable of handling 775 cubic feet per second. As regards quality of the municipal supply, such treatment would place this project essentially on a par with theVyrnwy supply for

Liverpool, where the water of a sparsely populated mountainous area is filtered, largely to remove vegetable discoloration.

If Schroon River water is taken into conduit just above mouth of stream, the sewage of Warrensburg village and the manufacturing establishments would be properly carried in a close conduit or pipe to a point below the diversion weir. The estimates for sanitary protection include the cost of the necessary special constructions for this purpose.

There is considerable summer population about Schroon, Brant, Paradox and other lakes of Schroon area, and the estimates for sanitary protection further include cost of properly caring for waste products at hotels and cottages, etc.

The following presents the main points of comparison for dams at Tumblehead Falls, storing 13.5 and 18.0 inches on the catchment area, respectively:

Storage. In inches on catchment area.	Storage. In cubic feet.	Elevation of flow line contour.	Height of dam. In feet.	Area of water surfaces of full reservoir. Acres.	Square miles.
13.5	16,246,000,000	840.6	60.6	14,800	23.1
18.0	21,662,000,000	850.5	70.5	16,900	26.4

By reference to the U. S. Geological Survey topographical sheets, the significance of these figures may be easily appreciated.

In order to ensure thorough control of the margins, it is suggested that an area of 50 square miles should be taken. The estimate herewith submitted includes such taking.

The following is the estimated cost of constructing Schroon Valley pure water reservoir and diversion weir, with necessary gate houses, sanitary protection and other special constructions:

Land damages	$1,000,000
Clearing and stripping	500,000
Dam at Tumblehead Falls	600,000
Diversion weir	250,000
Sanitary protection	300,000
Miscellaneous	350,000
Amount	$3,000,000

The data for the foregoing estimate are not very complete, but it is believed that the sum of $3,000,000 is large enough to meet somewhat adverse conditions.

The construction of Schroon Valley reservoir as here proposed would submerge several villages of which the cost is included in land damages.

With a total storage of 21,662,000,000 cubic feet and total cost of $3,000,000, the cost per million cubic feet stored becomes roundly $138.50. In the same way, the cost per million gallons stored becomes about $18.50.

Injury to Water Power on Hudson River.

The foregoing discussion of Schroon Valley reservoir project shows that not only may all injury to existing water power in Schroon Valley be obviated, but that 10,639 gross horse-power may be permanently created there. With Hadley dam ultimately constructed, as proposed in my Upper Hudson Report of 1895, there would be stillwater in Hudson River from mouth of Schroon River to Hadley. Inasmuch as Hadley dam is intended as a regulator of Upper Hudson reservoir system, without any special water power development connected therewith, no injury to water power above regulating dam on account of diversion of 775 cubic feet per second would occur. But from the regulating dam down, the Hudson River water powers would suffer, but not to the extent of the value of 775 cubic feet per second for the whole year. Broadly, the proposition takes this form: On account of large temporary storage on Schroon, Brant and Paradox lakes, the mean summer flow of Schroon River is higher than it would otherwise be for the given catchment area. Taking into account this natural advantage, what injury can be done to Hudson River water powers from Hadley to Troy, by the continuous diversion of 775 cubic feet per second, the quantity so diverted to be drawn, not from the natural flow of the river, but from a large storage reservoir substantially regulating the entire flow for a series of years?

In answering this question, we must take into account the character of the water power development on Hudson River. The most of it is 24-hour power used for pulp-grinding and paper-making. Pulp may be ground in high water flow and stored for use in months of minimum flow. This circumstance has led to development of Hudson River water powers to far beyond the low water flow of the stream. Thus, at Glens Falls, enough water-wheels have been set to use 3,521 cubic feet per second, and at Fort Edward there is a wheel capacity of 4,175 cubic feet of water per second.*

The great significance of the foregoing figures is exhibited when it is mentioned that flows of 1,000 to 1,200 cubic feet are not uncommon at Glens Falls and Fort Edward, and the measured minimum is as low as about 800 cubic feet per second.

Without going into an elaborate discussion at this time, I consider that under the actually existing conditions, to substantially divert the entire flow of Schroon River would be fairly equivalent to taking from 500 to 600 cubic feet per second from all water powers on Hudson River from the George West paper mill, at Hadley, to Troy. This does not mean that 600 cubic feet per second would be taken away in the low water months—a glance at Table No. 5 will show that from 160 to 300 cubic feet per second is the proper figure—but that for an average of all years, the runoff of Schroon catchment area is equivalent to about 500 to 600 cubic feet continuously when applied to Hudson River water powers. As a provisional figure, accurate enough for present purposes, we may use 550 cubic feet per second.

The following tabulation, of which the main data are mostly derived from Table No. 12 in the Upper Hudson Storage Survey Report, shows in Column 4 the net power at 75 per cent. efficiency of 550 cubic feet of water per second on the stated heads:

* For detail of use of water at other Hudson River points see Table No. 12, Showing Water Power Actually in Use on Hudson River in 1895 (facing page 150), in my first report on Upper Hudson Storage Surveys (1895).

Designation of dam. (1)	Working head on wheels. (2)	Approximate net horse-power actually developed in 1899. (3)	Net power at 75 per cent. efficiency of 550 cubic feet per sec'd. (4)	Difference of columns (3) and (4) (5)
George West, Hadley.....	18	1,350	845	505
Palmer's Falls............	83	14,500	3,897	10,603
Canal Feeder Dam......	10 to 12	1,450	515	935
Glens Falls	16 to 38	7,931	1,784	6,147
Sandy Hill...............	12	1,293	564	729
Baker's Falls............	58	3,500	2,724	776
Fort Edward	18	6,393	845	5,548
Fort Miller...............	10	1,485	469	1,016
Saratoga Dam...........	18*	3,130	845	2,285
Stillwater	6	514	282	232
Mechanicville	16	3,355	751	2,604
Hudson River Power Co..	18	3,000	845	2,155
Troy	7	1,345	329	1,016
Totals	314	49,246	14,695	34,551

The foregoing tabulation shows that on the assumed basis of 550 cubic feet per second, the total decrease in water power would be 14,695 net horse-power, amounting to nearly 30 per cent. of the whole.

Let us now examine rapidly as to the approximate value of Hudson River water power.

In the fall of 1898, in the course of an extended study for the U. S. Board of Engineers on Deep Waterways, the author gathered the statistics of water power on Black River, where a total of 55,360 net horse-power is in use in 93 manufacturing establishments of various sorts and kinds. Of these, 36 are paper mills using 46,587 net horse-power. The approximate total value of the annual product of the 36 paper mills was found to be $5,242,620, whence the average value of the annual product per net horse-power becomes $112.50. Similar statistics have not been gathered for Hudson River where the mills are fewer in number but so much larger than on Black River that the annual product approximates $8,000,000 in value. Undoubtedly the cost of manufacturing in large, thoroughly

*The head at the Thomson Pulp and Paper Company's mill is 18 feet; at the Thomson and Dix sawmill it is from 8 to 10 feet.

equipped modern mills is less than in small mills, and the author provisionally places the value of the annual product of Hudson River paper mills, per net horse-power actually used, at $135. On both Black and Hudson rivers, the mills themselves grind a large proportion of the pulp used, and when this is done, the net profits of the paper business, over and above interest on invested capital and all other fixed charges, may be assumed to range from 10 to 15 per cent. We will take 12 per cent. as an average. On this basis, the net annual profit on each net horse-power in use at Hudson River paper mills becomes $16.20, which at 5 per cent. represents a capitalized value of $324. In the absence of more exact data, and for the purposes of this discussion, we will use this figure as representing the approximate value of a net horse-power on Hudson River.* At this rate, the value of 14,695 horse-power becomes $4,761,180, which is the approximate damage to the Hudson River water powers from Hadley to Troy, to result from taking the mean quantity of 775 cubic feet per second from Schroon Valley catchment area.†

Compensating Reservoirs.

However, reservoirs capable of supplying 500 to 600 cubic feet per second compensation could be constructed on head waters of main North River and Sacundaga River for less than $4,761,180.

Thus far the trend of legal decisions in the State of New York, and in the United States generally, has been against compensation in kind in water diversion cases. Our courts have usually held that money compensation may be exacted in such cases. But on Hudson River, where water rights are not only appreciating in value rapidly, but are furthermore mostly held by strong manufacturing corporations, it is possible that the principle of compensation in kind could be applied by simple agreement with the present owners. At any rate, we may assume for present purposes that this is true, and accordingly

* At Troy there is a small amount of miscellaneous manufacturing to which a larger figure could be properly applied.

Thus on Black River, in 8 machine shops the average value of the animal product per net horse-power is $1,728; in 9 flour and feed mills, $627.20, etc.

† Probably some addition to this sum should be made to cover various contingencies, but for present purposes $4,761,180 is sufficient.

briefly discuss a system of compensating reservoirs large enough to supply 500 to 600 cubic feet per second, either continuously or so far as might appear necessary after a more thorough study of the regimen of the stream.

From Table No. 8 it appears that with Hudson River runoff the capacity of a reservoir capable of certainly furnishing 650 cubic feet per second continuously should be, roundly, 16,000,000,000 cubic feet. To furnish 550 cubic feet per second continuously, about 12,000,000,000 cubic feet would answer. The location and approximate cost of a series of reservoirs of this capacity would be as follows:

Name of reservoir.	Location. On what stream.	Estimated capacity. In cubic feet.	Tributary catchment area. Sq. miles.	Estimated cost.
Conklinville....	Sacundaga River	4,000,000,000	900	$400,000
Lake Pleasant..	" "	1,400,000,000	45	110,000
Piseco Lake....	" "	1,725,000,000	55	100,000
Arietta Flow...	" "	1,400,000,000	40	80,000
Wakely Flow...	Cedar River....	1,819,000,000	58	150,000
Boreas and Cheney ponds.	Boreas River...	1,411,000,000	45	160,000
Totals....................		11,755,000,000		$1,000,000

Taking into account the large catchment area tributary to proposed Conklinville reservoir, it is considered that the foregoing total storage of 11,755,000,000 cubic feet would fully compensate—on the basis already outlined—for the permanent diversion of 775 cubic feet per second.*

The total estimated cost, as per the foregoing, of $1,000,000, is based on present labor conditions, etc., in State of New York. So far as I can determine with the data at hand, $1,000,000 will construct the compensating reservoirs proposed by the foregoing.

Inasmuch as four of these reservoirs are located in Sacundaga River catchment, which stream is tributary to Hudson River below proposed Hadley regulating reservoir, that reservoir is not included in present series.

* The stated tributary catchment area of 900 square miles above Conklinville is exclusive of Lake Pleasant, Piseco Lake and Arietta Flow catchments. The total, with these included, is 1,040 square miles.

The foregoing shows the following difference in cost as between paying water power damages and providing a system of compensating reservoirs:

Water power damages	$4,761,180
Cost of compensating reservoirs	1,000,000
Difference	$3,761,180

With the system of compensating reservoirs, the total estimated cost of reservoir system for supply of 775 cubic feet per second becomes $4,000,000. But if water power damages were to be paid in money, as per the foregoing, the approximate figure becomes $7,761,180. For even figures, we may say take this latter at $8,000,000.

If, however, we assume that, owing to legal difficulties, not only the principle of compensation in kind cannot be applied, but that a partial taking of the properties is impracticable, it follows that the amount to be paid on account of the proposed diversion of 775 cubic feet per second—supplied from a single large reservoir substantially controlling the entire flow of Schroon River—becomes considerably greater. The data are not at hand for accurately estimating the full value of the several properties affected, but from casual examination the provisional figure of from $12,000,000 to $15,000,000 may be assumed. In any case, if the entire properties were acquired by the City of New York, apparently the rational procedure would be to make such reservations as might seem necessary in order to secure the city's right to 775 cubic feet per second, or any other quantity fixed upon, and to then sell the properties subject to such reservations. By proceeding on this line, the City of New York ought to be able to acquire the right to draw 775 cubic feet of water per second at a cost not exceeding the sum of $3,761,180, previously found. Or, as an alternative proposition, the city might build the compensation storage and realize the full value of the property when sold.

The author is aware that the foregoing discussion of the value of Upper Hudson River water rights is somewhat general. This is necessarily so because the data for complete estimate of values are not yet gathered. Moreover, the discussion is mostly from the engineer's point of view—without special reference to the legal difficulties—and, hence, to be taken as suggestive rather than conclusive.

The dams proposed for the several reservoirs herein discussed are to be mostly of rubble masonry laid in American Portland cement mortar with the granitic stone of the region. The general quality of the work estimated upon is shown by the illustrations to a monograph on Indian Lake dam constructed in 1898, to be found in *Engineering News* for May 18, 1899, a copy of which has been furnished to your committee. Some of the constructions would preferably be partly of earth.

As to the Minimum Flow of Hudson River.

Referring to the summaries, Tables Nos. 7 and 8, it will be observed that Schroon Valley reservoir is developed with some leeway in the storage. As shown by column (11) of these two tables, even in the lowest months of the twelve-year period discussed, considerable storage would remain in the reservoir. The object of this is to provide a reserve to meet the emergency of some water year much dryer than any experienced since the beginning of a detailed record in 1887.

The lowest measured runoff of Hudson River occurred in 1895, when, with a rainfall for the water year of 36.67 inches, the runoff was only 17.46 inches. In 1899, the rainfall was 35.79 inches, and runoff 19.54 inches. In seeking for a reason why, with less rainfall in 1899 than in 1895, the runoff was still greater, we may refer to Tables Nos. 2 and 4, from which it is readily seen that the difference is due to greater rainfall and runoff in storage period. In 1895, rainfall of this period was only 15.79 inches, and runoff 11.68 inches; while in 1899, rainfall of storage period was 19.48 inches, and runoff 15.15. It is the rainfall* of storage period which chiefly decides as to whether the runoff for entire water year is to be large or small.

Without attempting to give reasons in this place, I will simply state that my studies of New York State meteorology, in comparison with known runoff of New York streams, have convinced me that there have been years in which runoff of

* The word *rainfall* is used throughout this discussion same as *precipitation*, and includes snow as well as rain.

Upper Hudson probably did not exceed 10 or 11 inches on the tributary catchment area.* Assuming that this is true, it is necessary, therefore, to provide enough reserve to tide over the extreme low water year whenever it again arrives.

Supply from Lake George.

About 1880 the New York and Hudson Valley Aqueduct Company was incorporated to construct a water supply from Lake George and Upper Hudson for New York and other cities of Lower Hudson Valley. Reports on this project were made by Col. J. T. Fanning, chief engineer, under dates of December, 1881, and November, 1884. In general terms, Colonel Fanning proposed to divert Hudson River above Glens Falls, utilizing the extended area of Lake George for storing flood flows. In this way it was considered that a supply of 1,500,000,000 gallons per day could, if necessary, be obtained (2,315 cubic feet per second). Since Colonel Fanning's reports are readily obtainable, space will not be taken to give his conclusions in detail. The following are the main elements of the Lake George project, as deduced from the topographical sheets of the United States Geological Survey:

Elevation of lake surface above tide water	323.0 ft.
Catchment area, including water surface	229.0 sq. mi.
Area of water surface	43.4 sq. mi.
Area of 340 contour	49.2 sq. mi.
Storage between 323+tidewater and 340	21,043,308,540 cu. ft.

Lake George is surrounded by mountains rising to an altitude of about 1,500 to 2,700 feet above tidewater. There is little special knowledge of the rainfall, but it cannot be materially different from that of Hudson River catchment area. The outlet is at northern end of lake, and has a fall in a distance of about a mile of 222 feet, which is largely utilized in paper-making, information at hand indicating a total development of from 4,000 to 5,000 net horse-power. Taking the value of water power as previously used and damage to Lake George outlet,

*The reasons for this view have been presented in detail in my Report on Water Supply of Summit Level of Oswego-Mohawk route, to the U. S. Board of Engineers on Deep Waterways.

water powers may be computed at $1,458,000. But since the entire properties would be taken we may, in this case, estimate that the final damage would not be less than $2,000,000.

There are many large hotels and summer resorts about Lake George which would be mostly destroyed by raising lake surface from 17 to 20 feet. The taking of an additional strip, for sanitary protection, as in Schroon Valley, would include nearly all of these, as well as the village of Caldwell.

Basing Lake George project on 775 cubic feet per second supply, the same as for Schroon Valley, it is found that from 300 to 350 cubic feet per second would come from Lake George catchment area.* The balance can be obtained from Schroon Valley by a tunnel through the intervening ridge at a point above Warrensburg, where the distance across is only 3.25 miles (17,160 lin. ft.). A diversion weir with proper regulating headworks would be required on Schroon River. The elevation of Schroon River at the point of diversion is about 670 feet. With Lake George taken at 323 feet, the difference becomes 347 feet.

On referring to Table No. 5, it is seen that for several months of each year the runoff of Schroon River exceeds 550 cubic feet per second, the mean runoff for the four years included in Table No. 5 being 1,112 cubic feet per second. Hence, a mean of 550 cubic feet per second could be diverted into Lake George and still leave Hudson River water powers substantially unimpaired.† The connecting tunnel should, therefore, have a ca-

* The mean runoff of Hudson River for 12 years, as per Table No. 3, in cubic feet per second per square mile of catchment area, is 1.74 cubic feet. On Lake George catchment area, water surface is proportionally so much larger than on Hudson area that—on account of larger evaporation—we may take mean runoff at somewhat less, say 1.50 cubic feet per second per square mile of catchment area. Whence, we have from a catchment of 229 square miles, a mean runoff of 343 cubic feet per second.

To show that some reduction of mean runoff per square mile per second is reasonable for Lake George area, we may consider that land evaporation on Hudson River catchment amounts to an average of about 21 inches per year, and water surface evaporation, as per Table No. 6, to about 35 inches per year. The mean evaporation from Lake George catchment, therefore, stands as follows:

Land area	82.4	per cent. of the whole.
Water area	17.6	" " " " "

Hence, $(82.4 \times 21) + (17.6 \times 35) = 23.46$ inches, an increase of about 2.46 inches on Lake George area over Hudson catchment area, because of proportionally larger water surface area.

† If Lake George catchment area furnishes a mean of 343 cubic feet per second, the average amount to be drawn from Schroon River catchment will only be 432 cubic feet per second.

pacity of about 2,600 to 2,800 cubic feet per second, in order to divert the full flood flows.

Such arrangements would not damage materially Hudson River water powers as they now stand, but for the sake of the argument we will admit a small amount of compensation storage in the estimate.

The following is an approximate estimate of cost of Lake George storage with diversion tunnel from Schroon Valley, etc.:

Land damages, Lake George	$1,500,000
Dam at foot of Lake George	200,000
Water rights on Lake George outlet	2,000,000
Sanitary protection	400,000
Clearing and stripping	300,000
Diversion weir and headworks on Schroon River	100,000
Diversion tunnel	1,500,000
Compensation reservoirs	200,000
Miscellaneous	500,000
Total	$6,700,000

A comparison of this estimate with the foregoing for Schroon Valley project fairly leads to the conclusion that independent of lack of elevation at Lake George the Schroon Valley project is preferable. The quality of Lake George water—the same as Schroon River—is unexceptionable.

Reservoir System for River Regulation Only.

This project proposes the development of a large amount of storage on headwaters of Hudson River in order to hold low water flow at as high a point as possible, thereby driving salt water further down stream and consequently permitting of taking a supply from Lower Hudson by pumping lower down than would otherwise be possible.

In the author's first report on Upper Hudson Surveys, it is shown that a reservoir system may be easily developed capable of maintaining the flow at Mechanicville at 4,500 cubic feet per second. The following tabulation gives the main elements of such a system of reservoirs so far as worked out, together with the approximate cost of the same. All based on 13.5 inches on the catchment except Schroon Valley, which is here taken at 18 inches:

Name of reservoir.	On what stream located.	Estimated capacity. Cubic feet.	Tributary catchment. Sq. Miles.	Estimated cost.
Conklinville,	Sacundaga River,	4,000,000,000	—	$400,000
Lake Pleasant,	" "	1,400,000,000	45	110,000
Piseco Lake,	" "	1,725,000,000	55	100,000
Arietta Flow,	" "	1,400,000,000	40	80,000
Hadley,	Main North River,	4,000,000,000	—	750,000
Thirteenth Pond,	" " "	439,000,000	14	160,000
Chain Lakes,	" " "	1,819,000,000	58	45,000
Catlin Lake,	" " "	784,000,000	25	50,000
Lakes Rich, Harris & Newcomb, etc.	" " "	2,603,000,000	83	250,000
Lake Henderson,	" " "	565,000,000	18	40,000
Tahawus Flow,	" " "	2,101,000,000	67	240,000
Boreas River, etc.,	Boreas River,	1,411,000,000	45	160,000
Wakely Flow,	Cedar River,	1,879,000,000	58	150,000
Tumblehead Falls,	Schroon River,	21,662,000,000	518	1,700,000
Totals		45,728,000,000		$4,230,000

The capacity of Indian Lake reservoir, constructed in 1898, of about 5,000,000,000 cubic feet, should be added to the foregoing total of 45,728,000,000 cubic feet, giving a final total storage on Upper Hudson River and its tributaries of about 50,728,000,000 cubic feet. Further examination will probably show that a somewhat greater storage can be obtained, but thus far the data for final conclusions have not been gathered. A moderate amount of storage may also be constructed on headwaters of Mohawk River, but only general statements can be made for lack of definite data. Probably enough storage can be made here to give a final storage on Hudson and Mohawk rivers of about 60,000,000,000 cubic feet.

The foregoing estimates of cost also take into account present labor conditions, etc., in State of New York. The approximate cost per million cubic feet of storage is found to be $92.50.

The present estimate for Schroon Valley reservoir omits all additions to previous estimate on account of extra land, sanitary protection, stripping, diversion weir, etc., the figure of $1,700,000 being for a storage reservoir for river regulation only.

The advantages of such a system of reservoirs to Hudson River water powers have been so fully set forth in my several papers and reports, as to render further discussion under that head unnecessary in this place.

Leaving for the present the possible storage of Upper Mohawk River out of account, and basing conclusions on 50,728,000,000 cubic feet storage on Upper Hudson, we may say, taking into account low water flow of Mohawk River and other tributaries of Hudson River below Mechanicville, that the fresh water inflow of Lower Hudson River may be kept up to about 6,000 cubic feet per second. At present it is occasionally somewhat less than 2,000 cubic feet per second. The effect of flows of 5,000 to 6,000 cubic feet per second on the depth of water at Albany may be obtained from a series of diagrams of tidal fluctuations at Albany, for the summer seasons of 1895-1898, inclusive. The first of these diagrams is Plate VI. of my first Upper Hudson storage report (1895), and the second, Plate VII. of report on Water Supply of Summit Levels, to U. S. Board of Engineers on Deep Waterways (1899). It appears to me that by plotting Lower Hudson synchronous tide records in a similar manner, and comparing them with cross-sections at several points, the problem may be easily solved.

My thanks are due to Hon. E. A. Bond, State Engineer and Surveyor, for permitting the use of a large amount of Upper Hudson storage data as yet unpublished in official reports.

It is hoped, gentlemen, that this report may be of assistance to you. I am,

Respectfully submitted,

GEO. W. RAFTER.

FEB. 1, 1900.

TABLE NO. I.

RUNOFF OF HUDSON RIVER AT MECHANICVILLE, FOR THE WATER YEARS 1888 TO 1899, INCLUSIVE.

(In Cubic Feet Per Second, On the Catchment Area of 4,500 Square Miles.)

	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
December	8,018	10,014	13,226	3,244	8,577	4,031	7,217	4,367	10,889	6,913	13,741	5,436
January	6,367	10,983	11,272	8,284	18,857	3,192	6,757	3,876	6,787	4,007	7,723	6,668
February	3,714	3,790	7,913	11,664	9,263	4,805	4,836	3,543	4,668	3,895	6,754	5,258
March	6,845	8,280	11,129	17,736	10,929	8,250	14,738	4,204	13,600	12,214	20,220	9,618
April	21,200	13,690	15,053	20,021	21,554	17,889	11,135	23,822	24,972	19,080	13,712	23,645
May	21,420	8,871	17,931	5,533	19,622	22,285	7,566	6,850	4,610	12,151	11,095	9,752
Storage Period	11,289	9,337	12,821	11,021	14,831	10,114	8,759	7,759	10,893	9,754	12,300	10,070
June	4,917	6,869	7,392	3,200	12,395	4,801	7,097	2,816	4,738	11,861	5,280	2,598
July	1,537	5,727	1,950	2,337	9,287	2,521	3,168	2,559	2,772	10,722	2,570	2,273
August	1,725	4,272	2,019	2,666	5,485	5,005	2,456	3,901	2,442	8,240	5,101	1,393
Growing Period	2,703	5,718	3,748	2,957	9,019	4,102	4,209	3,095	3,302	10,257	4,307	2,083
September	2,851	1,963	8,844	2,040	4,448	6,870	1,889	2,629	2,879	2,756	3,872	2,074
October	4,608	3,740	9,215	1,472	2,819	3,865	3,649	2,631	4,106	2,524	7,895	2,617
November	10,642	7,888	9,121	4,088	7,604	3,639	6,379	8,421	11,352	9,962	9,243	6,382
Replenishing Period	6,018	4,522	9,061	2,521	4,934	4,781	3,969	4,539	6,090	5,053	7,013	3,680
Water Year	7,820	7,197	9,597	6,867	10,909	7,271	6,418	5,780	7,791	8,709	8,962	6,464

TABLE NO. 2.

RUNOFF OF HUDSON RIVER AT MECHANICVILLE, FOR THE WATER YEARS 1888 TO 1899, INCLUSIVE.

(In Inches on the Catchment Area of 4,500 Square Miles.)

	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean.
December	2.05	2.57	3.39	0.83	2.27	1.03	1.85	1.12	2.79	1.77	3.67	1.40	——
January	1.62	2.81	2.89	2.12	4.83	0.82	1.73	0.99	1.74	1.03	1.97	1.71	——
February	0.89	0.88	1.83	2.70	2.22	1.09	1.12	0.82	1.12	0.90	1.56	1.22	——
March	1.75	2.12	2.85	4.55	2.80	2.11	3.78	1.08	3.49	3.13	5.18	2.47	——
April	5.26	3.39	3.73	4.97	5.35	4.44	2.76	5.91	6.20	4.73	3.40	5.86	——
May	5.49	2.27	4.59	1.42	5.03	5.71	1.94	1.76	1.18	3.04	2.83	2.49	——
Storage Period	17.06	14.04	19.28	16.59	22.50	15.20	13.18	11.68	16.52	14.60	18.61	15.15	16.20
June	1.22	1.70	1.83	0.79	3.08	1.19	1.76	0.70	1.18	2.94	1.30	0.65	——
July	0.39	1.47	0.50	0.60	2.38	0.65	0.81	0.66	0.72	2.74	0.64	0.62	——
August	0.44	1.09	0.52	0.68	1.41	1.28	0.63	1.00	0.63	2.11	1.30	0.36	——
Growing Period	2.05	4.26	2.85	2.07	6.87	3.12	3.20	2.36	2.53	7.79	3.24	1.63	3.50
September	0.71	0.49	2.19	0.51	1.10	1.70	0.47	0.65	0.71	0.68	0.96	0.51	——
October	1.18	0.96	2.36	0.38	0.72	0.99	0.94	0.69	1.05	0.65	2.02	0.67	——
November	2.64	1.96	2.26	1.01	1.89	0.90	1.58	2.08	2.82	2.47	2.29	1.58	——
Replenishing Period	4.53	3.41	6.81	1.90	3.71	3.59	2.99	3.42	4.58	3.80	5.27	2.76	3.90
Water Year	23.64	21.71	28.94	20.56	33.08	21.91	19.37	17.46	23.63	26.19	27.12	19.54	23.60

TABLE NO. 3.

RUNOFF OF HUDSON RIVER AT MECHANICVILLE, FOR THE WATER YEARS, 1888 TO 1899, INCLUSIVE.

(In Cubic Feet Per Second Per Square Mile, On the Catchment Area of 4,500 Square Miles.)

	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
December	1.78	2.22	2.93	0.72	1.91	0.90	1.60	0.97	2.42	1.54	3.05	1.22
January	1.41	2.44	2.50	1.84	4.19	0.71	1.50	0.86	1.51	0.89	1.72	1.49
February	0.82	0.84	1.76	2.58	2.06	1.07	1.08	0.79	1.04	0.87	1.50	1.17
March	1.52	1.84	2.47	3.94	2.43	1.83	3.28	0.93	3.02	2.49	4.49	2.14
April	4.73	3.04	3.34	4.44	4.79	3.98	2.47	5.31	5.55	4.24	3.07	5.25
May	4.76	1.97	4.00	1.22	4.36	4.95	1.68	1.52	1.02	2.70	2.47	2.17
Storage Period........	2.55	2.08	2.85	2.45	3.30	2.24	1.96	1.72	2.42	2.12	2.72	2.23
June	1.09	1.52	1.64	0.71	2.76	1.07	1.58	0.63	1.05	2.64	1.17	0.58
July	0.34	1.28	0.43	0.52	2.08	0.56	0.70	0.50	0.62	2.39	0.57	0.54
August	0.38	0.95	0.45	0.59	1.22	1.11	0.55	0.87	0.54	1.83	1.13	0.31
Growing Period......	0.60	1.21	0.83	0.65	2.00	0.91	0.94	0.67	0.74	2.29	0.96	0.47
September	0.63	0.44	1.96	0.45	0.99	1.53	0.41	0.58	0.51	0.51	0.84	0.46
October	1.02	0.83	2.04	0.33	0.63	0.86	0.81	0.58	0.91	0.56	1.75	0.58
November	2.36	1.77	2.03	0.91	1.69	0.81	1.42	1.87	2.97	2.21	2.05	1.42
Replenishing Period..	1.34	1.00	2.02	0.56	1.09	1.06	0.88	1.01	1.46	1.09	1.55	0.82
Water Year...........	1.74	1.60	2.13	1.53	2.43	1.62	1.43	1.28	1.74	1.93	1.98	1.44

TABLE NO. 4.

PRECIPITATION RECORD OF THE NORTHERN PLATEAU, FOR THE WATER YEARS 1891 TO 1899, INCLUSIVE.

(In Inches.)

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
December	3.01	4.41	2.11	5.75	3.01	4.18	1.84	4.59	4.17
January	4.82	5.99	2.16	3.48	2.96	2.25	2.43	5.46	3.40
February	4.91	3.15	4.43	2.87	1.58	6.36	1.99	3.29	2.38
March	3.70	3.59	1.97	2.26	2.14	5.56	4.88	2.09	4.79
April	2.46	1.62	3.52	1.81	3.11	1.19	3.72	3.28	1.64
May	1.79	6.19	5.64	5.20	2.99	2.63	4.41	4.09	3.10
Storage Period	20.69	24.95	19.83	21.37	15.79	22.17	19.77	22.80	19.48
June	3.42	5.38	3.20	4.40	2.61	2.87	4.97	3.78	2.10
July	6.06	4.90	3.34	2.89	3.13	4.80	7.36	3.28	3.77
August	4.01	8.84	6.83	1.44	4.63	2.58	3.47	6.46	1.53
Growing Period	13.49	19.12	13.37	8.73	10.37	10.25	15.80	13.52	7.40
September	1.96	3.41	3.90	4.00	3.42	4.93	2.25	3.67	3.37
October	2.90	2.16	1.96	5.10	2.14	2.85	1.70	4.89	2.95
November	3.92	4.23	3.12	2.77	4.95	5.01	6.99	3.63	2.59
Replenishing Period	8.78	9.80	8.98	11.87	10.51	12.79	10.94	12.19	8.91
Water Year	42.96	53.87	42.18	41.37	36.67	45.21	46.51	48.51	35.79

TABLE NO. 5.

RUNOFF OF SCHROON RIVER AT WARRENSBURG, FOR THE WATER YEARS 1896 TO 1899, INCLUSIVE.

(Catchment Area, 562.5 Square Miles.)

	Cubic Feet per Second.				Inches on Catchment Area.						
	1896.	1897.	1898.	1899.	1896.	1897.	1898.	1899.	Mean for 4 Years.	Mean for same Years at Mechanicsville.	Difference.
December	1,233	243	2,776	783	2.53	0.48	5.92	1.61	2.58	2.41	——
January	2,779	335	852	606	5.70	0.69	1.75	1.25	2.35	1.61	——
February	516	188	416	478	0.93	0.35	0.77	0.89	0.74	1.20	——
March	1,664	738	3,194	564	3.41	1.51	6.55	1.16	3.16	3.57	——
April	3,280	3,164	2,853	2,877	6.51	6.28	5.66	5.72	6.04	5.05	——
May	728	1,822	2,203	3,150	1.49	3.73	4.52	6.47	4.05	2.38	——
Storage Period	1,711	1,085	2,017	1,417	20.57	13.04	24.94	17.10	18.91	16.22	2.69
June	827	2,384	568	1,093	1.64	4.73	1.13	2.17	2.42	1.52	——
July	276	1,426	216	210*	0.51	2.92	0.44	0.43	1.09	1.18	——
August	265	1,377	223	150*	0.54	2.82	0.46	0.31	1.03	1.10	——
Growing Period	452	1,722	333	477	2.75	10.47	2.03	2.91	4.54	3.80	0.74
September	215	281	166	234*	0.43	0.56	0.33	0.46	0.45	0.72	——
October	330	161	263	462	0.68	0.33	0.54	0.96	0.62	1.10	——
November	1,089	2,077	464	1,047	2.16	4.12	0.92	2.08	2.32	2.29	——
Replenishing Period	542	1,130	297	580	3.27	5.01	1.79	3.49	3.39	4.11	0.72
Water Year	1,102	1,184	1,191	971	26.59	28.52	28.76	23.50	26.84	24.13	2.71

* Records not kept from July 13 to September 19, inclusive. Flow for this period has been taken as 150 C. F. S., being the assumed leakage of Starbuckville dam.

TABLE NO. 6.

EVAPORATION FROM A WATER SURFACE, AS OBSERVED AT MOUNT HOPE RESERVOIR OF ROCHESTER WATER WORKS FOR THE INDICATED MONTHS AND YEARS.

Year.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	Period.	Mean.
Month.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
January	——	——	——	——	0.45	0.59	0.56	1896—1898	0.53
February	——	——	——	——	0.45	0.62	1.01	1896—1898	0.69
March	——	——	——	——	0.91	1.76	1.56	1896—1898	1.41
April	2.78	2.78	2.59	2.72	2.72	2.45	3.41	1894—1898	2.78
May	3.26	3.33	3.32	4.60	5.72	3.36	3.64	1892—1898	3.89
June	4.62	4.61	3.62	5.75	6.04	5.01	5.65	1892—1898	5.05
July	6.06	5.80	5.31	5.92	5.19	4.43	6.85	1891—1898	5.64
August	4.85	5.36	6.20	5.13	5.23	5.37	4.98	1891—1898	5.26
September	4.61	3.47	3.76	5.14	3.38	4.66	3.95	1891—1898	4.13
October	3.28	3.27	2.96	3.61	2.45	3.33	2.57	1891—1898	3.08
November	——	——	——	1.51	1.50	1.33	1.57	1895—1898	1.48
December	——	——	——	1.23	1.20	0.96	1.54	1895—1898	1.23
Totals	——	——	——	——	35.24	33.87	37.29	——	35.17

TABLE NO. 7.

SHOWING STATE OF WATER STORAGE IN SCHROON VALLEY RESERVOIR FOR THE WATER YEARS 1888 TO 1899, INCLUSIVE. BASED ON AN ASSUMED STORAGE CAPACITY OF THE RESERVOIR OF 18.00 INCHES OF RAINFALL AND A DIVERSION OF 775 CUBIC FEET PER SECOND FOR WATER SUPPLY OF GREATER NEW YORK.

(In Inches On Tributary Catchment Area of 518 Square Miles.

SUMMARY.

Water Year.	Inflow to Reservoir.	Total outgo, excepting waste.	Waste from Reservoir.	Am't stored in Reservoir at beginning of water year.	Am't stored in Reservoir at end of water year.	Yearly depletion of Reservoir = Difference of Cols. (5) and (6).	Increase in amount stored =Dif. of Cols. (6) and (5).	Lowest Condition of Reservoir during Year. Month.	Inches in Reservoir at end of Month.	Cubic feet in Reservoir at end of Month.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1888	23.64	21.89	0.00	4.00	5.75	—	1.75	Mar.	3.38	4,068,000,000
1889	21.71	21.84	0.00	5.75	5.62	0.13	—	Oct.	5.40	6,498,000,000
1890	28.94	21.84	0.00	5.62	12.72	—	7.10	Dec.	7.24	8,713,000,000
1891	20.56	21.84	1.22	12.72	10.22	2.50	—	Nov.	10.22	12,299,000,000
1892	33.08	21.89	5.70	10.22	15.71	—	5.49	Dec.	10.72	12,901,000,000
1893	21.91	21.84	2.35	15.71	13.43	2.28	—	Nov.	13,43	16,162,000,000
1894	19.37	21.84	0.00	13.43	10.96	2.47	—	Nov.	10.96	13,189,000,000
1895	17.46	21.84	0.00	10.96	6.58	4.38	—	Oct.	6.24	7,509,000,000
1896	23.63	21.89	0.00	6.58	8.32	—	1.74	Feb.	7.08	8,520,000,000
1897	26.19	21.84	0.00	8.32	12.67	—	4.35	Feb.	6.92	8,328,000,000
1898	27.12	21.84	2.72	12.67	15.23	—	2.56	Dec.	14.57	17,534,000,000
1899	19.54	21.84	1.82	15.23	11.11	4.12	—	Nov.	11.11	13,370,000,000
Means	23.60	—	—	—	—	—	—	—	—	—

TABLE NO. 7—(Continued).

Water Year 1888.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	4.00	—
December	2.05	0.05	1.72	1.77	0.28	—	4.28	—
January	1.62	0.02	1.72	1.74	—	0.12	4.16	—
February	0.89	0.03	1.61	1.64	—	0.75	3.41	—
March	1.75	0.06	1.72	1.78	—	0.03	3.38	—
April	5.26	0.12	1.67	1.79	3.47	—	6.85	—
May	5.49	0.17	1.72	1.89	3.60	—	10.45	—
June	1.22	0.23	1.67	1.90	—	0.68	9.77	—
July	0.39	0.25	1.72	1.97	—	1.58	8.19	—
August	0.44	0.24	1.72	1.96	—	1.52	6.67	—
September	0.71	0.18	1.67	1.85	—	1.14	5.53	—
October	1.18	0.14	1.72	1.86	—	0.68	4.85	—
November	2.64	0.07	1.67	1.74	0.90	—	5.75	—
Water Year	23.64	1.56	20.33	21.89	8.25	6.50	+ 1.75	—

TABLE NO. 7—(Continued).

Water Year 1889.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Outgo from Reservoir. Inches on Catchment Area. Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Outgo from Reservoir. Inches on Catchment Area. Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	——	——	——	——	——	——	5.75	——
December	2.57	0.05	1.72	1.77	0.80	——	6.55	——
January	2.81	0.02	1.72	1.74	1.07	——	7.62	——
February	0.88	0.03	1.56	1.59	——	0.71	6.91	——
March	2.12	0.06	1.72	1.78	0.34	——	7.25	——
April	3.39	0.12	1.67	1.79	1.60	——	8.85	——
May	2.27	0.17	1.72	1.89	0.38	——	9.23	——
June	1.70	0.23	1.67	1.90	——	0.20	9.03	——
July	1.47	0.25	1.72	1.97	——	0.50	8.53	——
August	1.09	0.24	1.72	1.96	——	0.87	7.66	——
September	0.49	0.18	1.67	1.85	——	1.36	6.30	——
October	0.96	0.14	1.72	1.86	——	0.90	5.40	——
November	1.96	0.07	1.67	1.74	0.22	——	5.62	——
Water Year	21.71	1.56	20.28	21.84	4.41	4.54	— 0.13	——

TABLE NO. 7—(Continued).

Water Year 1890.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	5.62	—
December	3.39	0.05	1.72	1.77	1.62	—	7.24	—
January	2.89	0.02	1.72	1.74	1.15	—	8.39	—
February	1.83	0.03	1.56	1.59	0.24	—	8.63	—
March	2.85	0.06	1.72	1.78	1.07	—	9.70	—
April	3.73	0.12	1.67	1.79	1.94	—	11.64	—
May	4.59	0.17	1.72	1.89	2.70	—	14.34	—
June	1.83	0.23	1.67	1.90	—	0.07	14.27	—
July	0.50	0.25	1.72	1.97	—	1.47	12.80	—
August	0.52	0.24	1.72	1.96	—	1.44	11.36	—
September	2.19	0.18	1.67	1.85	0.34	—	11.70	—
October	2.36	0.14	1.72	1.86	0.50	—	12.20	—
November	2.26	0.07	1.67	1.74	0.52	—	12.72	—
Water Year	28.94	1.56	20.28	21.84	10.08	2.98	+ 7.10	—

TABLE NO. 7—(Continued).

Water Year 1891.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Outgo from Reservoir. Inches on Catchment Area. Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Outgo from Reservoir. Inches on Catchment Area. Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	12.72	—
December	0.83	0.05	1.72	1.77	—	0.94	11.78	—
January	2.12	0.02	1.72	1.74	0.38	—	12.16	—
February	2.70	0.03	1.56	1.59	1.11	—	13.27	—
March	4.55	0.06	1.72	1.78	2.77	—	16.04	—
April	4.97	0.12	1.67	1.79	3.18	—	18.00	1.22
May	1.42	0.17	1.72	1.89	—	0.47	17.53	—
June	0.79	0.23	1.67	1.90	—	1.11	16.42	—
July	0.60	0.25	1.72	1.97	—	1.37	15.05	—
August	0.68	0.24	1.72	1.96	—	1.28	13.77	—
September	0.58	0.18	1.67	1.85	—	1.27	12.50	—
October	0.31	0.14	1.72	1.86	—	1.55	10.95	—
November	1.01	0.07	1.67	1.74	—	0.73	10.22	—
Water Year	20.56	1.56	20.28	21.84	7.44	8.72	—2.50	1.22

TABLE NO. 7—(Continued).

Water Year 1892.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	10.22	—
December	2.27	0.05	1.72	1.77	0.50	—	10.72	—
January	4.83	0.02	1.72	1.74	3.09	—	13.81	—
February	2.22	0.03	1.61	1.64	0.58	—	14.39	—
March	2.80	0.06	1.72	1.78	1.02	—	15.41	—
April	5.35	0.12	1.67	1.79	3.56	—	18.00	0.97
May	5.03	0.17	1.72	1.89	3.14	—	18.00	3.14
June	3.08	0.23	1.67	1.90	1.18	—	18.00	1.18
July	2.38	0.25	1.72	1.97	0.41	—	18.00	0.41
August	1.41	0.24	1.72	1.96	—	0.55	17.45	—
September	1.10	0.18	1.67	1.85	—	0.75	16.70	—
October	0.72	0.14	1.72	1.86	—	1.14	15.56	—
November	1.89	0.07	1.67	1.74	0.15	—	15.71	—
Water Year	33.08	1.56	20.33	21.89	13.63	2.44	+ 5.49	5.70

TABLE NO. 7—(Continued).

Water Year 1893.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	15.71	—
December	1.03	0.05	1.72	1.77	—	0.74	14.97	—
January	0.82	0.02	1.72	1.74	—	0.92	14.05	—
February	1.09	0.03	1.56	1.59	—	0.50	13.55	—
March	2.11	0.06	1.72	1.78	0.33	—	13.88	—
April	4.44	0.12	1.67	1.79	2.65	—	16.53	—
May	5.71	0.17	1.72	1.89	3.82	—	18.00	2.35
June	1.19	0.23	1.67	1.90	—	0.71	17.29	—
July	0.65	0.25	1.72	1.97	—	1.32	15.97	—
August	1.28	0.24	1.72	1.96	—	0.68	15.29	—
September	1.70	0.18	1.67	1.85	—	0.15	15.14	—
October	0.99	0.14	1.72	1.86	—	0.87	14.27	—
November	0.90	0.07	1.67	1.74	—	0.84	13.43	—
Water Year	21.91	1.56	20.28	21.84	6.80	6.73	— 2.28	2.35

TABLE NO. 7—(Continued).

Water Year 1894.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area.			Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
		Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York = 775 cu. ft. per sec.	Total Outgo from Reservoir.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	——	——	——	——	——	——	13.43	——
December	1.85	0.05	1.72	1.77	0.08	——	13.51	——
January	1.73	0.02	1.72	1.74	——	0.01	13.50	——
February	1.12	0.03	1.56	1.59	——	0.47	13.03	——
March	3.78	0.06	1.72	1.78	2.00	——	15.03	——
April	2.76	0.12	1.67	1.79	0.97	——	16.00	——
May	1.94	0.17	1.72	1.89	0.05	——	16.05	——
June	1.76	0.23	1.67	1.90	——	0.14	15.91	——
July	0.81	0.25	1.72	1.97	——	1.16	14.75	——
August	0.63	0.24	1.72	1.96	——	1.33	13.42	——
September	0.47	0.18	1.67	1.85	——	1.38	12.04	——
October	0.94	0.14	1.72	1.86	——	0.92	11.12	——
November	1.58	0.07	1.67	1.74	——	0.16	10.96	——
Water Year	19.37	1.56	20.28	21.84	3.10	5.57	— 2.47	——

TABLE NO. 7—(Continued).

Water Year 1895.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Outgo from Reservoir. Inches on Catchment Area. Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Outgo from Reservoir. Inches on Catchment Area. Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	10.96	—
December	1.12	0.05	1.72	1.77	—	0.65	10.31	—
January	0.99	0.02	1.72	1.74	—	0.75	9.56	—
February	0.82	0.03	1.56	1.59	—	0.77	8.79	—
March	1.08	0.06	1.72	1.78	—	0.70	8.09	—
April	5.91	0.12	1.67	1.79	4.12	—	12.21	—
May	1.76	0.17	1.72	1.89	—	0.13	12.08	—
June	0.70	0.23	1.67	1.90	—	1.20	10.88	—
July	0.66	0.25	1.72	1.97	—	1.31	9.57	—
August	1.00	0.24	1.72	1.96	—	0.96	8.61	—
September	0.65	0.18	1.67	1.85	—	1.20	7.41	—
October	0.69	0.14	1.72	1.86	—	1.17	6.24	—
November	2.08	0.07	1.67	1.74	0.34	—	6.58	—
Water Year	17.46	1.56	20.28	21.84	4.46	8.84	— 4.38	—

TABLE NO. 7—(Continued).

Water Year 1896.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Outgo from Reservoir. Inches on Catchment Area. Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Outgo from Reservoir. Inches on Catchment Area. Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	6.58	—
December	2.79	0.05	1.72	1.77	1.02	—	7.60	—
January	1.74	0.02	1.72	1.74	0.00	0.00	7.60	—
February	1.12	0.03	1.61	1.64	—	0.52	7.08	—
March	3.49	0.06	1.72	1.78	1.71	—	8.79	—
April	6.20	0.12	1.67	1.79	4.41	—	13.20	—
May	1.18	0.17	1.72	1.89	—	0.71	12.49	—
June	1.18	0.23	1.67	1.90	—	0.72	11.77	—
July	0.72	0.25	1.72	1.97	—	1.25	10.52	—
August	0.63	0.24	1.72	1.96	—	1.33	9.19	—
September	0.71	0.18	1.67	1.85	—	1.14	8.05	—
October	1.05	0.14	1.72	1.86	—	0.81	7.24	—
November	2.82	0.07	1.67	1.74	1.08	—	8.32	—
Water Year	23.63	1.56	20.33	21.89	8.22	6.48	+ 1.74	—

TABLE NO. 7—(Continued).

Water Year 1897.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	8.32	—
December	1.77	0.05	1.72	1.77	0.00	0.00	8.32	—
January	1.03	0.02	1.72	1.74	—	0.71	7.61	—
February	0.90	0.03	1.56	1.59	—	0.69	6.92	—
March	3.13	0.06	1.72	1.78	1.35	—	8.27	—
April	4.73	0.12	1.67	1.79	2.94	—	11.21	—
May	3.04	0.17	1.72	1.89	1.15	—	12.36	—
June	2.94	0.23	1.67	1.90	1.04	—	13.40	—
July	2.74	0.25	1.72	1.97	0.77	—	14.17	—
August	2.11	0.24	1.72	1.96	0.15	—	14.32	—
September	0.68	0.18	1.67	1.85	—	1.17	13.15	—
October	0.65	0.14	1.72	1.86	—	1.21	11.94	—
November	2.47	0.07	1.67	1.74	0.73	—	12.67	—
Water Year	26.19	1.56	20.28	21.84	8.13	3.78	+ 4.35	—

TABLE NO. 7—(Continued).

Water Year 1898.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area. Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.	Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	——	——	——	——	——	——	12.67	——
December	3.67	0.05	1.72	1.77	1.90	——	14.57	——
January	1.97	0.02	1.72	1.74	0.23	——	14.80	——
February	1.56	0.03	1.56	1.59	——	0.03	14.77	——
March	5.18	0.06	1.72	1.78	3.40	——	18.00	0.17
April	3.40	0.12	1.67	1.79	1.61	——	18.00	1.61
May	2.83	0.17	1.72	1.89	0.94	——	18.00	0.94
June	1.30	0.23	1.67	1.90	——	0.60	17.40	——
July	0.64	0.25	1.72	1.97	——	1.33	16.07	——
August	1.30	0.24	1.72	1.96	——	0.66	15.41	——
September	0.96	0.18	1.67	1.85	——	0.89	14.52	——
October	2.02	0.14	1.72	1.86	0.16	——	14.68	——
November	2.29	0.07	1.67	1.74	0.55	——	15.23	——
Water Year	27.12	1.56	20.28	21.84	8.79	3.51	+ 2.56	2.72

TABLE NO. 7—(Continued).

Water Year 1899.	Inflow to Reservoir = Runoff at Mechanicville in ins. on Catchment Area.	Outgo from Reservoir. Inches on Catchment Area.			Excess of Supply over Outgo.	Deficiency in Supply.	Amount in Reservoir at end of month.	Waste from Reservoir.
		Evaporation from water surface; from monthly means at Rochester.	Diversion for Water Supply of Greater New York =775 cu. ft. per sec.	Total Outgo from Reservoir.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
November	—	—	—	—	—	—	15.23	—
December	1.40	0.05	1.72	1.77	—	0.37	14.86	—
January	1.71	0.02	1.72	1.74	—	0.03	14.83	—
February	1.22	0.03	1.56	1.59	—	0.37	14.46	—
March	2.47	0.06	1.72	1.78	0.69	—	15.15	—
April	5.86	0.12	1.67	1.79	4.07	—	18.00	1.22
May	2.49	0.17	1.72	1.89	0.60	—	18.00	0.60
June	0.65	0.23	1.67	1.90	—	1.25	16.75	—
July	0.62	0.25	1.72	1.97	—	1.35	15.40	—
August	0.36	0.24	1.72	1.96	—	1.60	13.80	—
September	0.51	0.18	1.67	1.85	—	1.34	12.46	—
October	0.67	0.14	1.72	1.86	—	1.19	11.27	—
November	1.58	0.07	1.67	1.74	—	0.16	11.11	—
Water Year	19.54	1.56	20.28	21.84	5.36	7.66	— 4.12	1.82

TABLE NO. 8.

SHOWING STATE OF WATER STORAGE IN SCHROON VALLEY RESERVOIR FOR THE WATER YEARS 1888 TO 1899, INCLUSIVE. BASED ON AN ASSUMED STORAGE CAPACITY OF RESERVOIR OF 13.5 INCHES OF RAINFALL AND A DIVERSION OF 650 CUBIC FEET PER SECOND, FOR WATER SUPPLY OF GREATER NEW YORK.

(In Inches On Tributary Catchment Area of 518 Square Miles.)

SUMMARY.

Water Year.	Inflow to Reservoir.	Total Outgo, excepting Waste.	Waste from Reservoir.	Am't stored in Reservoir at beginning of Water Year.	Am't stored in Reservoir at end of Water Year.	Yearly Depletion of Reservoir = Difference of Cols. (5) and (6).	Increase in Am't stored =Dif. of Cols. (6) and (5).	Lowest Condition of Reservoir during Year. Month.	Inches in Reservoir at end of Month.	Cubic feet in Reservoir at end of Month.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1888	23.64	18.66	0.00	4.00	8.98	——	4.98	Feb.	4.21	5,066,000,000
1889	21.71	18.62	0.63	8.98	11.44	——	2.46	Dec.	10.05	12,094,000,000
1890	28.94	18.62	8.46	11.44	13.30	——	1.86	Aug.	11.13	13,394,000,000
1891	20.56	18.62	7.63	13.30	7.61	5.69	——	Nov.	7.61	9,158,000,000
1892	33.08	18.66	9.74	7.61	12.29	——	4.68	Dec.	8.38	10,085,000,000
1893	21.91	18.62	5.03	12.29	10.55	1.74	——	Nov.	10.55	12,696,000,000
1894	19.37	18.62	1.40	10.55	9.90	0.65	——	Oct.	9.79	11,781,000,000
1895	17.46	18.62	0.00	9.90	8.74	1.16	——	Oct.	8.13	9,784,000,000
1896	23.63	18.66	3.20	8.74	10.51	——	1.77	Oct.	9.16	11,023,000,000
1897	26.19	18.62	5.42	10.51	12.66	——	2.15	Feb.	9.90	11,914,000,000
1898	27.12	18.62	8.81	12.66	12.35	0.31	——	Sep.	11.10	13,358,000,000
1899	19.54	18.62	5.04	12.35	8.23	4.12	——	Oct.	8.12	9,772,000,000
Means	23.60	——	4.61	——	——	——	——		——	——

APPENDIX F

REPORT ON

AN AUXILIARY SALT-WATER SUPPLY FOR FIRE-PROTECTION, STREET-WASHING, SEWER-CLEANSING AND OTHER PURPOSES.

BY

FOSTER CROWELL,

M. Am. Soc. C. E., M. Inst. C. E.

LIST OF PLATES.

CONTENTS OF APPENDIX (F).

AN AUXILIARY SALT-WATER SUPPLY FOR FIRE-PROTECTION, STREET-WASHING, SEWER-CLEANSING, AND OTHER PURPOSES.

BY FOSTER CROWELL, C. E.

To the Engineering Committee of the Merchants' Association of New York, Thomas C. Clarke, Past President American Society Civil Engineers, Chairman:

GENTLEMEN:

In accordance with your resolution of December 8, 1899, I have made a careful investigation of the question of an auxiliary sea water supply for New York City, and herewith present my report.

Your instructions required that the report should cover fire protection, street washing, sewer cleansing, and other purposes for which salt water might be utilized.

The facts and figures from which my conclusions are drawn are set forth elsewhere in this report, arranged in separate chapters for convenient reference and study, together with tabular statements, detailed estimates of cost and citations.

The conclusions reached and the accompanying recommendations will now be stated in order.

I.

GENERAL CONCLUSIONS AND RECOMMENDATIONS.

The present New York water supply system is so constituted that in the greater part of the city it is impossible to obtain by gravity sufficient pressure at the hydrants for extinguishing fires, and reliance has heretofore been entirely upon the fire engines.

Moreover, the present pipe distribution system is not suitable for the introduction of a high pressure service by means of pumps; and even if the facts were otherwise, the high pressure would necessitate the separation of the fire service from the domestic supply of fresh water, or else require the replacement of the house fixtures with others suited to the higher pressure, both of which plans would be costly and unsatisfactory. In either case pumping would have to be resorted to.

The only portions of the city where it has been possible to secure both adequate pressure and sufficient volume of water without depending on the fire engines are the narrow margins of water fronts that lie within the radius of operation with hose by the fireboats. My first recommendation is to extend that radius, by means of fire pipe lines, into the heart of the city.

Such fireboat pipe lines are in use in the cities of Cleveland, Milwaukee, Detroit, Buffalo and Boston, and have given complete satisfaction, as will be seen by reference to the facts and figures in Chapters II and III.

Boston uses sea water, and the experience had there demonstrates conclusively the great value and advantage of using this source of supply; for, although no fires have occurred within the fire pipe district since the line was put into service, the very exhaustive tests made under service conditions prove beyond any doubt its power and effectiveness.

The germ of the pipe line system is the fireboat. New York has six fireboats in service, with an aggregate capacity of about 40,000 gallons per minute under high service conditions, which is equivalent to the work of ninety ordinary fire engines, as determined comparatively by the Boston tests. The largest of the boats, the "New Yorker," alone has a capacity of 13,000 gallons per minute, or the equivalent of thirty engines.

While the fireboats do magnificent work at fires sufficiently near to the water front, and are an indispensable feature of the New York fire service, yet the occasions for their use are so infrequent that for the greater portion of the time they are performing no useful work and yielding no return. Of course, the fires must be kept up and the crew be on duty at all times, and the aggregate expense involved, together with interest and deterioration charges, makes a very large item in the Fire Department budget. In common parlance, they are "eating their heads off" most of the time, useful and indispensable as they are.

Consequently, if their sphere of usefulness can be enlarged within reasonable cost, economy would demand its being done, apart from other advantages.

I recommend that the city should begin with a tentative adoption of the system in a limited district whose needs are greatest, and wherein the test would be most severe.

The "Dry Goods District," bounded by Chambers street on the south, Broadway, Canal street and Hudson street, unites the above conditions. (See Map, Plate XXVI.)

As will be seen from the detailed estimate, (a), Chapter X, the cost of introducing a full-powered fire pipe system over this district would be $110,000.

To introduce a similar system in the adjoining district, which extends north as far as Bleecker street, and from South Fifth avenue to Broadway, would cost (b) $104,060, and to apply it from Chambers street south to the Battery and from river to river would cost (d) $300,000. (See Map, Plate XXIV.)

A logical extension of the pipe line service is a means by which water can be carried under pressure to the level of the tops of buildings, and I recommend that a fixed stand pipe be provided at a convenient street intersection, so designed as not to occupy any of the roadway, to connect the proposed sea water pipe line with a roof service. Wherever buildings already have stand pipes provision should be made for connecting them directly with the pipe lines.

Effect of Sea Water in Extinguishing Fires.

On account of its greater density, salt water is more efficacious mechanically in extinguishing fires; it vaporizes at a higher temperature, and consequently its effect upon the fire is intensified and prolonged. There are no disadvantages in its use, so far as known, the objection sometimes urged of its greater injurious effect upon merchandise that is saturated with water to save it from destruction by the flames, being not entertained seriously by competent authorities in fire department and underwriting circles.

Confirmation of this statement may be found in the fact that of the total consumption of water by the fire department of New

York and Brooklyn in 1898 (the last year so far reported) 32 per cent. was sea water from the rivers. About the same proportion of sea water has been used for a number of years past, and so far no complaints have been heard, notwithstanding that the fireboats are obliged to take water from any point that may happen to be most convenient to the fire.

In the case of the pipe lines it is possible to locate and design the intakes so as to use only clean water.

The total annual consumption of water for extinguishing fires is comparatively insignificant, being only about 46,000,000 gallons for Manhattan and the Bronx.*

This is such a minute portion of the entire water consumption that at first sight it would not seem worth while to provide a separate source of supply; but when looked at from the standpoint of fire protection, it will be seen at once that, because of its smallness, it is both sensible and economical to supply it under the proper pressure instead of applying that same pressure to the enormous quantity of total consumption. From this point of view, the smaller the quantity of water consumed in extinguishing fires the more economical and effective is the system.

The conditions in Brooklyn are sufficiently like Manhattan's, especially in the water front districts, to call for a fire pipe system, but no specific recommendation is made to introduce it there at this time for the reason that, in my judgment, the best policy for the city would be to proceed on broadly tentative lines and confine the experimental installations to Manhattan.

Prices of materials of all kinds are now so high that it is a fair presumption that two or three years hence the cost of introduction may be materially reduced. The experience that could be gained meanwhile with the experimental installations recommended would enable the city authorities to design the extensions intelligently as they should be needed.

The conditions in the Borough of Queens are essentially different. There is no general water supply system, but there are detached pumping plants, some belonging to the city, but others

* Fire Department Reports, 1894, 1895, 1896, 1897, 1898. Maximum annual consumption, 45,771,156 gallons in 1896. Average for the five years, 36,000,000 gallons. Amount used in 1899 was 91,000,000 gallons.

owned by private companies who supply water under contract. These systems deliver under pressure, but the cost is excessive and the supply insufficient and precarious, being dependent upon subterranean stores.

In Long Island City the water conditions are unsatisfactory, and this would appear to be a good field for the auxiliary supply, especially that portion which lies south of Sanders Creek, bordering on the East River and Newtown Creek, and extending over Greenpoint in the Borough of Brooklyn. This would require a fireboat or a fixed pumping station. Could the latter be made a part of a suitable plant for the purification of Newtown Creek on the dilution principle, two important objects might be accomplished. The latter subject has no proper place in this report, and as the entire local situation is much complicated, I make no specific recommendation further than to suggest the importance of the consideration involved.

The Borough of Queens has many miles of expensive macadam highways, the proper care and economical maintenance of which call for a liberal use of water, salt water being better for the purpose than fresh. But excepting in favored localities, there is no provision for watering, and a very large mileage of the roads are at present rapidly going to destruction. Throughout the North Shore region and near Jamaica Bay there are a number of pumping stations located not far from tidewater. It would be a perfectly simple matter to supplement the pumping capacity of these stations and connect them with a sea water system of fire pipes along the main highways, with branches in the villages. This would solve inexpensively the present difficulty of the maintenance of the roads, and also the even more important question of fire protection throughout a very large portion of the Borough. (See Map, Plate XXV.)

In the Borough of the Bronx the conditions of the territory bordering on the East River and Long Island Sound resemble those just described for Queens, but in the thickly settled section they resemble those of Manhattan. Along the Harlem River, in both Manhattan and the Bronx, there are areas occupied by industrial establishments in which the detached system of separate fire pipes which is used in Milwaukee would find a better application than would an articulated system.

In the Borough of Richmond the conditions somewhat resemble those of Queens, though on account of the topographical conditions and the different state of development an auxiliary sea water supply, though fully available, would have a more limited natural application, and in general it may be said that an auxiliary sea water supply for Richmond will be needed in the future, both for road purposes and fire protection, the extent depending upon future circumstances.

Washing Streets.

Water for systematic street cleansing has not been much used in American cities. In New York we are familiar with the advance in street cleaning within the past few years, but, although the results show an immense improvement over the former conditions, they fall short of providing clean streets in any true sense of the word, and are attained at great cost.

There is no doubt that a higher standard of cleanliness can be and should be reached at less cost than at present by washing and scrubbing in addition to the sweeping.

Without a copious and cheap water supply this would not be practicable, especially in dry seasons when needed most, and when the fresh water supply should be carefully husbanded in order to provide for a scarcity for other purposes.

With a pipe line the street supply would be practically unlimited, and if the fireboats could be used systematically for this purpose, as well as for fire protection, the cost would be very small.

But in order to insure the regular periodic delivery for street cleaning it would be found necessary to provide special pumping plants, and I recommend that an experimental fire pipe line of the third order, with a fixed pumping station to be located on city property in Corlear's Hook Park, be established between Division street and Houston street, from the Bowery to the East River, which district I have selected both because almost all its streets are asphalted and because it teems with our wage-earning population, for whom, in the interests of all, the very best sanitary and protective provisions should be made.

This pipe line should also be provided with fireboat connection, so that it could be used independently of the stationary pumps, if necessary.

The estimated cost of a fire pipe system with pumping station for this district is (f) $326,700.

With an experimental plant of this nature the practical effect, cost and value of providing a large area with a copious supply of clean water can be ascertained, and the cost of future extension determined.

The pumping station in the location which I have recommended could also supply without additional maintenance expense the pumping for one or more adjacent districts, should it afterwards be determined to adopt them.

Flushing Gutters and Sewers.

To what extent it will be desirable to flush the gutters and sewers in New York City can only be demonstrated in the light of local experience. Doubtless an improved condition of the public health would follow the practice, and certainly the degree of cleanness that would be possible would be very much greater than under the present methods.

For further details in regard to this important branch of street service reference may be had to Chapter VI, in which will be found a tabular statement of the daily consumption of water in Paris for these purposes. A similar allowance per superficial unit of street surface in the part of the city lying south of Fifty-ninth street would amount to 4,500,000 gallons daily.

In the Corlear's Hook experimental district the daily consumption would be 300,000 gallons.

Chapter VII contains a discussion of the relative advantages of sea water and fresh water for street purposes, and cites the opinions of various experts upon the subject. The testimony is clear and conclusive not only as to the harmlessness of clean sea water, but also that there are decided relative advantages in its use.

Cooling the Streets.

The temperature of sea water being normally much lower than that of the air in summer-time, it would be entirely possible with a copious and cheap supply at hand, to greatly ameliorate the severity of the heat by cooling the pavements.

The temperature of asphalt pavements in New York frequently reaches 125 degrees Fahrenheit, and the heat is retained after a hot day throughout the night. It would be possible by means of cool sea water to lower the temperature very materially, and thereby enhance the comfort of residents and bring about a decrease in infant mortality. The percentage of deaths of children under five years of age in Manhattan and The Bronx has decreased from 53 per cent. in 1867 to about 36 per cent., which result is attributed to better sanitary arrangements through the Board of Health and a higher standard of living, as well as to the improved condition of the streets; and it is believed that a further reduction is entirely possible.

The extent to which this cooling might be carried is indicated in Chapter VIII, but no specific recommendations in reference thereto are here made, as it is a question which can only be intelligently settled after experience has been acquired.

Use of Sea Water in Office Buildings.

In Chapter IX will be found a discussion upon the possible application of a sea water supply to office buildings and industrial establishments.

Salt water, so far as known to me, has not been made use of in office buildings. Upon the question of its suitability the opinions of the owners and agents of steamship lines have been sought, as they have had analagous experience with the use of salt water in ships.

Their replies may be found summarized in Chapter IX. With practical unanimity they agree that there would be no possible objection to the use of clean salt water for flushing closets and urinals in office buildings, and many of them further claim that there would be distinct advantages in such use.

Our city is for the most part devoid of public water closets, urinals and lavatories, in which respect it falls behind in the march of civilization. With a bountiful supply of running water, such as would be afforded by the pipe lines, it would be possible to provide adequately and in a very satisfactory way for such public necessities.

The purposes to which sea water could be put in industrial establishments are more numerous than at first appear, the chief among them being for cooling steam condensers, stills and beer vats. For the latter purpose salt water is already often used in favorable locations, but, so far as known, always in connection with private pumping plants. This is a consideration which has no important bearing at present upon the real subject, but there is no doubt that if an abundance of cheap salt water could be applied for such purposes a very considerable revenue might be derived, and the expense of maintaining the plant be thus reduced.

It is manifest that if the sea water is to be furnished to private consumers the pumping must be practically continuous, and no data being at hand upon which to base our estimate of the private consumption, it would not be worth while at this time to attempt to make an estimate of the cost of providing and maintaining a plant of that description. Accordingly, I have no recommendation to make concerning this feature of the auxiliary supply, and have introduced it as a possibility merely.

It is quite evident, however, that if a pumping plant were already provided for the other purposes the additional cost of utilizing it for the purpose of private supply would not be great, and that the latter could be furnished at a low rate.

An experimental service for private consumption could be instituted in connection with the proposed Corlear's Hook installation.

In collating the data on which this report is based, I have endeavored to include nothing that is not definite and authentic. In all the cases the source of the information is credited.

To all the contributors of information, I take this opportunity to extend my thanks, and particularly to the officials of the cities of Cleveland, Milwaukee, Detroit, Buffalo, Boston, Cambridge, London, Glasgow, Paris, San Francisco, Oakland, San Diego and Coronado for their cordial response to our quest for information. Special acknowledgment of valuable services rendered in this connection are due to—

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M. K. MILLER, ESQ., C. E., Supt. Streets, Oakland, Cal.

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II.

FIRE PIPE LINES IN CLEVELAND, MILWAUKEE, DETROIT, BUFFALO, AND BOSTON.

It may not be out of place to mention that in 1897 I had the honor to be retained by the Board of Fire Commissioners of the City of New York to investigate and report upon a proposed sea-water fire pipe line, and that in that duty I visited the above named cities in turn and made a personal investigation into the practicality and efficiency of the separate system of water supply for fire protection. In each of the cities exhibitions and tests were given to demonstrate the actual working, and opportunity was afforded me in every case for a complete and careful study of the various details of the service.

The results of that investigation are to be found in my report published by the Fire Department in December, 1897.*

At that time, however, the plant for the Boston system, though approaching completion, was not yet in service, and that of Buffalo, while in perfect working order, had only been intro-

* Proposed Sea-Water Fire Pipe Line for the City of New York, Report to Hon. James R. Sheffield, President of the Board of Fire Commissioners, December, 1897, by Foster Crowell, Consulting Engineer.

duced a short time before. In order, therefore, to bring the results comprehensively up to date, I have recently spent several days in Boston, carrying on the investigation there and have corresponded with the authorities in the other cities.

The original investigation was made in company with Mr. Hugh Bonner, then Chief of the New York Fire Department, and thus took on not only the character of an engineering examination, but of a rigid test from the standpoint of the practical fireman as well.

Experience With the Separate System of Water Supply for Fire Protection in Cleveland, Ohio.

The credit of the first adoption of fire pipe lines is claimed by Cleveland, but Milwaukee also introduced them about the same time.

In Cleveland the fireboats had previously demonstrated their usefulness to such an extent that in 1888 their limited radius of operation along the river banks was extended by laying an ordinary 6-inch cast-iron pipe from the river bank to the top of the adjoining bluff, a distance of seven or eight hundred feet only, and without any idea of extending the system, but its advantages became so marked that in 1891 extensions were begun and have continued until, in 1897, there were four lines in service, comprising a total length of one and one-half miles; the longest distance covered by one line being 2,400 feet. There are provisions for further extensions. Eight-inch pipes were used on all the newer work; the original 6-inch pipes are still in service and as a necessary consequence great friction losses occur; but notwithstanding that drawback, the advantages obtained are very great.

It is to be remembered that there is no scarcity of water in Cleveland, which draws from the inexhaustible Lake supply, and that the fire pipe line there is simply and solely to be regarded as an improved piece of apparatus for extinguishing fires.

The tests that we saw made demonstrated its efficiency in a very striking degree. There are two fireboats in constant service and special communication is had with them by means of overhead telegraph wires. The system in Cleveland, as has been intimated, is to be regarded as an evolution proceeding along natural lines of improvement. For that reason the service tests which we made there are not here included. That branch of the subject will be discussed later on in this report with examples from the more modern plant of some of the other cities.

Experience at Milwaukee.

Milwaukee introduced its first fire pipe line in 1889. Here, as in Cleveland, there has been a vigorous development based upon the successive good results attained. The first installations were with 6-inch pipe, but this has since been relaid in part with 8-inch and 10-inch. The present rule is to proportion each line to its special service, 10-inch being the maximum. Many of the lines are planned for future extension and it may be said that this system is destined to be the chief dependence of the city.

Milwaukee now possesses twenty-five lines, with a total length of 41,419 feet (or nearly eight miles); 164 hydrants for the separate service, and three fireboats, each of 6,000 gallons capacity.

On account of the very cold weather at the time of our visit it was not deemed desirable to exhibit the working of the system in the heart of the city, but a very satisfactory test was made on a line 3,000 feet long, consisting of 10-inch and 8-inch pipe. We were shown the records and photographs of other tests, one being on a 10-inch line 2,158 feet long, where a 2½-inch stream was thrown over the Statue of Liberty on the Court House., the height of which is 198 feet above the hydrants and 255½ feet above the river level; in another, six 1½-inch streams were simultaneously thrown over buildings 150 feet high. Through the courtesy of Mr. James Foley, Chief of the Milwaukee Fire Department, I have been furnished with the photographic view of the Court House test, which accompanies this report.

Milwaukee, like Cleveland, is a Lake city, and can draw unlimited supplies of water, and the use of the fire pipe line is a practical demonstration of the most economical way, in their estimation, of securing for the portion of the total water supply that is required for fire protection the necessary high pressure for efficient service.

The various pipe lines, as shown on a series of blue prints which were kindly furnished me by Mr. George H. Benzenberg, M. Am. Soc. C. E., at that time president of the Milwaukee Board of Public Works, have been introduced from time to time so as to cover, in detached and independent sections, the chief business and industrial districts. They have not been extended to the residential sections as yet, nor connected together.

Mr. Benzenberg, in a recent letter, informs me that the system has given the very best of satisfaction and will, in all probability, be still further extended as soon as the funds are available.

Experience in Detroit.

At the time of my examination Detroit had fourteen completed fire pipe lines, 8-inch and 10-inch, with an aggregate length of nearly five miles, most of which are on parallel streets, running at right angles to the Detroit River, and served by one fireboat with a capacity of 6,000 gallons per minute. I am informed by the Secretary of the Detroit Fire Commissioners that recently an appropriation has been made for a second fireboat.

The work of the present Detroit system was demonstrated to us by a very satisfactory series of tests on the Shelby street line, which consists of an 8-inch steel pipe, 2,250 feet long. The fireboat "Detroiter" was connected with the main by five lines of 3½-inch hose.

The first test was made opposite the new postoffice, near the corner of Shelby and Lafayette streets, with two 1¾-inch streams. The water pressure at the pump was 200 lbs., and back of the nozzle 90 lbs.

The second test was made with three lines of 3½-inch hose, "siamesed" into 1¾-inch nozzle. This made a magnificent and very powerful stream, the gauge back of the point of junction indicating 180 lbs.

In the third test the 2-inch nozzle was substituted, the gauge pressure being 180 lbs. as before.

In the fourth test the 2½-inch nozzle was used, with a gauge pressure of 150 lbs., and the fifth, a 2½-inch nozzle, with pressure of 143 lbs.

A record of previous tests made on another of the Detroit lines, 4,600 feet in length, is as follows:

(a) Three 1½-inch streams, through 100 feet of 3-inch hose each, were thrown a distance of 225 feet.

(b) Two 1¾-inch streams, through same length of 3-inch hose, were thrown 250 feet.

(c) Two 2-inch streams, same hose, were thrown 325 feet.

The Detroit pipe lines and their appurtenances have been designed with great care and skill; the Shelby street line is typical, and may be advantageously described here in detail.

Steel pipe, such as used by the Standard Oil Company in pumping oil to the seaboard, was selected; it is 8 inches in diameter; 28 lbs. to the foot; lap welded, with screw couplings. It is dipped in asphaltum, and tested to 1,000 lbs. It is laid on a straight grade, the rise being but 19 feet in 2,000 feet, the result being shown in its very efficiency, as indicated by the low friction losses mentioned in the account of the tests. The slope is toward the river, and is sufficient to permit the quick draining of the pipe by gravity as soon as the pressure is removed.

The hydrants have a 6-inch stand pipe, with two 3-inch (hose) and one 4-inch (steamer) outlet.

Brick manholes are built opposite each hydrant, and a wire is run alongside the pipe to establish telephone connection between each hydrant and the boat.

In the manholes, at the ends of the pipes, are relief valves to guard against excessive pressure, with proper sewer connections to carry off any escaping water from the relief valves.

There is a blowoff manhole at the lowest point of the pipe, also connected with the sewer, and by means of a 4-inch gate valve the pipe can be emptied into the sewer.

At the end of each line there is an automatic air-escape valve, and there is a gate in the manhole at each hydrant by which the latter can be cut out.

Experience at Buffalo.

Buffalo's one fire pipe line at the time of its installation was notable for its greater length, larger diameter and completer equipment than any other then in service. It extends along Washington street, parallel to and one block from Main street, from the river as far as Chippewa street, a distance of 6,200 feet; its highest point is about 50 feet above the river level; it is of wrought iron, 12 inches in diameter, weighing 50 lbs. per foot, with screw joints.

The pipe sections are tested to 1,000 lbs. per square inch, and the line to 300 lbs. per square inch.

There are 26 special hydrants, each with four 3½-inch openings; the hydrant branches and standing pipes are 8 inches.

Opposite each hydrant is a manhole with a cover in two parts, a central one of small diameter, through which the turnkey of the valves can be operated, and an annular one of larger diameter, which need only be removed when it is necessary to enter the manholes; the valves are three-way, so constructed that either any hydrant can be cut off and the line left open, or the line can be shut off at that point.

Every hydrant has an automatic air-escape.

In the practical working of this line it is proposed to allow it to remain full of water during eight months of the year; adequate drainage into the sewers is provided by means of two-way valves.

Connection with the fireboat is made by means of two short branches, which unite a short distance up the line; each branch terminates in a cylindrical chamber, with seven openings for a 3½-inch hose; a special coupling, which can be instantaneously made or broken by a quarter turn of a spanner without the use of a screw thread, is used.

There are two fireboats, of a combined capacity of 10,000 gallons per minute. With both working together the entirely empty line can be filled ready for fire streams in three minutes and forty seconds. A most satisfactory test of this line was made for our benefit at the corner of Washington street and Broadway, 6,000 feet distant from the river, with one fireboat.

It is proposed to put in a main along the water front, and to adhere in all extensions to the diameter already adopted, viz., 12 inches.

Electric communication with the fireboat is provided close to each hydrant by means of an independent signal-box on an iron pillar, connecting with double wiring laid in a 2-inch iron pipe in the pipe line trench leading to the river, and a cable to the apparatus in the engine-room of the boat. By means of a key and bell at each end, constant reciprocal communication can be maintained between the two ends.

The Buffalo officials compute that their pipe line, complete with all the appurtenances as above described, has cost about $3.50 per linear foot, or about $22,000 for the line.

Altogether there are about 17 miles of fire pipe lines in service in the different cities.

III.

THE SALT WATER FIRE SYSTEM OF BOSTON.

The lines heretofore described, all being for fresh water service, fail to furnish one important element of information needed for New York's guidance, namely, the effect of salt water upon the structures.

Boston has introduced a salt water line which is an instructive example, but as only two years have elapsed since it was completed, the experience gained is somewhat limited. Observation in other fields, however, as to the effect of salt water upon metals is not lacking, and in the light of experience with cast-iron water pipe that has for many years conveyed a fresh water supply under salt water, that material was adopted for the fire pipe, with solid composition metal valves, gates and fittings, with pure rubber joints; the diameter of the pipe is 12 inches, and the metal is one inch thick; the bells and spigots are extra heavy, and cast with two calking jogs, as an additional precaution against leakage. Forty pounds of lead are used for each joint; the pipe is coated at the foundry inside and out with what is known as the "standard" coating. The line is tested for 500 lbs. per square inch.

At the time the line was under construction I visited it, and made personal examination of all the details.

The line is about 4,000 feet long, with both ends at the water side. Starting at Congress street bridge over Fort Point Channel, it extends up Congress street about 2,300 feet through Postoffice Square to Exchange Place, where it makes a right angle turn and goes through Exchange Place and Central street to the harbor at Central Wharf.

About midway on each leg cross-connections are laid for proposed future extensions, and a third branch is at Milk street, the length of the proposed extensions being about two miles, with one or more additional waterside connections.

Each end of the present line is designed with two fireboat connections, so that both boats, each with 3,000 gallon capacity per minute, can connect at either end, or one at each end, as may be most convenient and expedient. Each connection has six 3½-inch outlets, which can all be used at once, or as many of them as may be desired. The lengths of hose used between the boat and the "connection" vary from 13 to 50 feet.

There are 11 post hydrants on the line, each having three 3-inch outlets with independent valves; each hydrant may be gated off from the line.

By means of a tank on the roof of the Postoffice building, which is supplied from the fresh water system, the hydrants can be flushed out whenever the pipe line pressure is taken off; but it is not intended to flush the pipe itself under ordinary circumstances; being below tide level, it normally will remain filled with salt water continuously.

In the pipe trench, above the pipe, is a 4-inch duct through which the electric system communicates between the fireboats and each hydrant, the signal-box being contained in a small compartment designed to receive it at the back of the hydrant casing. All the gates and mechanism of the hydrants are of composition metal. Where cross-connections occur special strength in the joints is secured by means of straps and tie-rods.

The Boston officials estimated that the 4,000 feet under construction would cost at the rate of $6.00 per foot, including all materials, filling and labor, or $24,000.

In the construction of the Boston pipe line it was necessary to meet one condition concerning which very little data was on record, namely, the effect of salt water upon the valves and connections, for, as has been stated, Boston is the pioneer in this field as far as fire systems are concerned.

In regard to this point Mr. F. A. McInnes, C. E., of the Engineering Department of the City of Boston, has kindly furnished me with results of his researches, from which I have condensed the following general information:

One fact seemed well-established, namely, that iron, composition metal and salt water would prove a disastrous combination if situated as in the ordinary valve or hydrant; a galvanic action would undoubtedly result at the expense of the iron; the valves were, therefore, made of solid composition metal with flanged ends, and were insulated from adjoining pipes by heavy washers or rings of pure rubber. The hydrants are empty when not in use, and the only precautions taken as to them were to separate the composition valve-seat from the iron hydrant-pot by a lead joint, and protect the end of the main valve stem (of Norway iron) by a composition cap making a water-tight joint with the bottom of the rubber foot valve.

Before choosing the material for the pipe a number of cases in the neighborhood of Boston where salt water was pumped through cast-iron pipes were investigated, the history of water pipes subjected to salt water on the outside for many years was studied, and all available data considered.

The conclusion arrived at was that, while cast-iron pipe used for conveying salt water would suffer from corrosion rather more than if fresh water were flowing in it, yet it could be depended upon for a number of years.

No case was found where a pipe had failed where the question involved only cast-iron and salt water, and some were investigated where these conditions existed for more than twenty years.

Important Cases of the Use of Cast-Iron Pipes in Connection With Salt Water.

(1) In 1850 a cast-iron 20-inch pipe was laid from Chelsea to East Boston, about 750 feet of which lies between high and low tidewater, being entirely exposed to the action of the tides. In 1899 this pipe was in a dangerous condition, and had been out of service for some time. It was, however, good enough to carry successfully the supply to East Boston for four days during the past summer (1899). In many places the iron of this pipe can be readily cut by a knife to a depth of perhaps ½ inch.

(2) In 1871 a second cast-iron 24-inch pipe was laid between Chelsea and East Boston; the conditions of exposure are as described above in the case of 20-inch. This pipe is still (1900) carrying the supply for East Boston; it is affected in spots to a depth of about ¼ inch. This could not be termed a dangerous condition yet, but undoubtedly the deterioration has reached that point where wisdom demands a new pipe.

In the case of both the 20-inch and 24-inch from East Boston to Chelsea the lines below low water were laid in a dredged trench and covered up; no break due to the action of salt water has occurred in this portion.

In the case of the older pipe (20-inch) referred to above, it has been necessary to put on several clamps where small holes have developed.

(3) American Sugar Refinery, Granite street, South Boston. Engineer states that they have used salt water through 1,200 feet

20-inch cast-iron pipe for 20 years without a failure of the pipe; they consider that cast-iron is more affected by salt than by fresh water, but that it is undoubtedly good for 25 years with salt water. Specimens of pipe shown that had been in service for 20 years showed very little ill-effects; in places, perhaps 1/16 inch on the inside was soft; pipe always full of salt water.

(4) Squire's pork-packing establishment, Gore street, Cambridge. Mr. Boyer, engineer, states that they have had 1,800 feet 12-inch cast-iron pipe carrying salt water continuously since 1892 with no serious effect upon the iron, usually under 10 to 15 lbs. pressure. At a recent fire the pressure on this pipe was maintained at about 80 lbs. Mr. Boyer would not expect any disastrous results from the action of salt water on cast-iron in 25 years. Pipe always full of salt water.

(5) Quincy Cold Storage Company, Richmond street, Boston. Have used cast-iron pipes for eight years to carry salt water. Frequent examinations have been made by drilling, etc.; up to date the salt water has had no apparent effect on the cast-iron. Pipes always full of salt water. At condensers, where cast-iron and other metals come together, several parts have had to be replaced.

(6) Fitchburg Elevator, Water street, Charlestown. Use composition valves only. Water end of pump with cast-iron valve plate and composition valve seats, spindles, etc.,has been renewed several times in 20 years, and gives more or less trouble all the time. Would advise composition only, unless effective insulation can be made between metals. Engineer has numerous specimens of iron and composition taken out showing destructive action.

(7) U. S. Navy Yard, Charlestown. Assistant Engineer Lyman says that under no conditions would he use anything but Tobin bronze for valves; says action between cast-iron and composition begins practically at once; quoted several cases to prove his assertion.

(8) New England Elevator, South Boston. Fifteen years' experience pumping salt water. In less than a year found the water end of a pump badly used up; the iron in vicinity of composition was eaten away; they have adopted a composition lining for their pumps; they use metallic valves.

(9) Housatonic Elevator. Five years' experience. Have had trouble with the water end of their pump, and are now about to put in a new valve plant. They advocate composition only where it is feasible.

(10) Atlantic Works, East Boston. Mr. Boyd, engineer, is emphatic in recommending composition valves. Government work always calls for them, even in hand valves. He would consider the wisdom of lining cast-iron with composition.

(11) West End Railway, Albany street, Boston. In six years' experience have had absolutely no trouble with cast-iron and com-

position, as ordinarily used in valves, etc. They treat salt water just as they would fresh. Several pieces shown after immersion of five years in salt water to support above.

Under the conditions, with the salt water quiescent when the system is not in use, and with pipe of unusually heavy sections, it seems very possible, says Mr. McInnes, that conditions other than the salt water flowing through the pipe might limit its life. Electrolysis and local conditions surrounding the pipe may prove disastrous. If examination shows that the pipe is being quickly affected by the salt water it will be possible to fill the system with fresh water after service, and to so maintain it until its next use. Mr. McInnes, however, informs me that after two years of use there is no sign whatever of any deterioration either in the cast-iron or the other metals used in the valves and connections.

In my judgment, it is reasonable to expect that a suitable preservative coating can be applied to salt water pipe lines that will thoroughly protect them for many years both from corrosion and electroylsis, and so eliminate this question in the choice of the pipe material and permit of the adoption of wrought-iron or steel, if found more desirable on other accounts.

In the estimates which accompany this report cast-iron has been adopted.

IV.

Efficiency of the Boston Fire Pipe.

The City of Boston has been fortunate in having had no fires within the district served by the pipe line since its completion, and so the system has not yet had a practical demonstration of what it could accomplish, but three service tests of the system have been made with a view of determining its capacity and of familiarizing the fire department with its use.

The results of these tests I am able to put before you through the courtesy of Hon. Henry S. Russell, Fire Commissioner of Boston, and the department officials under his direction.

The first test was made in November, 1898, at a distance of one-half mile from the water front, with one fireboat in service. It proved very satisfactory. The following are some of the results obtained:

Two streams of 1,500 gallons each per minute were played simultaneously through 2½-inch nozzles, with a nozzle pressure of 150 lbs., three lines of 3-inch hose, each 300 feet long, being "siamesed" for each stream. Such an abundance of water could probably only be used to the best advantage at long intervals in actual fire fighting, yet the ability to do work of this kind when the necessity arises is invaluable.

Another trial was made with 1¼-inch nozzles, six independent streams being played, each through 300 feet 3-inch hose, with a total discharge of 2,760 gallons per minute, the nozzle pressure exceeding 100 lbs.

A third trial was made, using three separate lines of 3-inch hose and 1¾-inch nozzles; three very powerful streams were obtained, dispensing 2,200 gallons per minute, with a nozzle pressure of 61 lbs.

In the above trials the object was to determine power rather than capacity and more streams might have been added in each case without falling below a high standard.

The figures above given, while very impressive to those familiar with the subject, are more easily understood by examining some photographs (not reproduced) furnished me through the courtesy of Mr. McInnes. Each photograph represents one phase of the test which are summarized as follows:

Boston Salt Water Fire System, Post-Office Square, November 13, 1898.

No. III.—Three lines of 3-inch hose (each 150 feet long) from one hydrant, with three 1¾-inch nozzles.
Total discharge, 2,150 gallons per minute.
Average nozzle pressure, 60 lbs.

No. IV.—Six lines of 3-inch hose (each 300 feet long) from two hydrants, with six 1¼-inch nozzles.
Total discharge, 2,780 gallons per minute.
Average nozzle pressure, 101 lbs.

No. V.—Six lines of 3-inch hose (each 300 feet long) from two hydrants, "siamesed" into two 2½-inch nozzles.
Total discharge, 2,950 gallons per minute.
Average nozzle pressure, 50 lbs.

The height to which these streams were thrown is not recorded, but the photographs show that they reached higher than the top of an adjacent eleven-story building, with nozzle pressure of 150 lbs. This was for the entire deluge of water; of course, if the power had been concentrated upon a smaller quantity of discharge, a very much higher elevation could have been reached.

On May 7, 1899, a second very complete test was made, a description of which I quote verbatim from a letter addressed to me by Lieut. Greeley S. Curtis, Hydraulic Engineer of the Boston Fire Department, who, in connection with Mr. McInnes, representing the City Engineer's Office, supervised the experiment and recorded the results. Lieut. Curtis says:

"On May 7, 1899, our smaller fireboat (Engine 31) was connected to our salt water pipe system as though it were intended to fight a big fire. After two runs, in which first two, and then three, powerful streams were thrown, a third run was made under the following conditions: Nine streams, each through 100 feet of 3-inch hose, were played simultaneously. Three of these streams were taken from a post hydrant situated on the 12-inch pipe 2,940 feet from the boat connection. These three were 1¼-inch stream.

"Three more lines with 1½-inch nozzles were taken from the next hydrant, which was 285 feet further along the pipe; and the remaining three were 1¼-inch streams from a hydrant about 3,600 feet from the boat. The grade of the sidewalk at this hydrant was about 25 feet above mean low tide.

"The discharge was calculated from the pressures at the nozzles. They showed an average total of just 4,200 gallons per minute, giving an average of 466 gallons per stream.

"To find the number of engines required to throw the same amount of water at fires, I have neglected the capacity guaranteed by builders, and have looked up instead the number of gallons credited to the various engines on my books. Fifty-one such entries, for eight series of fires in the business and manufacturing districts of the city, give a total of 23,740 gallons, or an average of 465 gallons per engine, per minute.

"It is but fair to say that although the two self-propelling engines, one with a fire performance of over 1,100 gallons, are included in the total, yet on several occasions engines are credited with but one stream when they had previously been playing two, and other engines are entered because they were doing noticeably poor work.

"Thus it appears that this fireboat (Engine 31) actually threw as much water as nine engines ordinarily discharge at fires.

"The question whether the fireboat would do as well at a fire as it did at this trial, cannot be answered directly; but the following figures bear on the subject: Our larger fireboat (Engine 44) has a nominal pump displacement of 36 per cent. greater than that of Engine 31. At a lumber-yard fire on December 10 I observed Engine 44, when running at about two-thirds speed, discharging a total of 4,150 gallons per minute. At that time streams were being played from two stand-pipes and two hose lines under a pressure of 103 lbs. at the pumps. The engineer informed me that during the hottest part of fire, the boat had been playing three stand-pipes and four hose line streams at 90 lbs. pump pressure. These conditions would indicate a total discharge of nearly 5,900 gallons, which is about 40 per cent. greater than that of Engine 31 at the trial of the salt water system. The pump pressure maintained by Engine 31, however, was 189 lbs.

"I understand that the fireboat 'New Yorker' has twice the pump displacement of our Engine 31.

"In the comparison of the salt water trial with the average performance of engines an allowance should, of course, be made for the differences in the lengths of lines played through. But if 3½-inch hose of good quality is used to carry the water from the hydrant to the scene of the fire the loss of pressure in the hose will be much reduced. As you are aware, water can be carried about five times as far in 3½-inch hose as in hose just 2½ inches in diameter with the same loss of pressure.

"I send you, under separate covers, a blue print giving the locations and tabulated figures of the trial of May 7, as well as four small snapshots taken at a later trial on October 22, 1899. I am indebted for the blue print and all data respecting the trial of May 7 to the courtesy of the City Engineer's Office."

Photographs of this test also have been furnished me which show very clearly the description and effective character of the different fire streams. Results which they portray are summarized as follows:

Boston Salt Water System. Congress Street, May 7, 1899.

No. VI.—Three lines of 3-inch hose (each 60 feet long) from one hydrant, with three 2-inch nozzles.

Total discharge, 2,940 gallons per minute.

Average nozzle pressure, 59 lbs.

No. VII.—Three lines of 3-inch hose (each 100 feet long) from one hydrant, with three 1½-inch nozzles, and six lines of 3-inch hose (each 100 feet long) from two hydrants, with six 1¼-inch nozzles.

Total discharge, 4,300 gallons per minute.

Average nozzle pressure, 70 to 80 lbs.

No. VIII.—Six lines of 3-inch hose (each 300 feet long) from two hydrants, with six 1¼-inch nozzles.

Total discharge, 2,780 gallons per minute.

Average nozzle pressure, 101 lbs.

It is interesting to note by comparing the above records that a great reduction of pressure is due to an increase in the diameter of the nozzle.

Boston Salt Water Fire System. Practice Trial October 22, 1899.

This trial comprised five brief runs of between four and eight minutes' duration each.

SUMMARY OF RESULTS.

Number of Run	I	II	III	IV	V
Length of Line, feet.......	1,000	1,000	1,000	500	50
Diameter of Nozzle, inches.	1.26	1.57	2.02	2.01	2.02 2.02 1.75
Pressure at Hydrant, lbs...	184	200	190	195	(145)
Pressure at Nozzle, lbs....	61	34	13.3	69	63
Pressure Lost in Hose, lbs.	123	166	177	126	....
Height as Fire-stream, feet.	90	60	(20)	110	100
Gallons per Minute........	364	419	434	984	2,714

In these trials the fireboat was not pushed to more than half its capacity in any run. In the first three runs a single line of 1,000 feet of 3-inch hose was used, and three different-sized nozzles were tried in succession, in order to show the loss of pressure in a long line when large nozzles are used; this loss is given in the summary. The stream in the third run was too feeble to be considered a "fire-stream."

In the fourth run two 500-feet lines were connected to an Eastman Deluge Set, using a 2-inch nozzle. With the same pressure at the hydrant as before, considerably more than twice as much water was thrown by this nozzle than was thrown by a slightly larger nozzle at the end of the single 1,000-foot line. This improvement was due to the two shorter lines of hose being used.

In the fifth run two 2-inch streams and one 1¾-inch stream were played simultaneously from one hydrant, each line consisting of a single length of 3-inch hose. The hydrant pressure in the fifth run was measured at a hydrant some 200 feet beyond the one from which the streams were being taken, and the nozzle pressure at one of the two-inch nozzles.

All of the above hose have 3-inch couplings.

Between the fireboat and the hydrant were over 3,800 feet of 12-inch main, to which the boat was connected by two 30-foot and four 35-foot lines of 3½-inch hose.

The pressure at the fire-boat reached between 200 and 215 lbs. in the last four runs.

The photograph of the 2-inch "siamesed" stream was taken before the fireboat had fully got up speed, so that it shows a less powerful stream than that entered into the summary of the fourth run.

The figures given in the summary for the height of fire-stream are rough estimates. The extreme height of the jet is from 10 to 30 per cent. higher.

The photographs of the practice trial are not so impressive as those of the two other tests, but they show very clearly the effect above noted of the loss of efficiency for fire-fighting purposes due to the use of unduly large nozzles. The photographs show the first four tests given in the summary, and are as follows:

No. IX.—Run No. 1, 1,000 feet 3-inch hose, 1½-inch nozzle, hydrant pressure 184 lbs., nozzle pressure 61 lbs.
Discharge, 364 gallons per minute.

No. X.—Run No. 2, 1,000 feet 3-inch hose, 19/16-inch nozzle, hydrant pressure 200 lbs., nozzle pressure, 34 lbs.
Discharge, 419 gallons per minute.

No. XI.—Run No. 3, 1,000 feet 3-inch hose, 2-inch nozzle, hydrant pressure 190 lbs., nozzle pressure 13.3 lbs.
Discharge, 434 gallons per minute.

No. XII.—Run No. 4, two 500-ft. 3-inch lines, "siamesed" 2-inch nozzle, hydrant pressure 185 lbs., nozzle pressure 63 lbs.
Discharge, 940 gallons per minute.

Much space has been devoted to the results of the Boston tests for the reason that, apart from their valuable character, they are, as far as known, the only experiments that have been made and recorded on a scientific basis of this type of fire protection. They appear to have been made with the greatest care and comprehensiveness, jointly by the Fire Department and the City Engineer's Department, for the purpose of arriving at the actual practical value and usefulness of the system.

So far as known to the writer, Boston is the first American city, if not in the world, to make provision for an official hydraulic engineer as a member of the uniformed working fire force, having the rank of a lieutenant, and responding to the fire alarms for the purpose of exercising general supervision over the mechanical matters of the fire service, thus developing and recording the best results.

This is an example which every city would probably find much profit in following.

V.

PROPOSED SEA WATER PIPE LINE SERVICE FOR NEW YORK.

In the above chapters I have set forth at considerable length the experience gained in other American cities. I have not so far been able to obtain definite information as regards the practice in other countries, but while foreign examples might be instructive as to details of method, they are not needed in this connection, in view of the uniformly satisfactory experiences and demonstrations of efficiency in the various cities we have considered, where the system is applied under such a wide range of circumstances as to cover almost any conditions that could occur anywhere.

The usefulness and substantial value of a fire-pipe system as an auxiliary fire protection for New York would seem to require no further argument, but it may be appropriate, nevertheless, to mention some of the more important considerations involved.

First.—On economical grounds alone, the use of the enormous available power of the city fireboats at fires occurring beyond their limited hose radius would be found to amply justify the expense of installation of the pipe lines. By referring to what has been shown above as to the great loss of pressure due to length of hose, as contrasted with comparative small friction losses in pipe line, it must be apparent that the effective and economical radius of the fireboats is extremely limited. Just what its limit is in a given case, it would perhaps be difficult to determine, but while very excellent work has been done by the New York fireboats where the fire was at least one-quarter of a mile distant from where the boat lay, it is not to be expected that good work could be done at very much greater distances.

At a notable fire in Hudson street, the fireboat "New Yorker," whose capacity is 13,000 gallons per minute, with two sets of pumps, furnished at an average distance of 1,400 feet, a service that was estimated to be equivalent to twenty-five streams from one and one-half-inch nozzles, taking the place on that occasion of the number of fire engines that would have been required to supply a similar number of streams and producing a very much greater effect on the fire.

It is obvious that with a pipe line similar to Boston's, the theatre of action could be transferred as far as Broadway, or even further, and extended within that width of territory indefinitely up and down in a direction parallel to the rivers. These remarks apply not only to the Hudson River and the East River water fronts of New York, but to all the water front of Greater New York, should future developments require it; it is not meant by this that the occasion now exists throughout the whole extent of water front, but merely that such a system could be applied anywhere and everywhere.

The Fireboats.

The germ of the pipe-line system is the fireboat. The Borough of Manhattan at the present time has four fireboats and the Borough of Brooklyn two. Their names and capacities are as follows:

Manhattan.

Name.		Capacity.
"W. F. Havemeyer,"	(Engine 43)..	3,000 gals. per minute
"Zophar Mills,"	(" 51)..	6,800 " " "
"New Yorker,"	(" 57)..	13,000 " " "
"Robert A. Van Wyck,"	..	6,500 " " "

Brooklyn.

Name.	Capacity.
"Seth Low,"	.. 3,500 gals. per minute
"David A. Boody,"	.. 6,500 " " "

The joint capacity of the above equipment of fireboats is 39,300 gallons per minute, which is almost ten times the capacity of the Boston fireboat No. 31 in the test made May 7, 1899, before described.

While the fireboats do magnificent service at the fires directly on the water front, or among the shipping, and are, as experience proves, an indispensable feature of the New York fire service, yet it is a fact that the occasions for their services are so infrequent that for the greater portion of the time they are yielding no return and performing no useful work. Of course, at all times, steam must be kept up and the crew on duty, and the aggregate expense involved, together with interest and deterioration charges, make a very large item in the fire department budget. In common parlance they are "eating their heads off" most of the time, useful and indispensable as they are. Consequently if their sphere of usefulness can be enlarged within reasonable cost, economy would demand its being done.

Second.—A greater size and power of fire streams from this source enables the pipe line to do far more effective work on a fire than is possible with streams from engines. This proposition has been established, I think, by the results already given. Moreover, much of the water of small streams is evaporated in fierce fires when it reaches the flames, and may even in certain situations serve to increase the heat; but a large stream may have sufficient body and momentum to reach the very heart of the fire.

Third.—The opportunity afforded for a roof pipe service which is beyond the reach of the present fresh water supply; also the ability it will afford, if properly designed, to the firemen to reach the top stories of the tallest buildings.

Fourth.—The saving of time in many cases in getting the first streams on a fire. The first precious moments are of more value than are hours later on, and the importance of getting to work at the earliest possible instant cannot be over-estimated. The whole theory and practice of our modern fire department is based upon that truth, and no ways are spared and no effort is thought too arduous to reach the fire in the shortest possible space of time where even seconds are counted. It is, of course, apparent that usually the scene of a fire can be reached more quickly with the hose than by the engines. A pipe line system can be and should be so designed as to make the arrival of the water through the pipe under the required pressure quicker than either.

Fifth.—The ability to concentrate practically unlimited quantities at any point on the pipe line, either in connection with the fresh water supply or alone.

Sixth.—The means it will afford of cleansing streets and flushing sewers at a very moderate cost.

In another chapter of this report the question of adopting salt water for other uses than those above enumerated will be discussed. For the present, consideration will be given to the questions of fire protection and street cleansing. The term "sea water" has been used to designate the proposed supply, for the reason that it is a misnomer to call it river water, except in its local significance, while the use of the term "salt water" is not sufficiently definite.

It is proposed to take the supply from properly constructed in-takes located near the pier heads, sufficiently far beneath the surface at low tide insure reasonably clean conditions.

At present the fireboats obtain their supply directly from the surrounding water as they lie at the bulkhead, their hulls being built with a suction chamber into which the water enters through a large number of small orifices in the outer skin; the suction pipes draw from this chamber.

In the case of the "New Yorker," the suction chamber is in the form of a bay built in the side of the boat having 2,000 holes ½-inch in diameter, through which the water enters.

The effect of this arrangement is to strain the water of nearly all floating foreign substances and that has been found amply sufficient heretofore. But if the fire pipe system should be adopted, it would doubtless be found desirable to attain a higher standard in this particular.

Were it not for the fact that the sewers discharge directly into the river, no special precautions would be needed, as it has been found that the ordinary condition of the river water at points sufficiently remote from the mouths of the sewers is entirely satisfactory. In fact, the swimming pool in the Produce Exchange Building is supplied with clean water taken directly from the river at a point distant about 800 feet from the nearest sewer mouth. The pumping, however, is only done on the flood tide. The water of the Floating Baths is clean. In estimating for the cost of the proposed sea water system, provision is made for protecting the in-takes.

General Features of the Proposed Sea Water System.

It may be said comprehensively that there are no unsolved engineering problems involved in the introduction of an auxiliary salt water supply for New York, but a very careful study of the local conditions now obtaining is necessary in order to properly design the plant.

Certain general limiting considerations can at the outset be laid down to govern the design.

(a) Considered in connection with the use of fireboats, the proposed system divides itself into a number of separate units, each consisting of a main pipe of the maximum length and diameter dependent upon the pumping capacity, with the proper number of branch pipes, hydrants, stand-pipes, fire telegraph service, gates, valves and in-takes, all so designed that the unit forms a complete system in itself adapted to the area which it serves. In other words, it forms what the firemen would call a sea water fire district.

In the parts of the city where the separate units adjoin one another, they should be directly connected, both through the mains and the branches, so as to supplement one another and be so provided with gates at junctions that they could be thrown together and used separately, in whole or in part, according to the requirements.

With the above arrangement, it is obvious that the fireboats could be used separately to supply different pipe line districts or be concentrated upon a particular one should an extensive conflagration call for it.

This arrangement of units would be required irrespective of the number of districts.

(b) Considered in connection with permanent pumping stations, but also depending in part upon the fireboats; the same arrangement as above described would be necessary, but would require in addition larger communicating mains and an adjustment of gates so that the several units served by one pumping station would form a gridiron system.

(c) Should it become desirable to make use of a salt water supply for other purposes than fire protection, street cleaning and sewer flushing, all of which call for an intermittent service only, then the unit system would give place to a universal system in which the supply must be continuously available to the consumers, through constant pumping.

Whatever the extent of the future development, it is apparent that the system in New York should begin with the basis of the fireboats, and, accordingly, I have designed and estimated the cost of the auxiliary salt water supply upon that basis.

In so doing I have proceeded along the following lines:

As a first step, typical fire pipe line districts have been selected. In the adoption of their limits it has been considered important to treat the matter practically, and in harmony with the city fire districts as they now exist.

In my report to the Board of Fire Commissioners I recommended that what is known as the "dry goods district" be supplied with a fire pipe system; as that recommendation was specific, and I have seen no reason to essentially modify it, I here reproduce it.

Former Recommendations.

"I recommend that an experimental main pipe be laid in convenient locality adjacent to the dry goods district; say from the foot of Franklin street, North River, through Franklin street to Broadway, with an intersecting main on Church street from Worth to Canal streets, and a branch on Worth street from Church to Broadway; these pipes forming part of a future system, to be extended, if found desirable, by means of a lateral pipe, south on Church street to Chambers street and Broadway, with east and west branches in intermediate streets.

That a fixed standpipe be provided at a convenient intersection, so designed as not to occupy any of the roadway, to connect the pipe line with a roof service.

That the river end of the pipe be provided with suitable connections for two fireboats.

That the line be provided with the best and most approved hydrants, gates, valves and other appurtenances, built of composition metal; that it be drained into the sewers at the crossings of West Broadway and West street. Also, that it be furnished with the Buffalo type of electro communications, with duplex wiring between each hydrant and the fireboat.

That a positively controlled communication be made between the Croton water mains and the sea water hydrants, so that whenever necessary the latter can be flushed out with fresh water.

The pipe line should be laid as near the street surface as practicable, consistent with the avoidance of vertical bends, on account of other pipes or sewers.

The above specifications are general; before preparing definite plans, careful detailed surveys and explorations of the streets to be occupied will be necessary."

Subsequently the Fire Department prepared a diagram, a copy of which is here subjoined: (See Plate XXVI.). It carries out the recommendation and possesses the added value of being an expression of views from the practical fireman's standpoint, built up on correct theoretical lines.

This diagram covers the area between Chambers street on the south and Canal street on the north; Hudson street on the west, and Broadway on the east. The intervening streets between Hudson street and the water front are not directly reached by the pipe line, as it is considered that this territory, being only about one thousand feet in width at right angles to the river, can be better served by the fireboats direct.

A slight modification from the original plan has been made by placing the branch main on West Broadway instead of Church street, which in some respects is an improvement. The other arrangements remain unchanged from the original recommendations.

The Fire Department also designated an adjoining section extending from Canal street to Bleecker street, from Broadway to West Broadway, and on the west by Houston street, through which the main pipe was projected, leaving the intervening area between West Broadway and the river to be protected by the existing means. If desired, addition branches could be at any time supplied from the Houston street pipe.

In the practical arrangement of the fire hydrants, fire telegraph stations, gates, etc., these diagrams, representing as they do the experience and wisdom of the New York Fire Department, have been adopted by me as a basis for estimating the cost of what I shall term the "first order" pipe line suitable for districts where the fire protection should be of the highest grade of excellence. In other districts, where the requirements are not so rigid, systems of the "second order" or "third order" may prove entirely sufficient; the modifications which distinguish the inferior orders being reduction in size of mains and branches and in the provision of fewer hydrants, the limit of the latter being, roughly speaking, the present practice in the city.

In special localities skeleton lines of main pipes, with few branches, such as compose the Milwaukee system for the most part, will best serve the purpose.

I have made a personal examination of the water fronts of Greater New York, in the endeavor to arrive at some practical basis for a general estimate of what will be required. I do not consider that it would be judicious to introduce the system universally, even in the occupied sections, and in the Boroughs of Brooklyn, Queens, Richmond and the Bronx there are very large districts so remote or otherwise unsuitable that it is questionable whether a general introduction of salt water in such localities will ever be desirable; and certainly, at the present time the idea need not be entertained. Accordingly, I have adopted a method of specific recommendations, with the approximate cost in each case, leaving it for your committee to pass judgment upon the question of the extent of the recommendations.

In the application of the auxiliary supply to the Borough of Manhattan, the question is beset with many difficulties, not only because of reasonable doubts as to the immediate needs of various districts, but also by the uncertainty attached to the state of efficiency of the pipes in the present fresh water system.

In regard to the latter my individual opportunities for research have not been sufficient to enable me to dispose of the question. It is very probable that the investigation which your committee are now having made in that particular direction will furnish the data necessary to either confirm or to disprove the conclusion which I have reached, and which, broadly stated, is that the present fresh water system is so inadequately designed, and probably so impaired by age, corrosion and accident, that the city's modern needs and economy demand the replacement of a very large portion of the present distribution system with new and larger pipes, modern hydrants, and in many cases an entirely different layout of the mains and laterals.

I have before me the Seventeenth Annual Report of the Boston Water Board for the year ending January 31, 1893, in which, among various other matters, are set forth the results of a comprehensive inquiry into the question of the proper capacity of a distribution system for fire purposes. The investigation was made under the direction of the City Engineer, by Mr. Dexter Brackett, M. Am. Soc. C. E., and possesses great value, because it covers the principal large cities of the United States. In this duty Mr. Brackett made a personal inspection of the distribution systems of New York, Brooklyn, Philadelphia, Baltimore, Washington, Pittsburgh, Cincinnati, St. Louis, Chicago, Detroit and Cleveland. The primary object of the investigation was to establish conclusively the relative position of Boston among other cities in the capacity of its distribution system to supply water for extinguishing fires; but incidentally, it contains the material for a similar comparison for each of the other cities named, including New York. The examination was made in 1892, since which time some changes have been made here, but they consist chiefly of additional large mains, by which the system has been very considerably strengthened, and the laterals in the downtown districts practically remain as they were; and this is true in the districts which I have outlined above.

I have extracted from the report some general facts which are of interest to us in this connection and cannot be found elsewhere, and I have also condensed from it the comparative tables opposite.

Table I shows that in 1892, New York City had 423 miles of 6-inch and six miles of 4-inch pipe, out of a total of 685 miles, or 62.5 per cent.; while Brooklyn had 63.6 per cent. of 6-inch pipe. Boston had 42 per cent., Detroit 34 per cent., and Cincinnati 30 per cent. of 6-inch pipe.

Mr. Brackett mentions that pipe less than 6 inches diameter is of very little value for fire protection, a proposition which is amply borne out by experience everywhere. In fact, it may be said without fear of contradiction that in most situations a pipe less than 8 inches diameter is unsuitable for fire protection.

Mr. W. E. Badger and Mr. E. V. French, in their Report Upon the Tests of the Fire System Belonging to the Proprie-

TABLE I.

MILES OF PIPE AND PERCENTAGES OF DIFFERENT SIZES IN USE IN SOME OF THE LARGE CITIES OF THE UNITED STATES, JANUARY, 1892.

Condensed from Report of Boston Water Board, 1893, by Foster Crowell, C. E.

	3-in.	4-in.	4½-in.	6-in.	8-in.	10-in.	12-in.	14-in.	15-in.	16-in.	18-in.	20-in.	24-in.	30-in.	36-in.	40-in.	42-in.	46-in.	48-in.	Total. Miles.	% less than 6-in.	% less than 8-in.
New York.	—	6.2	—	422.6	—	1.2	168.4	—	—	3.2	—	37.9	2.2	7.9	21.6	—	—	—	14.3	685.5	—	—
Per cent.	—	0.9	—	61.6	—	0.2	24.6	—	—	0.5	—	5.5	0.3	1.2	3.1	—	—	—	2.1	—	0.9	62.5
Chicago...	3.2	203.9	—	580.8	242.1	5.1	78.9	3.3	—	36.8	—	1.7	33.9	1.0	14.3	—	—	—	0.3	1205.3	—	—
Per cent.	0.3	16.9	—	48.2	20.1	0.4	6.5	0.3	—	3.1	—	0.1	2.8	0.1	1.2	—	—	—	—	—	17.8	65.4
Philadelphia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1001.6	—	—
Per cent.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn..	—	0.7	—	286.3	77.9	—	35.9	—	—	2.1	—	19.7	—	6.4	8.9	—	—	—	12.1	450.0	—	—
Per cent.	—	0.2	—	63.6	17.3	—	8.9	—	—	0.4	—	4.4	—	1.4	2.0	—	—	—	2.7	—	0.2	63.8
St. Louis..	11.9	1.9	—	239.1	10.5	9.8	40.9	—	10.2	—	—	25.8	—	7.1	10.6	—	—	—	0.2	368.0	—	—
Per cent.	3.2	0.5	—	65.0	2.9	2.7	11.1	—	2.8	—	—	7.0	—	1.9	2.9	—	—	—	—	—	3.7	68.7
Boston.....	—	24.0	—	216.0	59.5	8.3	147.0	—	—	13.2	—	11.3	11.0	10.9	4.0	4.4	—	—	4.8	514.4	—	—
Per cent.	—	4.7	—	42.0	11.6	1.6	28.6	—	—	2.6	—	2.2	2.1	2.1	0.8	0.8	—	—	0.9	—	4.7	46.7
Baltimore..	108.7	126.6	13.8	64.2	6.3	35.8	11.7	—	—	7.2	1.2	22.1	—	10.5	5.3	7.4	—	—	—	420.7	—	—
Per cent.	25.8	30.1	3.3	15.3	1.5	8.5	2.8	—	—	1.7	0.3	5.2	—	2.5	1.2	1.8	—	—	—	—	55.9	74.5
Cincinnati.	11.1	91.7	—	85.9	12.6	45.6	3.9	—	—	6.3	—	17.9	1.2	0.1	4.8	0.7	—	0.7	0.1	282.6	—	—
Per cent.	3.9	32.4	—	30.4	4.5	16.1	1.4	—	—	2.2	—	6.3	0.4	0.1	1.7	0.2	—	0.2	—	—	36.3	66.7
Cleveland..	2.7	23.9	—	187.4	58.0	21.6	5.7	—	—	5.4	—	3.3	2.9	14.5	7.9	—	—	—	—	333.3	—	—
Per cent.	0.8	7.2	—	56.2	17.4	6.5	1.7	—	—	1.6	—	1.0	0.9	4.3	2.4	—	—	—	—	—	8.0	64.2
Pittsburgh.	—	52.0	—	95.6	23.4	6.0	10.6	0.3	7.0	1.0	—	8.0	1.8	5.2	6.3	—	—	—	0.7	217.9	—	—
Per cent.	—	23.9	—	43.9	10.8	2.7	4.8	0.1	3.2	0.5	—	3.7	0.8	2.4	2.9	—	—	—	0.3	—	23.9	67.8
Washington	5.5	24.0	—	142.0	1.1	2.3	14.5	—	—	—	—	3.8	0.5	6.2	4.3	—	—	—	5.6	209.8	—	—
Per cent.	2.6	11.4	—	67.7	0.5	1.1	6.9	—	—	—	—	1.8	0.2	3.0	2.1	—	—	—	2.7	—	14.0	81.7
Detroit....	15.9	150.3	—	135.1	35.8	18.3	0.7	—	—	4.9	—	0.1	13.9	9.3	0.1	—	8.5	—	—	392.9	—	—
Per cent.	4.0	38.3	—	34.4	9.1	4.7	0.2	—	—	1.2	—	—	3.5	2.4	—	—	2.2	—	—	—	42.3	76.7

tors of the Locks and Canals at Lowell, Mass., in 1897, give the results of experiments on 20-inch, 16-inch, 12-inch and 8-inch mains which warrant the conclusion that nothing smaller than 8-inch should be used, even for short lengths.

Bearing this in mind, a study of Table I shows very clearly the comparative value of the distribution pipe systems of the different cities.

Table II shows the hydrant conditions in the different cities, with the number and size of their hose connections.

"The efficiency of a system for fire protection," says Mr. Brackett, "depends not only upon the size of the mains, but also on the number and capacity of the fire hydrants. If, as in some of our large cities, the hydrants used are of small capacity with a single outlet, allowing of but one steamer connection each, and spaced from 300 to 500 feet apart, the efficiency of the system is much diminished by the inability to concentrate a large number of steamers near any given point. To perform effective service, the steamers should not be obliged to use more than 500 feet of hose to reach the fire. With a line of 2½-inch hose of 600 feet in length, a water pressure of 120 lbs. at the steamer will give an effective fire stream about 60 feet above the ground, and will discharge 240 gallons per minute, while with 100 feet of hose the same pressure will give an effective stream of 94 feet in height and discharge 340 gallons per minute. It is, therefore, of great advantage to have the hydrants of large capacity so located that a large number of streams can be placed within a short distance of the fire. In Brooklyn, the hydrants have but one outlet or hose connection. In New York, 80 per cent. of the hydrants have but one 2½-inch outlet, and all the hydrants set there during the past year (1892) were of this pattern."

Table II shows the hydrant conditions in the different cities, with the number and size of hose connections.

The above report did not deal with the question of pressure capacity in the different cities, and I am not in possession of accurate figures in regard to what working pressures are possible in New York City distribution, especially in the older portions of the city.

But it may safely be inferred that the system is far below the modern requirements in this respect. Mr. John R. Freeman, M.

TABLE II.

NUMBER OF HYDRANTS AND FIRE RESERVOIRS IN USE IN DIFFERENT CITIES.*

	Number and Diameter of Hydrant Nozzles.												Fire Reservoir Connected with Main.	Total Number of Hydrants and Reservoirs.	Hydrants per Mile of Distribution.	Total Number of Hydrant Nozzles.	Hose Connections per Mile of Pipe.
	One 2-in.	One 2½-in.	One 3-in.	One 4-in.	Two 2½-in.	Two 3-in.	Two 2½-in. 4-in.	Three 2, 2½-in. 1, 4-in.	Two 4-in.	Three 2½-in.	Three 1, 2½-in. 2, 4-in.	Four 2, 2½-in. 2, 4-in.					
New York	—	6,825	—	—	—	—	1,927	—	—	—	—	—	—	8,752	12.8	10,679	15.6
Chicago	—	2,739	—	—	6,328	—	—	2,203	566	—	—	—	87	11,923	9.9	23,397	19.4
Philadelphia	—	3,696	—	1,032	—	—	—	—	2,408	—	969	—	—	8,105	8.1	12,451	12.4
Brooklyn	—	4,538	—	—	—	—	—	—	—	—	—	—	—	4,538	10.1	4,538	10.1
St. Louis	—	—	3,715	—	—	—	—	—	—	—	—	—	—	3,715	10.1	3,715	10.1
Boston	—	1,191	—	—	—	—	—	1,467	—	—	—	3,024	238	5,920	11.5	18,402	35.8
Baltimore	—	—	—	—	—	—	—	1,359	—	—	—	—	—	1,359	3.2	4,077	9.7
Cincinnati	—	—	1,530	—	—	223	—	—	—	—	—	—	300	2,053	7.3	2,876	10.2
Cleveland	200	—	—	—	3,490	—	—	134	—	—	—	—	—	3,824	11.5	7,582	22.7
Pittsburgh	—	500	—	986	—	—	—	—	250	—	—	—	—	1,736	8.0	1,986	9.1
Washington	—	—	—	—	300	—	—	—	—	600	300	—	—	1,200	5.7	3,300	15.7
Detroit	—	—	—	1,768	—	—	—	—	200	—	—	—	439	2,407	6.1	3,485	8.9

* From the Report of Boston Water Board, 1893.

Am. Soc. C. E., a very high authority on the subject of fire streams, gives the minimum desirable hydrant pressure at from 80 to 90 lbs. In the present conditions, it is not at all probable that such working pressure is attainable anywhere in the City of New York.

The conclusions seem to be warranted, then, that in order to provide an effective and economical fire protection in connection with the present water supply a very large expenditure would be necessary in providing a new system of pipes, and, if that conjecture is correct, it is obvious that if the auxiliary sea water supply should be introduced its extension over a very large portion of the territory now imperfectly supplied with the fresh water would not only be justified, but might prove very desirable, leaving the present system of pipes to be used chiefly for domestic service.

In order to treat the subject conservatively, and in such a manner as will permit of an intelligent comprehension, I have estimated the cost of an auxiliary sea water system in that part of the city lying below Twenty-third street, and extending from river to river, and also computing the cost of separate districts, so that your committee can consider the question with reference to all or only to portions of that area.

The method of computation adopted has been to make an exact estimate, based upon present prices, of the costs of the system for typical districts, ascertain the proportionate cost per unit of superficial area, and thus obtain co-efficients which can be readily applied to other "first order" districts.

In the same way the proportionate cost per surface unit for lesser degrees of fire protection have been arrived at, and their co-efficients obtained.

In order to be able to present accurate figures of cost, I have obtained estimates from the manufacturers of various kinds of apparatus required, and the results may be relied upon as a close approximation; while in regard to labor items, the estimate has been framed with due regard to the very costly character of the work of pipe-laying, building manholes, readjusting pipes and sewers, and other features, due to the crowded and unsystematic arrangement of all sorts of sub-surface constructions underlying our streets.

It is, of course, out of the question to make an exact estimate of that feature of the work in the absence of detailed information, much of which can only be obtained after the work itself is begun, but it is believed that the average cost is fairly represented in the prices which have been assumed.

Detailed estimates will be found in Chapter X, giving respective costs of

(a) Typical Sea Water Fire Protection System of the First Order, with 14-inch supply main, 12-inch secondary mains and 8-inch connections and standing pipes. Hydrants with three hose connections and one steamer connection. A special manhole for each hydrant, containing the valves for control and air-escape. System gated so that it may be concentrated in localities as desired, and provided with special electric communication at each hydrant. Covering the area bounded by Chambers street, Broadway, Canal and Hudson streets, with supply main on Franklin street. Three fireboat connections.

(b) Fire Pipe System of the First Order for the adjoining district on the north included between Canal street, West Broadway, Bleecker street and South Fifth avenue, with main on West Houston. Dimensions and appurtenances as above described.

(c) Estimate for a Second Order System for the same section as (b), using 12-inch supply main and 10-inch secondary mains, other fixtures the same as above.

(d) The cost of introducing First Order for protection from Chambers street to the Battery.

(e) The Cost of the Second Order System from Chambers street to the Battery.

(f) Cost of Third Order System, with a Fixed Pumping Station, from Division street to Houston street, Bowery to East River.

(g) Cost of introducing the Fire Pipe System generally, south of Twenty-third street.

(h) Interest and depreciation.

(i) Annual cost of operation of (a).

(j) Annual cost of operation of Steam Fire Engines.

(k) Cost of Pumping Station and annual cost of its operation.

Remarks Upon a General Installation of Fire Pipes South of Twenty-Third Street.

The entire area south of Twenty-third street, and extending from river to river, now covered by fire protection is 2,919 acres, as given in the Fire Department Reports, of which about 500 acres can be reached directly from the fireboats, leaving in round numbers 2,400 acres to be covered by the proposed fire pipe system, the cost of which, as will be seen by reference to the estimates, is about $1,000 per acre, making the entire sum about $2,400,000, exclusive of fixed pumping stations.

The average annual fire losses in this portion of the city, as shown by the Fire Department Reports for 1894, 1895, 1896 and 1897 (figures for 1898 and 1899 not at hand), are $2,454,227.

We may say, therefore, that the present cost of installing the improved system would not exceed the money loss by fire for one year, leaving out of consideration the loss of life.

VI.

Possible Use of Sea Water for Street Washing and Sewer Cleansing.

The use of water, either salt or fresh, for systematic street cleansing, has not heretofore been practiced in American cities, or at least to an extent which throws much light upon the subject.

In New York City we are familiar with the decided advance in street cleaning which has come about within the past few years, but although, comparatively speaking, the results show an immense improvement over the former conditions, still they fall very far short of providing clean streets in the true sense of the word and are attained at a very great cost.

There is no doubt that a higher standard of cleanliness can be reached at a reduced cost by resorting to a system of street washing and scrubbing in addition to the sweeping, scraping or brushing which they now receive.

Without a copious and cheap water supply, the frequent washing of the streets would be impracticable, especially in dry seasons, when needed most, and when the fresh water supply should be carefully husbanded to guard against a scarcity for other purposes.

With a pipe line service, the supply available for the streets would be practically unlimited, and if the fireboats could be used systematically for this purpose, as well as for fire protection, the cost would be very small.

But, in order to insure the regular periodic delivery for street cleaning, without the danger of interruption of the work because of fires occurring in other parts of the city, it would be found necessary to provide special pumping plants for the purpose.

An estimate of the cost of such provision will be found in its appropriate place.

Assuming for the present that the cost will not be found prohibitive, we may profitably study the other features of the problem in the light of what has been accomplished elsewhere.

This consideration divides itself into two questions:

(a) The use of water in street cleaning.

(b) The effect of salt water vs. fresh.

The practice of washing pavements has, in this country, usually been confined to the sidewalks. In comparatively few cities abroad it is used for cleaning the roadways.

In London, Paris, Berlin and Glasgow some of the streets and public places are systematically washed; particulars in regard to them will be found below. So far as I have been able to learn, roadway washing has not yet been resorted to in Brussels, Munich, Cologne, Turin, Genoa, Vienna, Budapest and Birmingham, although in those cities the standard of street cleaning is generally high.

Experience in London.

In response to a request which I made to Sir Alexander Binnie, Chief Engineer to the London County Council, I have received through him from Mr. D. J. Ross, Engineer to the Corporation of London, copies of reports which contain all the information which is at present forthcoming upon the subject of street washing in London.

Mr. Ross, in a letter of January 4, 1900, says in answer to my categorical question: "I regret, however, to state that I have no observations with regard to the quantity of water per surface unit required to properly wash asphalt pavements, as the quantity used is not recorded separately for each street. The work is done entirely by the Corporation's own staff, and different streets are at times washed as their condition and the state of the weather renders necessary."

A study of these reports shows under the head of Street Cleaning, Street Watering and Washing, Dusting and Removal of Trade Refuse, that the carriageway pavements, when the weather permits and their condition renders it useful to do so, are washed by means of jet and hose. This, in the city, can only be done late at night, when there is scarcely any carriage traffic. The streets were last year more frequently washed than they had been in previous years. In the winter months, when this washing can be most usefully employed, great discretion is needed in using the water on account of the possibility of frost occurring.

The courts and alleys inhabited by the poorer classes were cleaned daily by the scavengers, and were also washed with jet and hose, some twice and some three times a week, between May and October, many more courts having been washed than formerly was the case.

This is in addition to the daily sweeping of the carriageways and the squeegeeing of the main thoroughfares in wet weather, two or three times during the day, and what is known as the street-orderly system for the immediate removal of droppings, etc., which is carried out in all main thoroughfares as well as in some of the secondary ones.

The quantity of water used for washing the streets and courts was as follows:

In 1896.................... 24,169,642 gallons.
In 1897.................... 26,329,666 gallons.

The number of nights when the washing was done was about 260 in each year, an average of five nights per week. This amounts to 100,000 gallons per night.

Street pavement washing, although regarded by London authorities as of transcendent importance, has only been applied so far to the "City," which occupies a central area covering only about one square mile, with a night population of only about 37,000, but whose day population is about eight times that much, while more than one million persons enter it on every weekday, and its street traffic amounts to nearly one hundred thousand carriages per day.

It can be said that the London authorities consider that the washing of the pavements is a necessary process in a crowded city if it is to be kept clean.

Experience in Glasgow.

Glasgow, one of the most progressive cities in point of the excellence of its municipal administration, waters the streets very thoroughly and regularly washes by means of hose the courts and other public places.

From the latest report that I have been able to obtain, by Supt. D. McColl, it is learned that the watering of the streets is resorted to during the night, for the purpose of preventing dust arising from the operations of the sweeping machine, as also when the streets are in such a pasty condition as to render machine sweeping difficult. A plentiful supply of water for this purpose is obtained from the fireplugs throughout the city.

Experience in Berlin.

In Berlin, the use of water in connection with the street cleaning operations is a very important element.

In Waring's report of observations made in the summer of 1896 occurs the following quotation from the Annual Report of Street Cleaning in the City of Berlin, 1895:

"The first principle in sprinkling is that all the streets that are regularly swept be also regularly sprinkled. * * * * The expression 'regularly' sprinkled means that the streets must be sprinkled twice a day, and under certain circumstances three or four times, as may be required.

"An exception is made with regard to asphalt pavement. Asphalt ought really to be kept dry, since that is best for carriages and traffic. This cannot be done, however, on account of the fact that cannot be made clean without a liberal water supply, since horse manure, when it gets dry, does stick to asphalt and cannot be removed during dry weather unless it be previously soaked and scraped off. An ordinary amount of sprinkling would, therefore, not be sufficient on asphalt streets. They must be flushed. After this has been done squeegees are used to scrape off the remaining dirt, and at the same time dry off the asphalt; otherwise, same would be slippery."

In Berlin, as well as in the neighboring town of Charlottenburg, experiments have been made by authorities with sweeping and washing machines. The information which I have received as to the economy of such machines is conflicting, Charlottenburg having reported a very great saving, while Berlin officials state that, although they have provided an equipment of the combined sweeping and washing machines, they do not regard their operation as satisfactory.

There can be no question, however, whatever may be the fact in regard to the machine experimented with, that the use of water in connection with street cleaning is essential for good results.

In an article on Road-washing Machines by Dr. Th. Weyl in the "Gesundheits Ingenieur," August 31, 1899, p. 253, the great importance, from a sanitary point of view, which is now attached to the thorough cleansing of road surfaces is insisted upon, and attention is called to the unsatisfactory methods which at present prevail of removing dust and other accumulations from public highways. He describes the two mechanical system now in use for road-washing and watering; in one the work is done by revolving brushes, which merely collect the dry dust, and the watering forms a subsequent process; in the other the dust, as it is swept up by brushes, is previously moistened by water supplied from a receptacle, and the road is cleaned and watered at one operation. The plan of dry-brushing has enormous disadvantages, he says, and has been sharply criticised by experts; as, for instance, at the Madrid Congress in 1898. The advantage of a process by which both operations of watering and sweeping are combined cannot fail to be recognized. The author concludes that, from hygienic, administrative and financial considerations, the use of a machine of this nature is worthy of recommendation.

Experience in Paris.

The washing and flushing of streets is more extensively practiced in Paris than in any other city of the world.

As in the other municipal departments, the technical service for the proper care and operation of the street-washing system is very well organized, and the practice is, in many respects, a model for other cities.

In order to secure the latest and most reliable details on this subject from the fountain-head, I addressed a communication to my friend, Mr. Ernest Pontzen, corresponding member in Paris of the Am. Soc. C. E., enclosing a series of categorical questions framed to elucidate the leading points, which I requested him to transmit to the particular Parisian official who was best qualified officially to impart the desired information.

I received a very courteous reply stating that my letter had been handed to M. Bechmann, Ingenieur en Chef des Ponts et Chaussées, Chef du Service, Eaux et Assainissement, from whom I subsequently received a very valuable note prepared in the Water Department under his direction, giving very careful and full answers to the questions propounded.

As this note is really a compendium of the present Paris practice in regard to the use of water in the streets, I have translated it and reproduce it here in full, with the English equivalents:

Note on the Sprinkling and Washing of the Paris Streets: Quantities of Water Employed.

The water furnished in the public streets service of Paris for the operations involved in the care of the roadways is employed: First, in flushing the gutters; second, in washing and sprinkling the carriageways.

The sidewalks are neither washed nor sprinkled, with the exception of a few gravel sidepaths or bridlepaths, which are sprinkled in the summer-time, and which it is not worth while to include.

First.—Flushing the Gutters: The greatest quantity of water consumed is used in flushing the gutters (the developed length of which is 1,760 kilometres, equivalent to 1,093 miles), which constitutes a normal and regular operation of the street cleaning service; altogether in Paris there are 7,763 taps for street washing, which are opened daily for a period which varies according to the seasons, the developed length of the gutter served, the average length of which is 230 metres (equivalent to 755 feet), the volume of the street traffic, or the proximity of omnibus stations or of cab stands.

It varies also according to the nature of the roadway; asphalt, for instance, requiring less washing than other pavements, because less mud accumulates upon it.

The duration of the flushing averages about one hour per day, in two applications, with a minimum of 20 minutes in some places, and a maximum of 1½ hours in others.

The discharge is 108 litres (equivalent to 27 gallons) per minute from each outlet.

The outlets are not made use of during the freezing weather (25 days in each year).

The number of separate washings in a day is from two to three in the very largest avenues, two in the medium avenues, and one only in the ordinary streets.

The quantity of water consumed in that manner averages 25 litres per linear metre of gutter (equivalent to 2 gallons per linear foot).

Washing and Sprinkling the Roadways.

The washing and sprinkling of the roadways is accomplished in two ways: with the sprinkling cart and with hose.

The first method is confined generally to the narrow and less important streets; exception is made, however, for those streets upon which there is a very great traffic, like the Grand Boulevards, where the employment of the hose apparatus is not feasible except very early in the morning; watering by the sprinkling carts requires less quantity of water; the water carts are filled by means of special hydrants, of which there are 283.

The watering with the hose is accomplished by means of hydrants of a particular model, of which the number is 6,883 for the whole of Paris, or else by means of ordinary hydrants arranged with couplings for the hose. The allowance of water per square metre is greater by this means than with the sprinkling cart.

(a) Washing.

The wooden pavements are washed frequently; in the wide streets every day or two, or three times a week, according to their importance; in second streets, only once a week. The washing is done between 4 and 9 o'clock in the morning, and is done throughout the entire year excepting in freezing weather (25 days during the year).

The stone pavements are washed less frequently, excepting in the case of very much frequented streets; but, as the tendency is more and more towards providing all such with wooden pavements, the average of one washing per week may be taken.

The macadam pavements do not need washing except in damp and rainy weather, in the intermediate seasons, the spring and fall, when they will require one washing per week; in the other seasons sprinkling is sufficient, if thoroughly done.

The asphalt pavements, which retain less dust than either the wooden or the stone, require, because of the danger of slipping on their surface, one or two washings per week on the average.

(b) Sprinkling.

The street sprinkling varies greatly, according to the seasons and the nature of the roadways. Generally those pavements which have been washed in the morning will not need to be sprinkled until noon; in the spring and fall two light sprinklings in the course of the afternoon are often sufficient, but in the summer certain of the wooden and stone pavements must be sprinkled repeatedly up to five or six times.

The following table gives a résumé of the average daily allowance of water per square metre for the different orders of pavements; also, per square yard:

TABLE III.

PARIS DAILY WATER ALLOWANCE FOR STREET PURPOSES.

From the Official Records, 1899.

Translated and Adapted by Foster Crowell, C. E.

Nature of Pavement.		Flushing the Gutters.		Washing and Sprinkling the Pavements.			
				With Carts.		With Hose.	
		Per Lin. M. Litres.	Per Lin. ft. Gals.	Per Sq. M. Litres.	Per Sq. yd. Gals.	Per Sq. M. Litres.	Per Sq. yd. Gals.
Wood	Min.	20	1.6	0.10	0.02	0.75	0.165
	Max.	30	2.4	1.80	0.40	7.00	1.54
	Mean	25	2.0	0.70	0.16	2.40	0.53
Stone	Min.	20	1.6	0.03	0.07	0.50	0.1
	Max.	30	2.4	1.50	0.33	5.70	1.25
	Mean	25	2.0	0.53	0.12	1.50	0.33
Macadam	Min.	20	1.6	0.05	0.01	0.05	0.01
	Max.	30	2.4	1.80	0.40	9.00	2.00
	Mean	25	2.0	0.90	0.20	2.40	0.53
Asphalt	Min.	15	1.2	0.03	0.006	0.03	0.006
	Max.	25	2.0	1.50	0.33	4.00	0.88
	Mean	20	1.6	0.50	0.11	0.90	0.198

The information above given is the result both of our personal experience and from records of work furnished in 1894 by the Department of Public Streets, and continued by the Department of Water Distribution daily to 1889.

PARIS, January 10, 1900.
L' Inspecteur Adjoint,
(Signed) J. VIBERT.

Approved and transmitted by the undersigned Water Inspector.

PARIS, January 10, 1900.
(Signed) BAUTETUER.

I also received an interesting letter from M. Bechman, in which he states that in addition to the water used for sprinkling and washing pavements as set forth in the above report, there is a very large daily quantity consumed in flushing the sewers.

He states that the Paris sewer system, including altogether about 1,100 kilometres (equivalent to 682 miles), is supplied with

3,200 flushing tanks with automatic siphon discharge, each supplying from four to ten cubic metres per day, which would require an average daily supply of about 25,000 cubic metres, equivalent to nearly six million gallons per day.

This serves to give a graphic idea of the extent to which these important measures for public health and comfort are carried out in Paris.

Experience in Cleveland.

In the City of Cleveland water is used for flushing both asphalt and block stone pavements, with the following results, which have been kindly communicated to me by Mr. Edward Cowley, Superintendent of Streets:

The water is supplied to the Street Department by the City Water Works Department at a cost of 5 cents per 1,000 gallons; the outfit used is a 2½-inch hose, from 200 to 400 feet in length, shifted from one fireplug to another as the case may require; a small three-wheel dolly is used under each connection to prevent the hose from chafing on the pavement, with a horse to pull; the shifting is done by three men.

The cost is about as follows, viz.:

Three Men, at $2.00, 9 hours................	$6.00	
One Horse and Wagon......................	2.75	
One Foreman	3.00	
Say, for Water............................	2.00	$13.75

The force will flush about 400,000 square feet in the above time, and consume about one gallon of water per square yard. Three flushings per week are required.

The expense is about 35 cents per square (10,000 square feet), as against average price of street sweeping in Cleveland of 50 cents per square, a saving of 30 per cent., and the results are far more satisfactory, as far as dust in concerned. Good block stone pavement with cement joints requires less water and is less expensive to clean than the asphalt, says Mr. Cowley in conclusion, as there is more tendency for fine dirt and sediment to stick to the latter.

VII.

SEA WATER *vs.* FRESH FOR STREET PURPOSES.

All the above information bearing on street-washing and sprinkling is based upon experience with fresh water.

In our present consideration it is necessary for us to proceed a step farther to inquire into the question of what would be the effect of using salt water, upon the health and comfort of the people and horses, and upon the durability of the pavements.

As for the first question, we may safely assume that there is no reason for the belief that clean sea water would be at all injurious either to human beings or to animals, if used copiously in washing the streets. On the contrary, there is reason to expect that such use of salt water would be beneficial in itself, and be more effectual for the purpose than fresh water.

The testimony of owners and managers of ocean steamship lines, which is based upon their own experience with the use of salt water on their ships, is unanimously in favor of the supposition that no harm could possibly follow in its use in the streets.

In regard to the effect upon materials of asphalt pavements and their durability, pains have been taken to obtain the expert views of a number of gentlemen engaged in the asphalt paving business.

I quote briefly from their replies:

From the Barber Asphalt Paving Company.

Mr. P. W. Henry, Assoc. M. Am. Soc. C. E., Vice-President and Manager Barber Asphalt Paving Company, says: "In regard to the action of salt water on asphalt pavements, we would state that neither salt nor fresh water has any action on asphalt pavements, unless allowed to act continuously upon the surface, so that it is always wet; and that under such conditions, salt water acts less injuriously than fresh. As far as this company is concerned, we see no objection to cleaning the asphalt pavements by the flushing process, and would be inclined to favor it."

From the Warren-Scharf Asphalt Paving Company.

Mr. S. Whinery, M. Am. Soc. C. E., Vice-President Warren-Scharf Asphalt Paving Company, says: "In relation to the action of salt water on asphalt pavements, experiments have shown conclusively that fragments of asphalt pavement immersed in a solution of common salt and water retain their original condition for a much longer period than when immersed in fresh water. While I am not aware of any instance where salt water has been used for washing asphalt pavements, there is every reason to believe that it will be decidedly preferable to fresh water for the purpose."

From the Brooklyn Alcatraz Asphalt Company.

This company says: "In our opinion, salt water could be used without any injurious effects on asphalt streets."

From the Sicilian Asphalt Paving Company.

The Sicilian Company state that they have hitherto made no investigations in regard to the action of either fresh or salt water.

From the New York Mastic Works.

Mr. T. Hugh Boorman, Manager of the New York Mastic Works, states that he has no reason to doubt that the effect of salt water on asphalt pavements would be precisely the same as fresh water.

From Cranford & Co., Asphalt Pavements Contractors, Brooklyn.

Cranford & Co. say: "The investigations made by our company in connection with this matter consist of observing the action of salt on asphalt when in continuous contact. We have found most invariably that where asphalt pavements have been laid in front of ice-cream manufacturing establishments, where the pavement is kept saturated with salt water, there has been a rapid deterioration of the pavement. While we hardly think the salt water used in the way of flushing the streets would have a very serious effect upon the pavement, still we should much prefer not to subject the pavement to its action."

From the Atlantic Alcatraz Asphalt Company.

This company replies: "As far as it has come under our observation, the use of salt water for flushing asphalt streets has no deteriorating effect; in fact, we think it immaterial whether salt or fresh water be used."

It will be seen from the above testimony that the opinion in regard to the harmless effect of salt water is unanimous with one exception, the opinion of Messrs. Cranford & Co., and that their objection is based upon the effect of salt in a mixture with ice, which is a producer of intense cold, besides containing a large amount of free salt. These conditions are so very different from those under which sea water would be applied that we may safely consider that the other opinions quoted are not contradicted by it.

In regard to the effect upon horses of the use of salt water in the street, an objection has been urged in some quarters growing out of the injurious action noticed on the hoofs of the street-car horses in former times, when salt was used profusely as a means of melting the snow upon the tracks. These conditions were undoubtedly very severe, both from intense cold and from the astringent effect of the concentrated brine in which the horses' feet were practically pickled.

Pure sea water contains usually not more than three per cent. of salt in solution, and the quantity of salt in the North and East rivers is even less than this.

This, in consideration with the fact that water used for street washing would not usually flood the streets to any appreciable depth, would seem to dispose of the question so far as injury to animals is concerned.

An objection may be raised on the score of possible injury to the rubber tires of automobiles and bicycles. I believe it to be a fact that there would be ground for this objection if sea water was the only injurious element to be considered in this connection, but it may confidently be urged that the advantage of having perfectly clean streets would outweigh, in this consideration of the subject, the deteriorating effect of the salt water upon the tires, which at the worst would not be nearly so injurious as the injury which comes from the greasy mud that is to be universally encountered unless the streets are kept scrupulously clean.

Any theoretical objection on the above score would largely be eliminated by the adoption of the plan in Paris and London of washing the streets at night or in the very early morning hours, and it is thought that any resulting damage to the tires that might result from the use of salt water for sprinkling the streets would be much more than compensated by the superior conditions of the traction obtained.

The use of salt water for street sprinkling is not a novelty. Many of the seaport towns in England have made use of sea water for this purpose for years, and it is probable that the same is true of other countries, although no reliable statistics in regard to them have so far been collected.

In this country, a few cases are on record. Formerly, as I am informed, the streets of Cambridge, Mass., were sprinkled with sea water exclusively for a period of many years. This was before Cambridge had a public supply of fresh water. Subsequently, the use of salt water was discontinued, excepting for occasionally short periods of insufficiency of the fresh water supply.

The present Chief Engineer of the City of Cambridge advises me that about fifteen years ago salt water was largely used there for street sprinkling, and he considers it more efficacious and better in every way, it having been discontinued for financial reasons when the city procured an increased fresh water supply, which cost less than salt water pumped by hand into the watering carts, as had been the practice. He adds that they are now considering the question of a separate supply of salt water for this purpose.

I am informed by the City Engineer's Department of Boston that salt water was exclusively used for street watering in parts of Boston previous to 1891. In that year the city took charge of all the watering and a change was made from salt to fresh water purely from financial reasons, as in the case of Cambridge, just cited.

H. H. Carter, Superintendent of Boston Streets, 1891-4, says that he never heard of any complaint of salt water, considers it more efficient than fresh water for the purpose, and did not make the change in 1891 on account of objections to the use of salt water.

Chas. Harris, the present Boston agent of the Barber Asphalt Company, formerly Superintendent of Streets in Boston, 1864-1883, used salt water while Superintendent; considers it much better for macadam or block pavement, and estimated that one portion will do as much as three of fresh. He thinks it not so well suited to asphalt, at least some experience of his with salt water and tar concrete leads him to think so; he, however, confesses that the Barber Asphalt people in New York think the reverse is true with regard to salt water and asphalt. Had more or less complaints of damage to varnish of carriages, etc., and thinks that bicycles would suffer to some extent.

H. K. Potter, agent and inventor Studebaker watering cart, considers salt water much better than fresh; has had a number of years' experience in watering streets with salt water in Boston; knows of no serious objection; for macadam and block pavements it is undoubtedly superior to fresh water; in the case of asphalt, the question of slipperiness enters, unless care is taken in the use of water, and this trouble will occur more readily in the case of salt water. It is harder on varnish, bicycles, &c., than fresh water, but if the sprinkling and watering be carefully done, no serious objection could be made. Has at different times talked with a number of veterinary surgeons and horse-shoers, but has never been able to find that salt water injures the feet of horses. Generally it was satisfactory; occasionally had complaints in regard to horses or carriages. He believes it desirable from a sanitary point of view.

Mr. Proctor, Mayor of Somerville, Mass., watered streets in Boston with salt water for ten years; considers it better than fresh under all conditions of pavement. Only intelligent work is needed to overcome any objections in regard to damage to varnish. The use of salt is beneficial to the feet of horses, and thinks that contrary opinion has arisen from the use of salt in *winter time* by street railways, &c. Considers salt water an advantage from a sanitary point of view. Had at times complaints of damage to varnish, but was never called upon to pay any bill for such damage. In a long dry spell, salt water must be used with great care, as it forms a coating or crust which is apt to get slippery on smooth surfaces.

A writer in the American Architect and Building News, of August 18, 1895, on the use of salt water in cities, states that the returns from seventeen English coast towns where salt water is used for sprinkling purposes, show that the macadam street surface had gradually become cementized and greatly improved in smoothness, wearing capacity and greater absence of dust and that the mortality had decreased.

In 1895, the Olympic Salt Water Company was incorporated for the purpose of introducing sea water in San Francisco, offering to the city free of cost all the salt water needed for sprinkling purposes in sections supplied by their mains.

San Francisco Experiments With Salt Water.

The Merchants' Association of San Francisco, in response to my request for information as to what had been accomplished in that city, replied that they have for several years strongly advocated the use of salt water for street sprinkling and made a number of experiments in that line. They enclosed a copy from the Report of their Supt. Mr. L. M. King, in 1897, giving an account of the experiments referred to and a copy of a very instructive article upon the subject, printed in the *Merchants' Association Review* of July, 1898, by Mr. Jos. D. Grant, the Director of the Merchants' Association. They also make reference to a previous report by Mr. Ernest McCullough, then Consulting Engineer of the Association, based upon the experience with the use of salt water in a number of English cities, and stating that salt water was being used successfully in all these cities except one, the City of Hastings, in which the opposition from the old fresh water company was so strong that the use of salt water had been abandoned. The names of these cities are as follows:

Great Yarmouth,	Birkenhead,
Hastings,	Worthing,
Eastbourne,	Brighton,
Blackpool,	Ryder,
Ryhl,	Torquay,
Margate,	Plymouth,
South Shields,	Tynemouth,
Barrow-in-Furness,	Ilfracombe.

The quotations from the above sources are introduced below, as they have a very practical bearing on the question of salt water sprinkling.

The results of the movement in San Francisco for the use of salt water are summarized by the Association in the following language:

"Two of our macadamized streets have been sprinkled with salt water for some time with great success. The principal obstacle in the way of its general use in this city is the fact that at present the salt water mains and hydrants cover only a few streets in the city.

"Plans are now being considered for a system of salt water mains through the business portion of the city for the purpose of extinguishing fires, and, if carried out, street sprinkling by salt water will, no doubt, be adopted."

Supt. King states, after describing the details of the experiments:

"The difference between fresh and salt water sprinkling is very marked, and the results attained so far were all that were anticipated. Salt water, when used for sprinkling, has the following advantages over fresh:

"First.—It binds the dirt together between the paving stones so when dry there is no loose dust to be raised by the wind.

"Second.—It does not dry so quickly as fresh water, and it is claimed in those cities which use salt water that one load is equal to three of fresh water. The correctness of this claim is not being studied by the experiments made.

"Third.—The salt water which is deposited on the street absorbs moisture from the air during the night, so that during the early morning the street is thoroughly moist and has the appearance of having been freshly sprinkled. This effectually prevents a dust being raised by the wind or street sweeper before the regular sprinkling carts can get over the ground in the morning and thus overcome one of the great nuisances.

"Fourth.—It is more healthful than fresh water for the reason that salt water will destroy many disease germs now contained in the dirt in our streets.

"The above advantages are particularly noticeable on a portion of Market street, where the north side and center of the street between the tracks are sprinkled with salt water, while the south side is sprinkled with fresh water. Along the north side and center, the dirt is compactly bound together, is always moist between the stones so that there is never any dust raised there, and during the early morning that portion appears as though partly sprinkled. The business men along that portion of the street should observe and compare the two sides of the street."

The article by Director Jos. D. Grant, after summarizing the experiments above referred to, states:

"Every seaside city in Europe that sprinkles the streets at all, uses salt water, and the use of sea water for that purpose is increasing. For example, selected at random, the town of Great Yarmouth, in England, decided in 1886 to erect a pumping plant to obtain sea water for street sprinkling purposes.

"In 1892 (after five and one-half years of use), the Borough Engineer reported that much more sprinkling and sewer flushing was done than had been done with fresh water; and that where the town had previously used seven million gallons per annum of fresh water at a cost of 24 cents per one thousand gallons, it now only used five million gallons of salt water at a cost of 5 cents per thousand gallons." In other words, the salt water cost only one-seventh as much as fresh.

The results, as summarized, are as follows:

1.—The cost of maintaining macadamized roads was decreased about 15 per cent. There is no evidence that roads were made stronger or built up, but there was less dust, and, therefore, less tendency for the worn surface to blow away.

2.—There were no complaints of dust.

3.—No complaints were received from storekeepers or of injury to goods. Some jewelers had even asked for an extension of the sprinkling service.

4.—By watering late on Saturday night, the watering of streets on Sunday was rendered unnecessary.

5.—No increase in slipperiness of the streets was noted.

With respect to sewer flushing, the findings are:

1.—Its specific gravity was a great advantage.

2.—It prevented the generation of sewer gases, and all former stenches disappeared.

3.—The sewers had less deposits than when fresh water was used.

4.—No injurious effects have been noticed on the cements and metals in the sewers.

5.—No evil effects have yet been traced to the sulphates in the water.

The article also states that salt water is better than fresh water for flushing sewers, on account of the sanitary effect, citing the fact that along the streets where the Lurline Bath empties its water the neighborhood is freer from infectious diseases than any other part of the city, as proven in the reports of the Board of Health. Salt water is preferable to fresh in both sanitary and economical aspects, and has no detrimental effect on bituminous pavements.

The article also quotes a report to the Merchants' Association by Prof. Price as to the relative effect of salt and fresh water upon pavements and upon public health. The conclusions are unqualifiedly in favor of salt water.

I have also received a letter from the J. D. Spreckels Bros. Company, of San Francisco, stating that the Olympic Salt Water Company has given the city authorities free use of salt water for sprinkling the Park roads and some of the principal streets in the city, with highly satisfactory results.

Experience in Coronado and San Diego.

Salt water has been used for several years on the streets of Coronado, California, and Mr. E. S. Babcock, President of the Coronado Beach Company, writes me that its use has been satisfactory in every way.

In 1898 the City of San Diego considered the introduction of sea water, and consulted me in regard thereto. Experimental sprinkling there has proved very satisfactory, and will, no doubt, be used regularly on all streets traversed by the street-car lines. In this case, the salt water is handled by a tank car.

Experience in Oakland and Alameda.

Salt water has been used in Alameda, California, for street sprinkling to a large extent, and with unqualified success, which has led her sister city of Oakland to take up the proposition of providing a separate distributing pipe system, with pump, reservoir, hydrants, etc., to supply salt water exclusively for street sprinkling purposes.

An elaborate report on a salt water plant for street sprinkling by Mr. M. K. Miller, C. E., Superintendent of Streets, to the City Council of Oakland has recently been adopted, and soon is to be submitted to a vote of the people to provide funds for its execution.

The report states: "Experience has proven the great economic value of salt water for street sprinkling purposes. The salt contained in sea water when evenly distributed over the surface of a macadamized street, forms an incrustation, which retains the moisture and thoroughly cements together the particles of macadam. One sprinkling with salt water is equal in effect to three or four with fresh water. In fact, after a street has been sprinkled with salt water for a few days it becomes so thoroughly hard and cemented that it can go for several days without sprinkling, and without any injurious results. The macadam is not only preserved, but all the finer particles of dust upon the street are incorporated with the incrustation of salt, and even upon a windy day scarcely any dust is noticeable. This will affect a very considerable saving in the cost of street repairs and street cleaning, and it will at the same time prevent the growth of weeds in the gutters and greatly reduce the quantity of dust and dirt which accumulates along the curbs. This will certainly reduce the cost of gutter cleaning at least 25 per cent."

"At least 96 out of 100 miles of macadamized streets in older Oakland will be served with salt water under this plan."

Very complete estimates of cost form part of this report, which, though they are not applicable to the New York conditions, being for a low pressure distribution of water for street sprinkling only, show a great reduction in the cost of sprinkling over present system, and large savings in repair of streets, street cleaning and sewer flushing.

Mr. Miller's figures show that the annual economic value of salt water sprinkling is nearly eight times as great as the annual cost of operation, including interest and deterioration.

Particular attention is called to these statements because, as mentioned elsewhere in this report, there is a large mileage of macadam roads in the Boroughs of Queens, Richmond and the Bronx, and this material will, in all probability, continue to be used for very many years to come. If proper care be taken the expense of maintenance of these roads would be moderate, and their use entirely satisfactory to the public; but under present conditions no systematic care is exercised, the roads quickly wear out; the expense of maintenance is enormous, and their use by the public, instead of being a cause of satisfaction, becomes extremely unpleasant because of the deterioration of the surface and the frequent dusty condition.

Watering Macadam Roads.

The proper care and economical maintenance of macadamized roads calls for a liberal use of water, salt water being better for the purpose than fresh. In the Borough of Manhattan the use of macadam is generally confined to the park drives, there being only 19.5 miles of macadam streets, which are well cared for; but in the other boroughs there are many miles of expensive macadam highways that are at present rapidly going to destruction because no provision is made for watering them.

In the Borough of Queens especially, which covers an area larger than the Boroughs of Manhattan and Brooklyn combined, all the improved roads are macadamized with the exception of Long Island City streets and one avenue leading to Jamaica from East New York. But, excepting in favored localities, there is no suitable provision for watering, and a very large mileage of the roads is at present too rapidly going to destruction. Moreover, the present water supply is limited and very expensive.

Throughout the North Shore region and near Jamaica Bay there are a number of pumping stations located not far from tidewater which could be supplemented and connected with a system of sea water fire pipes on the main highways, with branches in the villages, thus solving inexpensively the problem of the maintenance of the roads, and settling the more important question of fire protection throughout those portions of the borough. (See Map, Plate XXV.)

A word of explanation may be necessary here. At present throughout the Borough of Queens the old system of volunteer fire companies which existed prior to the creation of Greater New York is still in force, and it is recognized that to extend the operation of the paid fire department over this vast territory presents practical and economical difficulties. Moreover, many localities are devoid of a public water supply.

VIII.

Cooling the Streets.

At the beginning of my investigation it was suggested that, in the possible event of the general use of sea water for street cleaning purposes, the cooling of the pavements in very hot weather might be accomplished by copious flushing, and thus decrease the death rate and the accompanying sickness, a very important consideration, especially for congested districts.

I was accordingly requested to take up the investigation of this question in connection with the broader lines of inquiry and to include in this report, if possible, figures to show what could reasonably be expected to be accomplished in cooling the pavements, provided a sufficient supply of sea water could be afforded for that purpose.

In order to arrive at intelligent results, it is necessary to know both the specific heat values of pavements and the relative rapidity of cooling. It is apparent that if we can determine those figures and the prevailing temperature of the sea water during hot spells, and ascertain the maximum temperature reached in the pavements, the problem is easily susceptible of an exact theoretical solution.

But, practically, the subject is not a simple one because it is complicated with other considerations, such as the radiation of heat from buildings, the duration of the application of sea water and other local effects.

It is, therefore, impracticable, in the light of present knowledge, to dispose of the matter theoretically, and the conclusions that may be reached must be regarded as tentative and as indicative only of possibilities in this direction.

To secure the best results attainable, I have sought to obtain from experts in the making and care of pavements, exact data of temperature observed and the experiments made in this direction.

One of these gentlemen is Mr. A. W. Dow, Inspector of Asphalt and Cements in the office of the Engineer Commissioner of the District of Columbia, to whom I am greatly indebted for valuable information.

Mr. Dow has furnished me the results of experiments on the temperature of asphalt pavements compared with other pavements when exposed to the heat of the sun's rays, and also showing the relative rapidity of cooling. The three classes of pavements compared were sheet asphalt, asphalt block and gravel roadway. The investigations were made in a place where the three classes of pavements intersected and always received the same amount of sunshine and under the same conditions in every way. The point on any one pavement where the temperatures were taken was situated sufficiently far enough from the other pavements to insure their proximity not influencing the results, which are given in the following table:

TEMPERATURE OF PAVEMENTS: TAKEN TO SHOW HEAT ABSORBED FROM THE SUN.

WASHINGTON JULY 3, 1898.

	2 P. M. Far.	9 P. M. Far.
Temperature of air in shade	104	89
" of air in sun	115	—
" 2 ft. over gravel roadway	113	93
" on surface of gravel roadway	128	98
" 2 inches in gravel roadway	124	112
" 2 ft. over asphalt block pavement	114	90
" on surface of asphalt block pavement	112	94
" 2 inches in asphalt block pavement	124	104
" 2 ft. over sheet asphalt pavement	112	92
" on surface of sheet asphalt pavement	132	98
" 2 inches in sheet asphalt pavement	140	118

The pavements were all exposed to the sun when the temperatures were taken at 2 P. M., but the thermometer bulbs were shaded.

Experiments were made in regard to the loss of heat by the same three pavements at 4 P. M. on a sunny day to 8 A. M. the next morning. The temperatures in this case were taken by means similar to those of the 3d of July, except that no temperatures were taken on the surface of the pavement.

The record show the fall in temperature in the pavements themselves and in the atmosphere over the pavements of the three kinds of roadways enumerated in the above table. The asphalt sheet pavement cools somewhat more rapidly than the others, but the drop is very slow in all three and reaches its lowest point, about 66 degrees, at 3 A. M. and remains practically stationary at that elevation until 7 A. M., when there is another slight drop of about one degree in the next hour, notwithstanding that the air temperature was at that time rising, indicating the sluggishness of action of the material and its large powers of heat retention.

Through the courtesy of Mr. P. W. Henry, Vice-President and General Manager of the Barber Asphalt Paving Company, I have been furnished with a report by Mr. Clifford Richardson, Director of the New York Testing Laboratory, at Long Island City, who has had much practical experience in regard to asphalt pavements.

Mr. Richardson says:

"In reply to these inquiries, I would say that I have made extensive experiments and similar ones have been made by Dr. Wallace, Chemist of the Warren-Scharf Asphalt Paving Company, and Mr. Dow, Inspector of Asphalts and Cement, D. C., in reference to temperature of asphalt pavement in summer. From the results published in the report of the Engineering Department of the District of Columbia, for the fiscal year ending June 30, 1898, it appears that the highest true asphalt pavement temperature on a day when the air was 106 Far. in the shade of a tree three feet from the ground, was 126 deg. Far. This was in the mixture between the surface and one-half inch below it. The temperature at lower depths I have not determined.

"A fair measure of the possibility of temperature of an asphalt surface on summer days can be determined from observations of what is known as a solar radiation thermometer.

This consists of a thermometer bulb, blackened with soot, and enclosed in a globe exhausted to a high vacuum. Observations of such thermometers in New York show that the highest temperature which an asphalt pavement has reached in our experience is 129.5 on September 10, 1897."

It will be observed that the highest asphalt temperature established in New York by the above method does not equal the highest temperature of the sheet asphalt actually observed in Washington.

Mr. Richardson goes on to say in answer to my inquiries that the specific heat of asphalt pavements has never been determined by his Bureau of Tests. The chemist of the Warren-Scharf Company, who has made some rough experiments, had informed him that he found it not to differ greatly from that of sand. This is reasonable to suppose, for the reason that 90 per cent. of an asphalt pavement is sand or similar mineral matter. The specific heat of an asphalt pavement can be roughly determined from the known specific heat of sand, which is .190, and the assumed specific heat for the bitumen of asphalt, of .7589. This would give a specific heat considerably higher than that determined by experiment, but it must be remembered that the paving is not entirely a solid mass. Mr. Richardson thinks it probably contains about 8 per cent. of voids, which are filled with air and must be taken into account. He says that he has never undertaken to make any exact determination, but thinks it would be fair to assume that the specific heat of asphalt pavement would be about .21 to .25.

The latter figure has been adopted by me in the computation which follows as being conservative, in the absence of a more exact determination.

It is not known how far beneath the surface of an asphalt pavement the maximum degree is found, but the experiment in Washington, having been made at two inches below the surface, gives warrant for the supposition that the entire mass of asphalt composition is represented by that figure. To make the calculation consistent it would be necessary to introduce also the value of the temperature of the concrete foundation, in regard to which we have no data; but, in view of the low conductivity and sluggishness of action of the asphalt, it is not at all likely that the temperature of the concrete ever goes very high, so that the question of cooling applies in an important sense only to the thickness of the composition.

In endeavoring to ascertain the facts regarding the sea water temperatures along the city water fronts, I was confronted by the entire absence of any systematic records.

It is a part of the routine of the naval vessels to record temperatures of the water when at sea, but in port this is not done.

The U. S. Coast and Geodetic Survey does keep the record of water temperature at various points on the seacoast, but not at a point sufficiently near to be of value in this connection.

In the Produce Exchange Building there is a swimming pool supplied with sea water, which is pumped from the North River in the vicinity of Pier "A," and, although no systematic record of the temperature has been kept, the thermometer is constantly used to ascertain the temperature in the pool, and from the attendants I learn that during the summer months the temperature of the sea water frequently rises above 70 degrees Fahr., but has never been known to exceed 76 degrees. Its usual summer figure does not vary much from 70, and that has been taken in the computations.

Quantity of Water Required for Cooling Streets.

Taking, then, the specific heat of an asphalt pavement at .25, the temperature of the same at 120 degrees Fahr. and the temperature of the sea water at 70 degrees Fahr., I find that for equal weights the water has the capacity of cooling the asphalt to the temperature of 80 degrees Fahr., while for equal volumes the temperature of the asphalt might be brought down to 86.2 degrees. That is to say that, provided the surroundings were of a temperature no higher than that of the water, and excluding the element of time, a sheet of water as deep as the asphalt is thick would be required to bring the temperature of the pavement down to 86 degrees. But the element of time cannot be excluded, because, as has been shown, it would require quite a long period for the heat to pass out of the asphalt and into the water, and there would be a loss from evaporation. If the temperature of the surrounding objects and atmosphere were at the same time higher than 70 degrees, the water would be absorbing heat of radiation and convection, which would increase the quantity of water required.

The additional amount required would vary according to the atmospheric temperature and other causes. I have assumed that it would amount to at least 25 per cent., so that it may be said that the surface of an asphalt pavement of the usual thickness would require to be covered to a depth of three inches, and the water allowed to remain upon it, in order to reduce this temperature from 120 to 86 degrees.

The above, of course, is merely a figure of expression, for it obviously would not be practicable to inundate the streets in such a manner; but reference to the figures make it apparent that a thin sheet of water passing rapidly over the pavement from a sprinkling cart or a hose would not have time to absorb its quota of heat, consequently it is evident that a very much greater quantity of water would be required in this application than in the case we have assumed.

But it may with truth be said that such a degree of cooling would not be necessary, and that a very grateful relief from the glare and heat can be obtained by absorbing and carrying away only the ambient heat imparted to the atmosphere in the vicinity of the pavement. That there is an immediate effect that can be explained in this way is quite evident to anyone, although some of it is undoubtedly due to the evaporation of the water, and is comparatively of short duration. Nevertheless, even the lowering of the surface temperature a very few degrees will by contrast impart the sensation of relief, and remove danger of sunstroke which may have been imminent.

In this connection it is instructive to note the cooling effect of a summer shower which occurred on a hot day in Washington, while tests of an asphalt pavement were being carried on by Mr. Richardson, who has kindly furnished me with the results as follows:

TEMPERATURES OF ASPHALT PAVEMENT.

	Before Shower. 2:15 P. M.	After Shower. 4:30 P. M.	8 P. M.
Air in shade	108	92	84
Black-bulb Thermometer in sun	122	—	—
Air three inches above pavement	122	101	86
Below surface of asphalt pavement	126	111	98

A comparison of this table with Mr. Dow's plainly shows the sudden drop of 15 degrees in the temperature of the pavement produced by the shower.

We may adopt the conclusion, without attempting to estimate the extent to which the process of street cooling should be applied, that it would be extremely desirable to be able to apply it when most needed, and that, with a copious supply of cool sea water at other times of the day for other purposes, it would prove inexpensive and highly salubrious to make use of it for this purpose.

In Chapter X will be found an estimate for an experimental fire pipe line of the third order, with a fixed pumping station, extending from Division to Houston streets, and from the Bowery to the East River, with constant supply of sea water both for fire purposes and street uses.

IX.

Possible Use of Salt Water in Office Buildings and Industrial Establishments.

Heretofore, so far as has been developed in the course of this inquiry, no use has been made of salt water for any purpose in office buildings, but the question naturally suggests itself as to whether, in the event of the opportunity being afforded by the proposed auxiliary pipe system for the city to supply the sea water at reduced rates, there would be a demand for it.

As this would constitute an entirely new departure from the present practice, it cannot be treated from the standpoint of experience, but must be reached in some other way.

The purposes to which salt water might be put in industrial establishments are more numerous than at first appear. The chief of its more obvious uses is for the purpose of cooling steam condensers and beer vats. For these two purposes salt water is already often used in favorable locations, but, so far as known, always in connection with private pumping plants. There is no doubt it is applicable for such purposes. In office buildings it could not be used for lavatory purposes, and its chief, if not its sole, use would be for the flushing of water closets and urinals.

As theoretical conditions might weigh heavily in this consideration, I have attempted to obtain light on this division of the subject by propounding a series of questions calling for categorical answers, which have been sent to the representatives of all the different lines with offices in New York City, for the purpose of obtaining their experience and an impression of their views upon the probable desirability of the use of salt water for the purposes which have been above outlined.

Answers to these questions have been received from the following:

	Name of Line.	Agent.
1.	HAMBURG-AMERICAN LINE	EMIL L. BOAS
2.	NORTH GERMAN LLOYD	OELRICHS & CO.
3.	ANCHOR LINE	HENDERSON BROS.
4.	WHITE STAR LINE	W. M. SMITH
5.	NEW YORK & TEXAS S. S. CO	MALLORY & CO.
6.	HUDSON RIVER DAY LINE	E. E. OLCOTT
7.	PANAMA R. R. S. S. CO	W. J. HERRON
8.	ATLAS S. S. CO	PIM, FORWOOD & KELLOCK
9.	CARTER, MACY & CO.	
10.	RED D. LINE	BOULTON, BLISS & DALLETT
11.	OLD DOMINION S. S. CO	JAMES A. SMITH
12.		KUHNHARDT & CO.
13.	QUEBEC S. S. CO	A. E. OUTERBRIDGE & CO.
14.		FUNCH, EDYE & CO.
15.	HOLLAND-AMERICAN LINE	J. W. WIERDSON
16.		BUCK & KEVONS
17.		T. HOGAN & SONS
18.	AMERICAN MAIL S. S. CO	DAVID C. REID
19.	CUNARD S. S. CO.	
20.	N. Y. & PORTO RICO S. S. CO	MILLER, BULL & KNOWLTON
21.	COMPAGNIE GENERALE TRANS-ATLANTIQUE.	
22.	RED CROSS LINE	EDMUND RUKS & CO.
23.	N. Y. & PACIFIC S. S. CO	W. R. GRACE & CO.
24.	COMPANIA TRANS-ATLANTICA	J. M. CEBALLOS & CO.
25.	AMERICAN LINE	INTERNATIONAL NAV. CO.

Following are the categorical questions, with a classification of answers received in each case:

Question 1.—Is Sea Water Used Upon Your Vessels for Flushing Closets and Urinals?

Answers.—Twenty-four in the affirmative and one in the negative, the exception being in the case of the Atlas Line.

Question 2.—If So, Is It Used to the Exclusion of Fresh Water?

Answers.—Twenty-three state that salt water is exclusively used for the above purpose, one that it is exclusively used when the steamer is at sea, and one, the Atlas Line, as before, answers negatively.

Question 3.—Is Its Use Followed by Disagreeable Resulting Odors?

Answers.—Twenty-three agree that there is no disagreeable odor; one adds that as a disinfectant it is preferable to fresh water; one line uses disinfectants.

Question 4.—Are Special Fittings and Connections in Piping Required on Account of the Salt in the Water?

The answers vary in detail, but all agree that the plumbing is, or should be, of the heaviest and best material for either salt or fresh water, and most of them agree that either brass or copper fittings, with lead-lined tanks, should be used, although some state that no special fittings are required, but only separate pipes and fittings. On the other hand, some of the important lines, such as the Hamburg-American Line and the North German Lloyd and the White Star Line, answer the question in the negative.

Question 5.—What Daily Quantity Per Capita Approximately is Used for the Above Purpose?

Answers.—The answers to this question are stated variously. Some state that no account is taken of the quantity; others give the total consumption of water without attempting to specify the number of uses. The reason for this is that on board ship special pumps, or else fire pumps, are kept running continuously for this supply and no record is made. The answer of the Hamburg-American Line states that 225 gallons of water per hour for one closet and urinal are required, if running continuously. It was thought that the answers to these questions would throw some light on the question of proper consumption, but, owing to the circumstances, they do not.

Question 6.—Is Sea Water Used Inside for Washing and Scrubbing, Woodwork, Paint, Etc.? To What Extent?

Answers.—On this point the practice varies. A num- of the lines do not use salt water for inside scrubbing, but a number of them do; among them the Panama Railroad S. S. Co. say that they use it exclusively, with special soap. The American Mail S. S. Co. answer affirmatively, as does also the White Star Line; the latter adds that work is usually afterward washed with fresh water. The object for including this question was to bring out the fact whether a tendency was to avoid the use of salt water in confined situations. Answers, though not conclusive, indicate that there is no objection to salt water for this purpose, other than its unsuitability for especial purposes.

Question 7.—In Your Judgment and Experience is the Use of Sea Water for the Above Purposes Detrimental to Health or Otherwise Objectionable?

Answers.—Messrs. Oelrichs & Co. say: "No; on the contrary, our captains consider the use of sea water for the purpose for which it is used on board our steamers to be healthy." The Panama Railroad S. S. Co., whose steamers sail to the tropics, say that on board ship the use of salt water is decidedly advantageous in every way, and is certainly not detrimental to health.

All the other answers are positive that it is not detrimental to health or objectionable, with the exception of the Atlas Steamship Co., which does not answer directly, as it does not use salt water.

Question 8.—Would You Consider a Similar Use of It Objectionable in Office Buildings on Land?

Answers.—In the opinion of Messrs. Oelrichs & Co., there would be no objection whatever.

Mr. Boas, General Manager of the Hamburg-American Line, says there would be no objection if clear sea water could be obtained, and not muddy water close to the piers on the borders of the Hudson. Messrs. Henderson Bros. think that salt water would be preferable for the purpose.

The White Star Line says that pure sea water would not be objectionable. Thinks river water would require filtering.

Messrs. Mallory & Co. say there would be no objection excepting that salt water tends to soften paint. E. E. Olcott thinks there would be no objection, because of his experience with it on the Hudson River day boats. The agent of the Panama Railroad S. S. Co. does not consider that the use of salt water in office buildings would be objectionable.

Messrs. Pim, Forwood & Kellock say they are not prepared to offer an opinion.

Messrs. Bolton, Bliss & Dallett say there would be no objection, if the plumbing be adapted to it.

The Old Dominion sees no objection.

Kunhardt & Co. state that they are unable to say positively, but do not consider it would be objectionable.

Messrs. Outerbridge & Co. say there would be no objection, if sufficient quantity of salt water is used.

Messrs. Funch, Edye & Co. answer, "No;" but they think the matter ought to be put before the Board of Health.

The Holland-American Company see no objection, provided pure sea water can be obtained; and all the other answers say unqualifiedly that there would be no objection.

It is clear that there is no serious diversity of opinion, as expressed in the above answers, on the part of the only class of persons who have had practical opportunities of observing in regard to this question.

The qualification made by some of them that the salt water must be clean and pure is well taken, and is, in fact, a necessary and fundamental requirement.

In order to sound the views that might be entertained theoretically by the owners and agents of office buildings on this subject, and to ascertain whether the idea would be favorably received, at least, a set of questions was formulated, answers for which are being sought by canvassers, who, under the direction of your committee, are collecting information in regard to the general questions of water consumption.

Although it seemed desirable to make this inquiry, it does not seem probable that the replies will throw very much light on the willingness of the business community to adopt an auxiliary supply of salt water for some of the possible purposes, for the reason that most business men would very naturally prefer to wait for a more developed stage in the matter, and not to commit themselves, even theoretically, in advance.

The asking of the questions, however, may produce inquiry and discussion, and thus lead to a basis for conclusions as to whether this feature of the subject is at present of sufficient importance to be considered practically.

X.

Estimates of Cost.

For convenience of reference the detailed estimates are grouped together, and will all be found in this chapter, the figures of cost in the other parts of the report being in all cases based upon them.

Specification.—First Order System.

Fourteen-inch cast-iron supply main, 12-inch cast-iron secondary mains, and 8-inch cast-iron standing pipes and connections, tested individually to a pressure of 600 lbs. per square inch with a line test of 400 lbs. and working pressure of 180 lbs.

Hydrants with three hose connections and one steamer connection, with rubber-faced solid gates and 6-inch secondary gates. A special manhole opposite each hydrant. System gated so that it may be concentrated in localities as desired, and provided with special electric communication near the hydrants. Connections for three fireboats.

All the hydrants, valves and connections are designed with protective features against electrolysis and galvanic action. Distance between hydrants averages 150 feet. First-class material and equipment throughout.

Second Order System.

Twelve-inch cast-iron supply main, 10-inch cast-iron secondary mains, and 8-inch cast-iron standing pipes and connections. In all other respects the specification is the same as for the First Order.

Third Order System.

Twelve-inch cast-iron supply main, 8-inch cast-iron secondary mains, and 8-inch cast-iron standing pipes and connections. The distance between hydrants is greater than in the First Order, varying according to local circumstances. In all other respects the specification is the same as for the First Order.

It will be seen that there is no great saving accomplished by reducing the size of mains.

Estimate of Cost.

(a)

First Order Fire Pipe System, Chambers Street to Canal Street, Hudson Street to Broadway.

1,500 Tons Straight Cast-iron Pipe	$30	$45,000
40 Tons Specials	50	2,000
174 Hydrants	60	10,440
15 12-inch Gates	95	1,425
2 14-inch Gates	110	220
3 8-inch Gates	30	90
2 14-inch Check Valves	100	200
4 Relief Valves	20	80
174 Air Escape Valves	4	696
2 Blow-offs	50	100
198 Manholes	24	4,752
30,600 lin. ft. Laying	1	30,600
73 Telegraph Posts and Instruments	12	876
18,000 lin. ft. Telegraph Cable and 2 ½-inch Iron Pipe and Drawing Wire..........	25c.	4,500
2,000 Joints	5c.	100
Intake and Fireboat Connections		4,921
Engineering and Contingencies		4,000
Total		$110,000

(100 acres; $1,100 per acre.)

Estimate of Cost.

(b)

First Order Fire Pipe System, Canal Street to Bleecker, South Fifth Avenue to Broadway.

1,526 Tons Straight Cast-iron Pipe	$30	$45,780
42 Tons Specials	50	2,100
142 Hydrants	60	8,520
22 12-inch Gates	95	2,090
2 14-inch Gates	110	220
2 14-inch Check Valves	100	200
4 Relief Valves	20	80
142 Air Escape Valves	4	568
2 Blow-offs	50	100
168 Manholes	24	4,032
27,040 lin. ft. Laying	1	27,040
57 Telegraph Posts and Instruments	12	684
20,000 lin. ft. Telegraph Cable, 2 ½-inch Pipe Pipe and Drawing Wire...............	25c.	5,000
2,500 Joints	5c.	125
Intake and Fireboat Connections		4,921
Engineering and Contingencies.............		3,500
Total		$104,060

($1,150 per acre.)

Estimate of Cost.

(c)

Second Order Pipe System, Same Territory as (b).

1,200 Tons Straight Iron Pipe	$30	$36,000
30 Tons Specials	50	1,500
142 Hydrants	60	8,520
22 12-inch Gates	95	2,090
2 14-inch Gates	110	220
2 14-inch Check Valves	100	200
4 Relief Valves	40	80
142 Air-Escape Valves	4	568
2 Blow-offs	50	100
168 Manholes	24	4,032
27,040 lin. ft. Laying	1	27,040
57 Telegraph Posts and Instruments	12	684
20,000 lin. ft. Telegraph Cable, 2 ½-inch Pipe and Drawing Wire	25c.	5,000
2,500 Joints	5c.	125
Intake and Fireboat Connections		4,921
Enginering and Contingencies		3,500
Total		$94,580
($1,050 per acre.)		

Estimate of Cost.

(d)

First Order Pipe System, Chambers Street to the Battery.

System similar in all respects to (a) or (b) $300,000
($1,100 per acre.)

Estimate of Cost.

(e)

Second Order Pipe System, Chambers Street to the Battery.

System similar in all respects to (c) $275,000
($1,000 per acre.)

Estimate of Cost.

(f)

Third Order Pipe System with Fixed Pumping Station, from Division to Houston Streets, Bowery to the East River.

12-inch Supply Mains on Division, Grand, Mangin and Houston Streets and the Bowery.
8-inch Secondary Mains on intermediate north and south street.

3,800 Tons Straight Cast-Iron Pipe, at	$30	$114,000
100 Tons Specials	50	5,000
340 Hydrants	60	20,400
4 12-inch Gates	95	380
80 8-inch Gates	30	2,400
2 12-inch Check Valves	100	200
4 Relief Valves	20	80
340 Air-Escape Valves	4	1,360
2 Blow-offs	50	100
432 Manholes	24	10,368
92,600 lin. ft. Laying, at	1	92,600
170 Telegraph Posts and Instruments	12	2,040
70,000 ft. Telegraph Cable, and 2 ½-inch Iron Pipe and Drawing Wire..............	25c.	17,500
7,000 Joints	5c.	350
Intake and Fireboat Connections		4,921
Engineering and Contingencies.............		5,000
Total		$276,700
Pumping Station as per Estimate (k)........		50,000
Total		$326,700

310 acres; $1,054 per acre.)

Estimate of Cost.

(g)

Cost of Introducing a Fire Pipe System Over the Territory South of Twenty-third Street, Borough of Manhattan.

Total area south of Twenty-third Street, river to river	2,919 acres
Deduct area that can be reached directly from the fireboats	519 "
Area of Proposed Fire Pipe System	2,400 acres
Approximate average cost of Fire Pipe System per acre	$1,000
2,400 acres at $1,000 per acre	$2,400,000

In the above territory the fire losses, as given in the New York Fire Department Reports during four years, were as follows:

1894	$2,685,380
1895	2,665,395
1896	2,162,592
1897	2,302,547
Total	$9,815,914
Average	$2,453,978

The average annual fire loss is thus found to be greater than the cost of providing a Fire Pipe System. (Annual cost of operation is $7\frac{3}{4}$ per cent. of fire loss.)

For the same period the average fire losses south of Chambers street were $398,077, or nearly 33 per cent. greater than the estimated cost of the Fire Pipe System for that district, as given in Estimate (c).

Estimate of Cost.

(h)

Interest and Depreciation.

Interest on cost of works is assumed at 3 per cent.
Depreciation of works is assumed as follows:

Structures, Apparatus, etc.	Life in years.	Annuity on one dollar.
Cast Iron Pipe	30	.02102
Hydrants	10	.08724
Gates, Valves, etc.	10	.08724
Engines and Pumps	30	.02102
Boilers	30	.02102
Telegraph System	10	.08724
Intake and Connections	10	.08724
Permanent Buildings	100	.00165
Masonry, Manholes, etc.	30	.02102

Estimate of Cost.

(i)

Annual Cost of Operation and Maintenance of the Proposed Fire Pipe System in the Dry Goods District.

Cost of Construction, as per Estimate (a)	$110,000
Interest on $110,000 at 3 per cent.	$3,330
Depreciation of Plant	3,550
Inspection and Testing	1,750
Total	$8,630

(The above is for 100 acres; per acre, $86.30.)

Estimate of Cost.

(j)

Annual Cost of Operation and Maintenance of One Steam Fire Engine, Under Present Conditions in New York, the Price of the Engine, All Fittings, Harness, Etc., Being Taken at $8,000.

Interest	$240
Depreciation and Repairs	425
Fuel	400
Oil and Waste	15
Horses, including Depreciation of the Same	120
Forage	265
Pay of Company Officers and Men*	15,800
Total	$17,265

Assuming an engine to be displaced by the fire-boats, there would be an offset to part of the cost of operations of the former, in the shape of like depreciations, fuel and pay of some officers and men, as follows:

Depreciation and Repairs, as above	$425
Fuel and Supplies	415
Pay of Assistant Foreman and Five Men	7,800
Total	$8,640
Net saving in annual cost of operation by dispensing with one engine	$8,625

*As fixed by Charter.

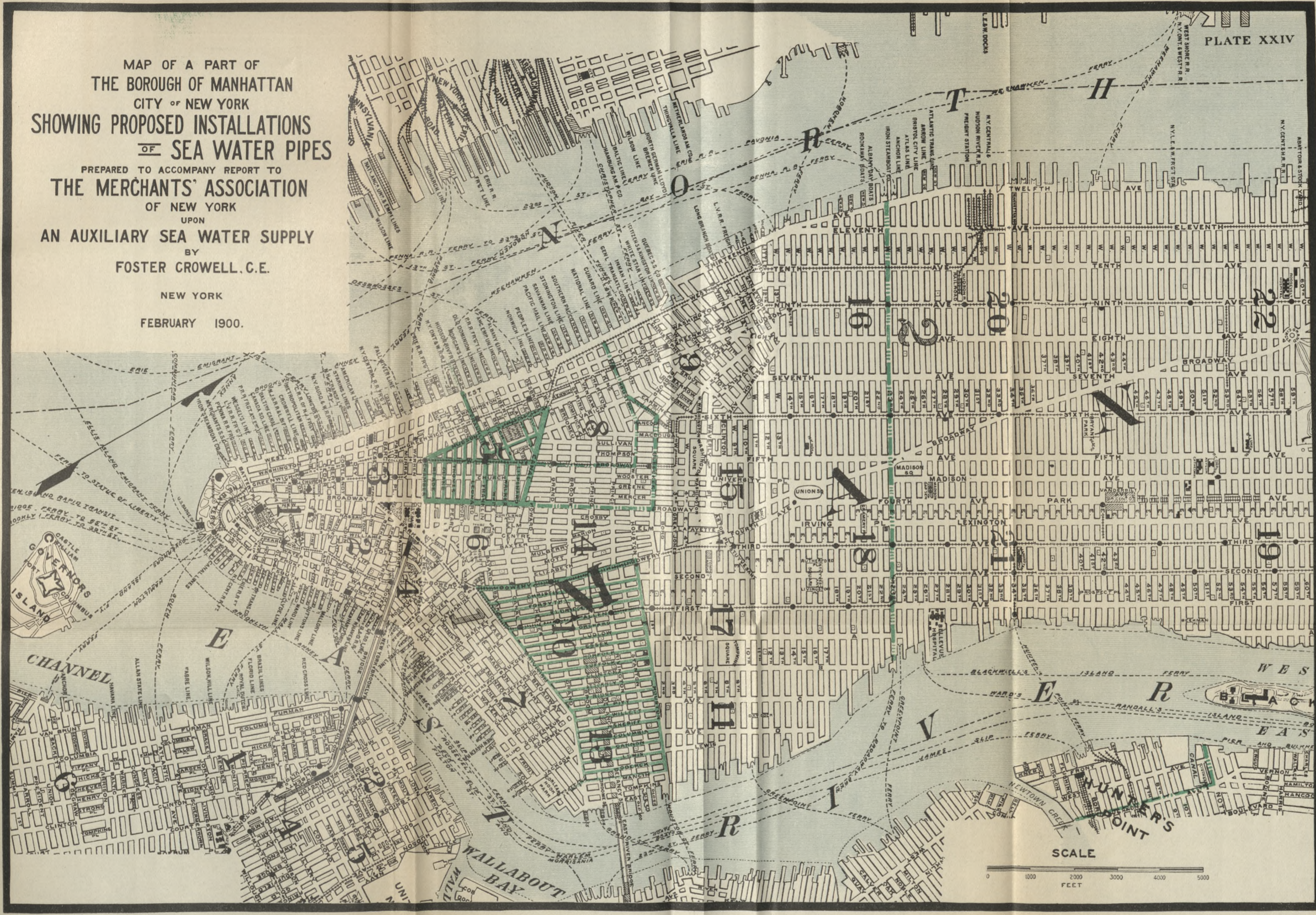


PLATE XXIV
MAP OF A PART OF
THE BOROUGH OF MANHATTAN
CITY OF NEW YORK
SHOWING PROPOSED INSTALLATIONS
OF SEA WATER PIPES
PREPARED TO ACCOMPANY REPORT TO
THE MERCHANTS' ASSOCIATION
OF NEW YORK
UPON
AN AUXILIARY SEA WATER SUPPLY
BY
FOSTER CROWELL, C.E.
NEW YORK
FEBRUARY 1900.
NORTH
EAST RIVER
MANHATTAN
GOVERNORS ISLAND
CHANNEL
WALLABOUT BAY
HUNTER'S POINT
NEWTOWN CREEK
BLACKWELL'S ISLAND FERRY
RANDALL'S ISLAND
UNION SQ.
MADISON SQ.
SCALE
0 1000 2000 3000 4000 5000
FEET


PLATE XXV
MAP OF A PART OF
THE BOROUGH OF QUEENS
CITY OF NEW YORK
SHOWING PROPOSED INSTALLATIONS
OF SEA WATER PIPES
PREPARED TO ACCOMPANY REPORT TO
THE MERCHANTS' ASSOCIATION
OF NEW YORK
UPON
AN AUXILIARY SEA WATER SUPPLY
BY
FOSTER CROWELL, C.E.
NEW YORK
FEBRUARY 1900.
SCALE
NORTH HEMPSTEAD
LITTLE NECK BAY
FLUSHING BAY
PUMPING STATION
PUMPING STATION
PUMPING STATION 4
FLUSHING CEMETERY
CEDAR GROVE CEMETERY
COLLEGE POINT
WHITESTONE
FLUSHING
CORONA
QUEENS
RICHMOND HILL
WOODHAVEN
BAILEYS POND

PLATE XXVI

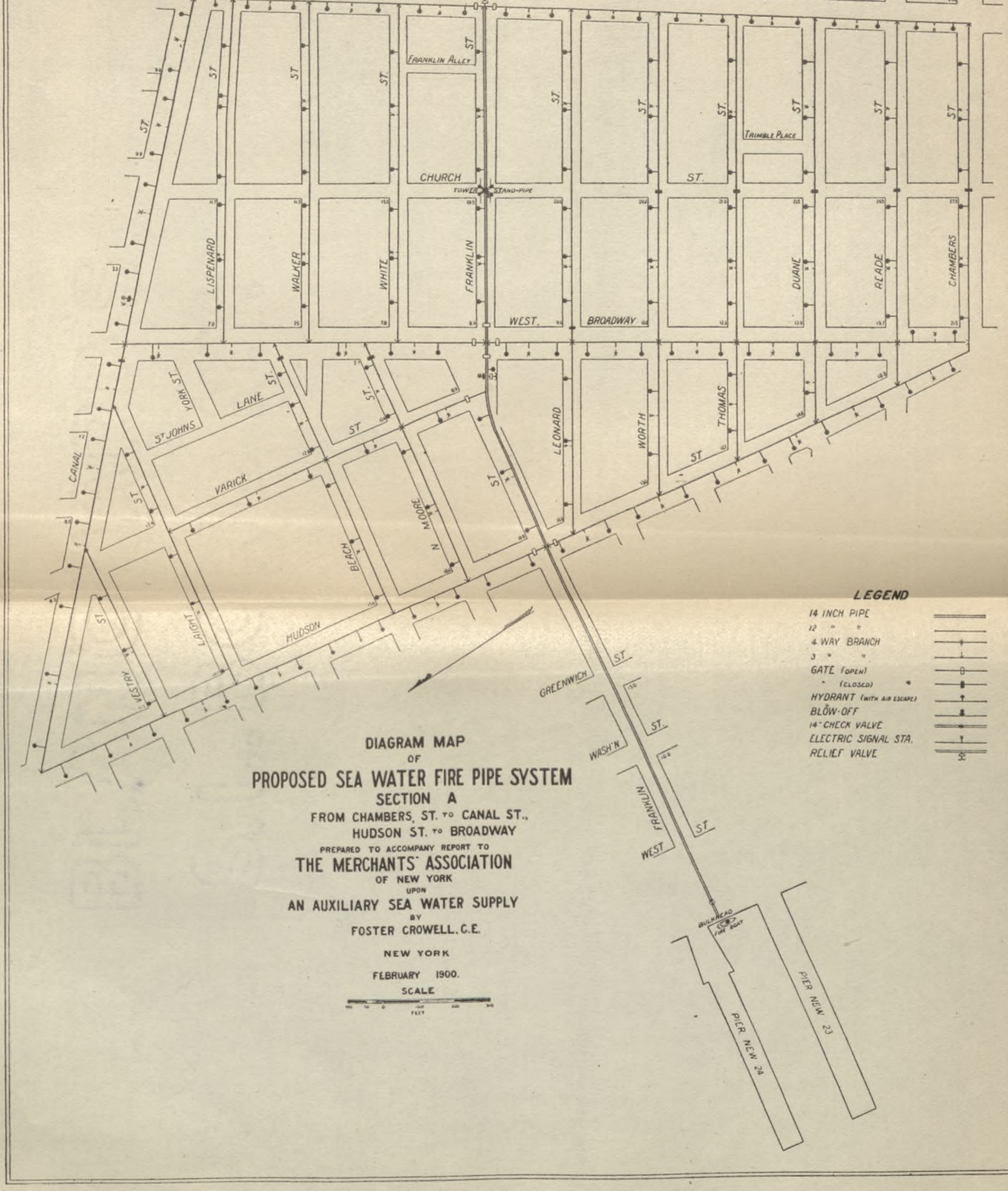


DIAGRAM MAP
OF
PROPOSED SEA WATER FIRE PIPE SYSTEM
SECTION A
FROM CHAMBERS, ST. TO CANAL ST.,
HUDSON ST. TO BROADWAY
PREPARED TO ACCOMPANY REPORT TO
THE MERCHANTS' ASSOCIATION
OF NEW YORK
UPON
AN AUXILIARY SEA WATER SUPPLY
BY
FOSTER CROWELL, C.E.
NEW YORK
FEBRUARY 1900.
SCALE
FEET
LEGEND
14 INCH PIPE
12 " "
4 WAY BRANCH
3 " "
GATE (OPEN)
" (CLOSED)
HYDRANT (WITH AIR ESCAPE)
BLOW-OFF
14" CHECK VALVE
ELECTRIC SIGNAL STA.
RELIEF VALVE
BROADWAY
CANAL ST.
LISPENARD ST
WALKER ST
WHITE ST.
FRANKLIN ST
FRANKLIN ALLEY
CHURCH ST.
TOWER
STAND-PIPE
WEST. BROADWAY
LEONARD ST.
WORTH ST.
THOMAS ST.
DUANE ST.
TRIMBLE PLACE
READE ST
CHAMBERS ST
YORK ST.
LANE ST.
ST JOHNS
VARICK ST
N MOORE ST
BEACH ST.
HUDSON
LAIGHT ST
VESTRY ST
GREENWICH ST
WASH'N ST.
FRANKLIN
WEST ST
BULKHEAD
FIRE BOAT
PIER NEW 24
PIER NEW 23

It will be seen by comparing (j) with (i) that, if only one fire engine were released from service by the proposed fire pipe line, there would be an economic value in the latter.

It is probable that several engines could be released, and either dispensed with altogether or placed in other parts of the city where the present fire protection might need extension.

Estimate of Cost.

(k)

Pumping Station in Corlear's Hook Park to Supply Sea Water for Fire Protection, Street Watering, Sewer Flushing, Industrial Establishments, Etc., in Connection With Fire Pipe System in Estimate (f).

Capacity of station, 2,500 gallons per minute at 150 lbs. pressure.

Two Pump Units of 1,250 Gallons each.
Two Boilers of 150 H. P. each.

Cost of Construction.

Station Building and Connections	$15,500.00
Engines and Pumps	25,000.00
Boilers and Mechanical Stokers	8,000.00
Feed Pumps (fresh water)	500.00
Miscellaneous	1,000.00
Total	$50,000.00

Annual Cost of Operation and Maintenance.

Interest	$1,500.00
Depreciation of Plant	816.98
Repairs	500.00
Fuel (approximated)	3,000.00
Staff	6,100.00
Total	$11,916.98
Annual Cost of Maintaining Pipe System as per Estimate (j)	19,805.30
Combined Annual Cost	$31,722,28

Comparison of Fire Loss in the Different Districts, With Annual Cost of Operation.

South of Twenty-third street, in the Borough of Manhattan, the average annual fire losses, as given in the New York Fire Department Reports during four years, were $2,453,978. The cost of a fire pipe system, as per Estimate (g), would be, in round numbers, $2,400,000, or somewhat less than the average annual fire loss.

There are no separate returns for the Dry Goods District, but the average fire losses during the same period in Fire Department Districts 2 and 3, of which the Dry Goods District forms a part, average $1,124,835, which is an average per acre of $3,000 per year, more than three times as great as the average loss over the entire area south of Twenty-third street.

It will be seen that the annual cost of operation and maintenance of the proposed fire pipe system in the Dry Goods District, as given in (i), is 2.8 per cent. of the annual fire loss.

For the same period the average fire losses south of Chambers street were, proportionately to area, only about half as great as in the Dry Goods District, so that there the annual cost of operation of a fire pipe system would be about 6 per cent.

The above figures of fire losses do not furnish a fixed basis of computation, for they might vary greatly in other years; but they serve to show the general relations.

In conclusion, I desire to express my sense of personal obligation to the members of your committee who have contributed valuable information and suggestions.

Respectfully submitted,

FOSTER CROWELL,
Consulting Engineer.

NO. 18 BROADWAY, NEW YORK.
February 19, 1900.

SECTION IV.

REPORTS AND OPINIONS OF THE COMMITTEE ON LEGISLATION.

PART I: REPORT.

PART I.

CONTENTS OF REPORT.

REPORT OF THE COMMITTEE ON LEGISLATION.

To the Committee on Water Supply of the Merchants' Association of New York, M. E. Bannin, Esq., Chairman:

GENTLEMEN:

The Committee on Legislation reports that various questions have been submitted to it by the Engineering Committee during the investigation into the water-supply for the City of New York. These questions have arisen during the Engineering Committee's examination of the possible sources of supply, from various watersheds: the Ten Mile and Ramapo Rivers, the Wallkill River, the Hudson above Poughkeepsie, the Upper Hudson, and, for the Borough of Brooklyn, territory on Long Island. This Committee has also been requested by the Committee of the Whole to draw various bills, the purpose of which was to give the City of New York larger powers of condemnation and larger sources of supply of water for the purposes of the City. To it was also submitted the drawing of a constitutional amendment which should provide that the bonds issued for indebtedness incurred by increasing the water-supply should not be included in the calculation of the city's total indebtedness; the purpose being that the City might be able to incur such indebtedness as was necessary without increasing the limit of indebtedness, and thus hampering improvements in other directions. The Committee submits the following conclusions, referring for further details to its reports made from time to time:

I.

INTERSTATE WATERS.

The questions asked of the Legislation Committee, in regard to the use of what may be called interstate waters, were asked during the investigation by the Engineering Committee of three sources of supply, the watersheds of the Ramapo, the Ten Mile and the Wallkill Rivers.

These questions as to the Ramapo and Ten Mile Rivers were quite similar: The Ramapo watershed included waters rising in New York, afterwards flowing through New Jersey to the sea. The Ten Mile River watershed included waters rising partly in New York and partly in Connecticut, flowing through New York and afterwards through Connecticut into the Housatonic River, and thence into Long Island Sound. We were of the opinion that a lower riparian owner in either New Jersey or Connecticut could by injunction prevent the use of these two watersheds for supplying the City of New York with water; and further of the opinion that even if New Jersey and Connecticut should, by their Legislatures, attempt to grant to the City of New York, or a corporation acting under its authority, the right of condemnation under eminent domain, such acts would be unconstitutional; and furthermore, that, at least in the case of New Jersey, it was extremely doubtful whether that State would even attempt to assist the City of New York, for the reason that recent legislation in New Jersey had indicated a policy on the part of the State to preserve for its own citizens in the large municipalities in the vicinity of New York the waters coming from the Ramapo watershed in the northern part of the State. The Committee on Legislation begs to refer, for its further and more detailed reasoning, to its letter addressed to the Engineering Committee on December 21 last.

The Engineering Committee further requested the opinion of the Committee on Legislation as to the possibility of using the waters of the Housatonic River. The Committee on Legislation, for the same reasoning as is involved in the discussion of the right to use inter-state waters, gave as its opinion that the waters of the Housatonic River could not be used by the City of New York.

A question was also asked whether the Borough of Richmond could be supplied by the East Jersey Water Company without the consent of the State of New Jersey. The examination of the charter of that company and of the legislation of the

State of New Jersey compelled us to answer this question in the negative.

In general, therefore, the Committee on Legislation advised that the City of New York cannot obtain any portion of its water-supply by condemnation from any locality other than the State of New York.

A distinction, however, should be made between the suppposititious cases of the Ramapo watershed and Ten Mile River watershed on the one hand, and the actual Croton watershed on the other hand. Waters rising in another State and flowing through the State of New York into the sea, without entering the confines of the other State, might properly be condemned for the purpose of a supply for the City of New York.

A further distinction should be made between the above-named sources and the Wallkill River.

The plan in regard to the Wallkill River involves the building of a reservoir at Phillipsburg, the surface of which should be at a height of 422 feet above sea level; the Wallkill River at that point is about 380 feet above tide water; the dam would flood an area of about 60 square miles, of which one-fifth is in the State of New Jersey; it further involves the building of filtration beds below the dam, thus saving the necessity of purchasing the streams for the purpose of protecting their banks from pollution, and saving the cost of clearing the land to be covered by the reservoir. If the City of New York can purchase the lands in New Jersey, it can, of course, flood them for the purposes of a reservoir intended to supply the City of New York. This involves the purchase of the entire area covered by the reservoir since, as the Committee has already advised, the City of New York cannot acquire title to these lands by condemnation. Subject, therefore, to this practical difficulty of purchase, this Committee sees no objection to using the Wallkill River and valley for a supply for the City of New York.

II.

WATERS FROM LONG ISLAND.

Questions have arisen as to the possibility of obtaining for Brooklyn increased supplies from Long Island.

A: The Suffolk County Supply.

The City of New York has power to condemn sources of water supply under three general groups of rights:

1st. Powers preserved by the present charter which existed under the former consolidation act, Laws of 1882, and subsequent statutory enactments.

2nd. Powers of the localities consolidated under the present charter, including Brooklyn and various towns and villages in the Counties of Queens and Richmond; and

3rd. Additional powers conveyed by the present charter.

Touching the water supply from Suffolk County, the present charter contains a provision that nothing in it contained shall be deemed to repeal the provision of Chap. 942 of the Laws of 1896. That Chapter forbids the use of any of the waters of Suffolk County, after certain proceedings have been taken by the Board of Supervisors of the county declaring the waters necessary for the inhabitants of Suffolk County. An investigation by the Committee on Legislation shows that practically all of the waters of Suffolk County have been declared by the Board of Supervisors necessary for the inhabitants of the county, and hence no additional supply can be obtained from Suffolk County. A bill was introduced in the Legislature during the past session to repeal the Suffolk County law, but the bill failed of passage. The Water Supply Committee of the Merchants' Association, although approving the bill, took no active measures to further its passage.

B: Other Waters on Long Island.

Recent decisions of the Court of Appeals and of the Appellate Division of the Second Department would seem to show that the Borough of Brooklyn will have to pay heavy damages for the use of certain waters in the other counties of Long Island. In the case of Smith vs. The City of Brooklyn, 18 App. Div. 340; 32 App. Div. 257; 160 N. Y. 357, the courts held that the City must pay damages for the diversion of underground waters, resulting in the drying up of a stream and of a pond used for ice-cutting and shipbuilding; and in the case of Forbell vs. the City of New York, 47 App. Div. 371, the Appellate Division of the Second Department held that the City must pay to the owners of the land, damages to the land and the crops, caused by a similar diversion; inasmuch as a large portion of the supply of the Borough of Brooklyn comes from driven wells, tapping subterranean sources and affecting large areas of land, it will be seen that the cost of this supply may be very great. The City will probably have to condemn the lands thus affected. Until the present time it had not been thought that the City would have to pay for the water obtained from these sources; it is of course impossible to forecast what the amount of damages will be; the Committee on Legislation desires only to call the attention of the Committee on Water Supply to this probability, in order that the increased cost of supplying Brooklyn may be borne in mind.

A further increased cost of the supply for the Borough of Brooklyn will be caused by Chapter 469 of the Laws of 1898. This statute requires the municipality to deepen tide waters to a depth of at least three feet in cases where fresh waters flowing into such tide waters have been diverted for the purpose of a water supply for the municipality, and where, prior to such diversion, the stream was navigable by vessels of 20 or more tons burden. The Committee understands that already a large claim has been filed by the Supervisors of the Town of Hempstead, and that possibly a large amount of work will have to be done by the municipality in obedience to this law.

III.

THE RIGHT OF EMINENT DOMAIN UNDER THE CHARTER OF THE CITY OF NEW YORK.

Almost all of the work before the Legislature of State of New York by the Merchants' Association during the past session of the Legislature has been aimed at the extension of the right of eminent domain possessed by the City. This work took the form of attempting to amend Section 472 of the Charter, by a bill known as the Morgan bill. This bill failed of passage in the Legislature, and hence the rights of the City are at present as they were before the session of the Legislature began.

In Sections 471 and 472 of the Charter are contained the powers of eminent domain possessed by the City of New York. They are seemingly very broad in character, but a proviso in Section 472 prevents the City of New York from acquiring any property rights in any water rights, which at the time of the initiation of the proceedings for condemnation were in whole or in part devoted to the supply of the water-works of the people of any other city, town or village of the State. This proviso was so sweeping in its character as to make it possible for a company possessing water-rights to make a contract with any municipality, no matter how small a part of the watershed was thus used, and thereby deprive the City of New York of any right to condemn the watershed for the purposes of the city. The proviso seems to have been drawn by a different hand from that of the framer of the rest of the section; it is vague and uncertain in its meaning, but the Committee on Legislation is of the opinion that the proviso must be repealed or amended before the City of New York can condemn any of the large watersheds under consideration for the supply of the City of New York.

It is of course proper that there should be a restriction upon the power of the City of New York to condemn specific and restricted watersheds which are actually and necessarily used for the supply of any other municipality of the State, but the proviso in Section 472 permits a private person or corporation to obtain a large supply and to make a small contract, and thus block New York City's right to condemn.

It seems likely that the Charter Revision Commission, to be appointed by the Governor, will take up this proviso in Section 472 and amend it so as not to cripple the City of New York in its attempt to obtain needed additional water.

IV.

The Rate of Wages and Hours of Labor Under a Contract for an Additional Supply.

The Committee on Legislation has advised the Engineering Committee that the rate of wages upon a contract by the City for an additional supply

> "shall not be less than the prevailing rate in the same trade or occupation in the locality within the State where such public work on, about or in connection with which, such labor is performed, or its final and completed form is to be situated, erected or used,"—(Section 3 of the Labor Law, Chap. 415 of the Laws of 1897 as amended by Chap. 567 of the Laws of 1899).

We were of the opinion that under this clause work done outside of the County of New York should be paid for at the rate of wages prevailing in the County where the work was done and not at the New York County rate; we were further of the opinion that the eight hours provision contained in the same section of the Labor Law, making eight hours a legal day's work, applies to work done for the City.

V.

The Proposed Adirondack Compensating Reservoirs.

The Engineering Committee, by letter from Mr. Hering, dated February 21, submitted to the Committee on Legislation the question of compensating reservoirs in the Adirondacks. The proposition was that reservoirs should be built in the Adirondacks, designed to store the flood waters and, so far as the lower riparian owners were concerned, to deliver such waters at an even flow during the entire year. We were asked whether it would be necessary to condemn the rights of lower riparian owners in order to build such compensating reservoirs.

We were of the opinion that, even on the assumption that the lower riparian owner would receive a more advantageous flow of water, nevertheless he could enjoin the building of such reservoirs unless the City should condemn his rights. The fact that the injury to the lower owner is apparently nominal is not in itself sufficient to prevent such owner from obtaining injunctive relief. His right to the flow of the water is absolute and cannot be taken away except by condemnation.

VI.

THE LIMITATION OF MUNICIPAL INDEBTEDNESS FOR WATER AND THE PROPOSED CONSTITUTIONAL AMENDMENT TO ABOLISH IT.

There is no constitutional restriction as to the amount of indebtedness which may be incurred by the City for its water supply, but the indebtedness thus incurred must be considered in fixing the limit of indebtedness which the City can incur for other purposes than water.

This Committee has been asked to draw a proposed constitutional amendment in order to obviate the inclusion of water supply indebtedness in the total indebtedness of the City, thereby lessening its power to borrow for other purposes. It submits the following:

The following is the whole section with the proposed amendment; new matter in italics:

Article 8, Section 10 of the Constitution.

"Sec. 10. No county, city, town or village shall hereafter give any money or property, or loan its money or credit to or in aid of any indivdual, association or corporation, or become directly or indirectly the owner of stock in, or bonds of, any association or corporation; nor shall any such county, city, town or village be allowed to incur any indebtedness except for county, city, town or village purposes. This section shall not prevent such county, city, town or village from making such provision for the aid or support of its poor as may be authorized by law. No county or city shall be allowed to become indebted for any purpose or in any manner to an amount which, including existing indebtedness, shall exceed ten per centum of the assessed valuation of the real estate of such county or city subject to taxation, as it appeared by the assessment-rolls of said county or city in the last assessment for State or county taxes prior to the incurring of such indebtedness; and all indebtedness in excess of such limitation, except such as may now exist, shall be absolutely void, except as herein otherwise provided. No county or city whose present indebtedness exceeds ten per centum of the assessed valuation of its real estate subject to taxation, shall be allowed to become indebted in any further amount until such indebtedness shall be reduced within such limit. This section shall not be construed to prevent the issuing of certificates of indebtedness or revenue bonds issued in anticipation of the collection of taxes for amounts actually contained, or to be contained in the taxes for the year when such certificates or revenue bonds are issued and payable out of such taxes. Nor shall this section be construed to prevent the issue of bonds to provide for the supply of water; but the term of the bonds issued to provide the supply of water shall not exceed twenty years, and a sinking fund shall be created on the issuing of the said bonds for their redemption, by raising annually a sum which will produce an amount equal to the sum of the principal and interest of said bonds at their maturity. All certificates of indebtedness or revenue bonds issued in anticipation of the collection of taxes, which are not retired within five years after their date of issue, and bonds issued *prior to the 1st day of January, 1901*, to provide for the supply of water, and any debt hereafter incurred by any portion or part of a city, if there shall be any such debt, shall be included in ascertaining the power of the city to become otherwise indebted. *Bonds issued after the 1st day of January, 1901, to provide for the supply of water, shall not be so included.* Whenever hereafter the boundaries of any city shall become the same as those of a county, the power of the county to become indebted shall cease, but the debt of the county at that time existing shall not be included as a part of the city debt. The amount hereafter to be raised by tax for county or city purposes, in any county containing a city of over one hundred thousand inhabitants, or any such city of this State, in addition to providing for the principal and interest of existing debt, shall not in the aggregate exceed in any one year two per centum of the assessed valuation of the real and personal estate of such county or city, to be ascertained as prescribed in this section in respect to county or city debt."

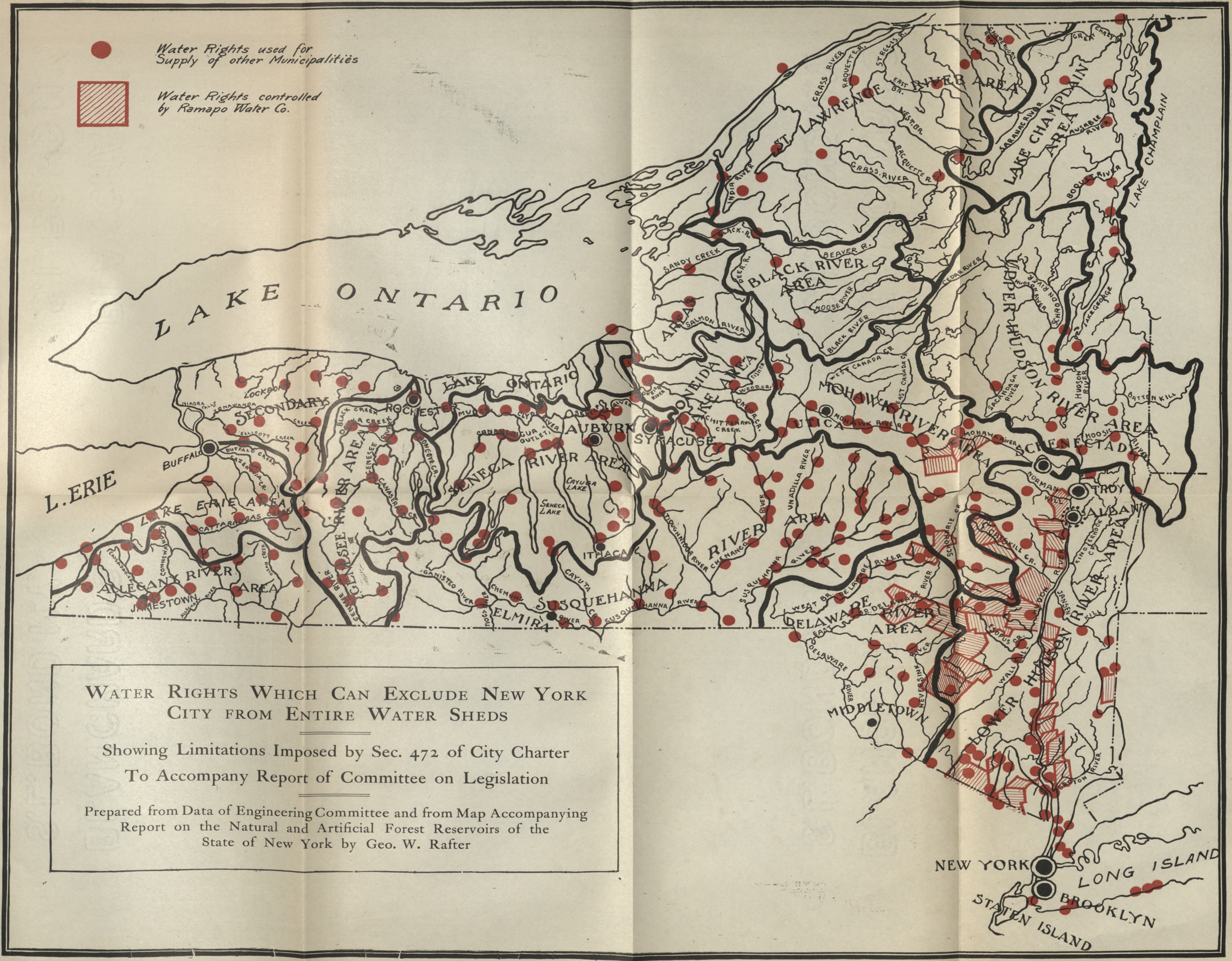
Respectfully submitted,

ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE,
Committee on Legislation.

SECTION IV.

REPORTS AND OPINIONS OF THE COMMITTEE ON LEGISLATION.

PART II: OPINIONS.



WATER RIGHTS WHICH CAN EXCLUDE NEW YORK CITY FROM ENTIRE WATER SHEDS

Showing Limitations Imposed by Sec. 472 of City Charter

To Accompany Report of Committee on Legislation

Prepared from Data of Engineering Committee and from Map Accompanying Report on the Natural and Artificial Forest Reservoirs of the State of New York by Geo. W. Rafter

CONTENTS OF PART II: OPINIONS.

Opinions: To Engineering Committee.

Opinions: To Engineering Committee.

OPINIONS

FOR THE GUIDANCE OF THE COMMITTEE ON WATER SUPPLY.

I. Relations of Borough of Richmond to East Jersey Water Company.

II. Power of the State of New York to Divert the Waters of the Ramapo River.

III. Power of the State of New York to Divert the Waters of the Housatonic River.

IV. Power of the State of New York to Divert the Waters of the Ten-Mile River.

V. Right to Divert Storm Waters.

VI. Acquisition of Sources of Water-Supply in Suffolk County.

NEW YORK, Dec. 21, 1899.

To the Engineering Committee:

GENTLEMEN:

The Committee on Legislation have considered the questions referred to them by you in your communication of December 11, 1899, and would respectfully report as follows:

I.

QUESTIONS AND CONCLUSIONS.

Question I.

"Whether the Borough of Richmond can be supplied "with water by the East Jersey Water Company without "the consent of the State of New Jersey."

The answer to this question involves the practicability from a legal standpoint of securing water supply for the residents of the Borough of Richmond from the East Jersey Water Company, a New Jersey corporation. Our conclusion, for the reasons set forth in the appended memoranda, is that it would be impracticable to look to the East Jersey Water Company for such supply.

Question II.

> "Whether the State of New York can divert to the "east side of the Hudson River the waters of the Ramapo "River now in its own territory, but afterwards flowing "through New Jersey to the sea, without the consent of the "State of New Jersey."

Substantially the same rules of law are applicable in answer to this question and the fourth, and therefore the two questions will be answered together.

The substantial question presented is, whether the City of New York has or can acquire the right to divert the flow of these interstate rivers without regard to the rights of riparian owners on these streams in New Jersey and Connecticut.

In our opinion the City of New York has no right to divert the flow of the Ten Mile River from the State of Connecticut nor to divert the flow of the Ramapo River from the State of New Jersey, and in case of such diversion of the Ten Mile River a lower riparian owner on the river in Connecticut could enjoin the proposed diversion, in an action either in the United States Courts or in the Courts of New York State.

In the same way a New Jersey riparian owner on the Ramapo could enjoin the proposed diversion of the Ramapo.

If the Legislature of the State of New Jersey or Connecticut should pass an act authorizing the City of New York, or a private corporation, for the purpose of the water supply of the city, to condemn the rights of the riparian owners in the respective States, we are of opinion that the constitutionality of such an act is too doubtful to make it advisable to proceed under any such act.

In the memorandum submitted herewith we have stated as briefly as possible the reasons which have forced us to these conclusions.

Question III.

"Whether the State of New York can divert into its "own territory the waters of the Housatonic River, which "now lie entirely within the State of Connecticut, without "the consent of the State of Connecticut."

For the reasons given in answer to question two and annexed memoranda we answer this question in the negative.

Question IV.

"Whether the waters of the Ten Mile River, now flow-"ing out of the State of New York into the Housatonic "River in the State of Connecticut, can be intercepted for "the use of Greater New York before entering the State "of Connecticut, it being understood that a part of this "water supply originates in the State of Connecticut."

The answer to this question involves the same considerations and propositions of law as question two, and is answered in the same way.

Question V.

"Whether the right to divert waters as set forth in "answer to questions two, three and four includes the right "to divert all storm waters as well as the normal flow."

The Committee have come to the conclusion that a different rule prevails in the case of storm waters than in the case of natural streams, and for the reasons given in the annexed memoranda we answer this question by saying that all storm waters may be taken without regard to the rights of riparian owners in other States.

Question VI.

"Is it possible under the charter and other existing "statutes for the City of New York to acquire certain desir-"able sources of water supply in Suffolk County?"

Our answer to this question is "No," for the reasons set forth in the accompanying memoranda.

II.

OPINIONS AND CITATIONS.

Question I.

"Whether the Borough of Richmond can be supplied "with water by the East Jersey Water Company without the "consent of the State of New Jersey."

The first question asked us by the Sub-Committee on Engineering involves the question of the practicability, from a legal standpoint, of securing a water supply for the residents of the Borough of Richmond, from the East Jersey Water Company, a New Jersey corporation.

An answer to the question requires a consideration of the present powers of that company, the possibility of the company receiving additional powers from the State of New Jersey; the attitude of the State of New Jersey toward such a project; and the possible hostility of private citizens of that State.

1: As to the present powers of the East Jersey Water Company.

This company, which was chartered in 1888, is organized under the general corporation act of 1875, and not under the Water Works Company Act. By its charter, its operations are confined to certain counties within the State of New Jersey. It could not in any event supply water to Richmond without an amendment of its charter in that respect. Such an amendment, however, could, probably, easily be procured.

By the terms of the Act under which it is incorporated, the company's power of eminent domain is confined to taking lands for purposes appurtenant to the damming of rivers and streams of greater width and volume of water than the Delaware at Phillipsburgh, below the junction of the Lehigh; and it is not permitted in any event to dam any river below the head of tidewater therein.

We are informed that in the pursuit of its great work of supplying water to Newark, this company did not attempt to exercise the right of eminent domain, but that all proceedings to acquire title were brought in the name of the City of Newark. In other cases it has used the right of certain small water works companies, the stock of which it controls.

If this company were to attempt to supply the Borough of Richmond it is reasonable to suppose that it would be necessary for it to extend its plant and accessories, which in turn would probably necessitate the exercise of the right of eminent domain. To obtain an extension of this right would require an amendment of the law under which the company was incorporated, and that brings us to the question of possibility of the Legislature enlarging its powers.

2: The possibility of the Water Company receiving larger powers from the State of New Jersey.

This question involves the attitude of the State of New Jersey toward the project under consideration.

Even if an act should be procured in New Jersey enlarging the eminent domain power, it would be open to the grave constitutional question of the right of one State to permit the exercise of eminent domain within its borders for the benefit of citizens in another State.

But we think that the public acts of the State of New Jersey indicate a policy on the part of that State to reserve for the use of its own inhabitants all the water which it controls.

In 1882 an act was passed establishing a commission to devise a plan for the storage of the waters within the State for the purpose of supplying cities and towns within the State with wholesome water.

In 1883 the Attorney-General was authorized by special act to institute proceedings in the name of the State to prevent any attempt that might be made to interfere with the free flow into the State of any waters having a source in a neighboring State.

In 1884, by a joint resolution of the Legislature, the Governor was authorized, if he thought necessary, to confer with the Governor of New York on the general subject.

That we do not find that anything affirmatively accomplished by these acts, is probably due to the fact that the apprehended evils at which they were aimed have not arisen; but we do think that they indicate a policy on the part of the State of New Jersey to conserve its waters for the benefit of its own citizens. Such a policy, if it exists, would have to be reversed before additional power could be secured by the East Jersey Water Company.

3. The possible hostility of private citizens of New Jersey.

That any attempt to use New Jersey waters in this State would be opposed by citizens of the former State, may be inferred with reasonable certainty from the fact that the East Jersey Water Company has recently been twice indicted by the Bergen County Grand Jury for committing a nuisance by decreasing the flow of the Passaic through that county. Any act on the part of the company which would tend further to decrease the flow would certainly meet with opposition.

Again, one of the streams affected by the operations of the East Jersey Company is the Ramapo. Several small water companies have rights in this river above the rights of the East Jersey Company. Any action which would increase the demands of the East Jersey Company on that stream, especially if such demands were for the benefit of non-residents, would be certain to meet with the opposition of those companies, and a case in this State (Pocantico Water Works v. Tarrytown, 4 N. Y., Supp. 317), would seem to indicate that they would be in a position to obtain injunctive relief.

For these reasons we think that from a legal standpoint it would be impracticable to attempt to resort to the East Jersey Company to obtain water for the residents of Richmond Borough.

Questions II, III and IV.

"Whether the State of New York can divert to the east "side of the Hudson River the waters of the Ramapo River, "now in its own territory, but afterwards flowing through "New Jersey to the sea, without the consent of the State "of New Jersey."

"Whether the State of New York can divert into its "own territory the waters of the Housatonic River, which "now lie entirely within the State of Connecticut, without "the consent of the State of Connecticut."

"Whether the waters of the Ten Mile River, now flow-
"ing out of the State of New York into the Housatonic
"River, in the State of Connecticut, can be intercepted for
"the use of Greater New York before entering the State of
"Connecticut, it being understood that a part of this water
"supply originates in the State of Connecticut."

The owner of land upon a stream has the right to use the water, provided such use does not divert the flow from the lower riparian owner. If the water is diverted from the lower riparian owner, such diversion is a tort, and may be prevented by injunction. An action for damages also lies.

These are elementary propositions established by numerous cases. The following are a few of these cases:

Corning v. Troy Nail and Iron Factory,
40 N. Y. 191. (1868, Grover J.)
Smith v. City of Rochester,
92 N. Y. 463. (1883, Rugers, Ch. J.)
Neal v. City of Rochester,
156 N. Y. 213. (1898, Haight, J.)
Mannville v. City of Worcester,
138 Mass. 89. (1884.)

The right of a lower riparian owner to the undiminished flow of water is a property right which cannot be taken from him except under the authority of the State, by eminent domain, and upon payment of compensation. Within the State of New York such property right could be condemned by the City of New York. But the right to take property by eminent domain is limited to property situated within the territorial limits of the State, and cannot be exercised upon property without the State.

Mannville v. City of Worcester,
138 Mass. 89.
Holyoke Water Power Co. v. Conn. River Co.,
52 Conn. 570.
more fully,
22 Blatch. 135.
Foot v. Edwards,
3 Blatch. 310.
Palmer v. Cuyahoga County,
3 McLean 226.
Crosby v. Hanover,
36 N. H. 404.
8 Harvard Law. Rev. 138.

Therefore, the City of New York cannot acquire by eminent domain the rights of riparian owners in New Jersey or Connecticut under any authority given or to be given by the State of New York; and as to such owners, statutes in New York giving rights of condemnation are of no effect.

Such riparian owners can bring an action in the United States Courts or in the Courts of New York and enjoin the city from diverting the water. In such an action the statutes of New York authorizing the diversion would be no defense, as the injury done is without the State and the statutes have no extra-territorial force; so the City of New York would be in the same position towards such owners as if it had diverted the waters of a stream without any authority so to do.

The cases cited above sustain these propositions, and are accepted by text-book writers as authority for them.

Am. and Eng. Enc. Law, 2d Ed., Title—Eminent Domain.
Randolph, Eminent Domain, Sec. 28.

The foregoing argument is based on the assumption that no statute is passed by New Jersey or by Connecticut, specifically authorizing New York City to condemn, for the purpose of its water supply, the necessary land in such State.

As a practical question it is at least doubtful if such legislation could be passed in New Jersey (See answer to question 1), but assuming that such legislation were passed, say in Connecticut, it is doubtful if it could be sustained.

A State can authorize condemnation for "public use" only, and the courts in Connecticut have been strict in holding that the use must be actually a public use, and not in fact a private use, under the guise of taking for the public. It is for the courts, not the Legislature, to say whether or not the use is public.

Farist Steel Co. vs. City of Bridgeport,
60 Conn. 278, at 291-292.

Certainly an act authorizing the City of New York to condemn for the purpose of its water supply lands in Connecticut, would not on its face be condemning for the public use of the citizens of Connecticut.

A distinction should be made between a condemnation by one State for the benefit of the Federal Government, and condemnation by one State for the benefit of another State. It has been held in many cases that the States have the right to condemn for the benefit of the United States as a distinct sovereignty.

See Kohl v. U. S., 91 U. S. 367, and cases cited.

In the Kohl case, however, the court approved the doctrine laid down by Cooley, J., in Trombley v. Humphrey, 23 Mich. 471, to the effect that the State could not condemn for the benefit of the United States, and asserted that the better doctrine is that the Federal Government should use its own undoubted power to that end.

The only case which we have been able to find in which one State has attempted to condemn for the benefit of another State is the Matter of Townsend, 39 N. Y. 171, where the right was upheld to condemn lands in New York for the benefit of the Morris & Essex Canal, operated by a New Jersey corporation and situated entirely within the limits of New Jersey, but this decision was put upon the specific ground that the canal was a benefit to the citizens of New York.

It is doubtful if a statute of Connecticut permitting the City of New York, or a private corporation, to condemn lands for the purpose of a water supply to the City of New York, could be held a constitutional exercise of the right of eminent domain.

Question V.

> "Whether the right to divert waters flowing from the State of New York into an adjoining State includes the right to divert all storm waters as well as the normal flow."

The Committee has come to the conclusion that a different rule prevails in the case of storm waters than in the case of water-courses. A natural water-course, as defined by Judge Andrews of the Court of Appeals of the State of New York, is

> "A natural stream flowing in a defined bed or channel, with banks and sides, having permanent sources of supply. It is not essential to constitute a water-course that the flow

should be uniform or uninterrupted. The other elements existing, a stream does not lose the character of a natural water-course because in times of drought the flow may be diminished, or temporarily suspended. It is sufficient if it is usually a stream of running water." (Angell on Water-courses, paragraph 4; Luther v. The Winnisimet Co., 9 Cush. 171.)

In the case of natural water-courses, the Committee has come to the conclusion that the right of condemnation, granted by the State of New York, would not be any protection against an action by a riparian owner in another State owning land lower down the stream. (See answers to questions II. and IV.)

But in case of storm waters or surface waters from rains and melting snows, a different rule prevails in most States.

"But it is to be observed that the law has always recognized a wide distinction between the right of an owner to deal with surface water falling or collecting on his land, and his right in the water of a natural water-course. In such water, before it leaves his land and becomes part of a definite water-course, the owner of the land is deemed to have an absolute property, and he may appropriate it to his exclusive use, or get rid of it in any way he can, provided only that he does not cast it by drains or ditches upon the land of his neighbor; and he may do this, although by so doing he prevents the water reaching a natural water-course, as it formerly did, thereby occasioning injury to mill-owners or other proprietors on the stream."

Barkley v. Wilcox, 86 N. Y. 147.

The rule, as adopted by the Courts of the State of New York, has also been adopted by the Courts of the State of New Jersey, in a well-defined line of cases. Mr. Chief Justice Beasley, in delivering the opinion for the Court in the case of Bowsby v. Speer, 31 N. J. Law Reports 352, said:

"The consequence is, therefore, that there is no such thing known to the law as a right to any particular flow of surface water, *jure naturae*. The owner of land may, at his pleasure, withhold the water falling on his property from passing in its natural course to that of his neighbor, and in the same manner may prevent the water falling on the land of the latter from coming on to his own."

31 N. J. Law Reports 352.

The rule as applied in the New York and New Jersey Courts is the English rule, and has been applied by nearly all the State Courts. We quote below a few of the propositions held by the various State Courts and by the English cases:

> "So far as the courts have passed upon the right of one on whose land the water falls to use the same, they seem to have all abandoned the civil law.
>
> "The owner of the soil has the absolute right to the water."
>
> Frazer v. Brown, 12 Ohio St. 300.
>
> "A land-owner may retain the water flowing thereon for his own purposes."
>
> Livingston v. McDonald, 21 Iowa 160, 89 Am. Dec. 563.
>
> "The owner may use or abandon the water as he pleases."
>
> Gibbs v. Williams, 25 Kan. 214, 37 Am. Rep. 241.
>
> "There is a right to appropriate surface water to the use of the owner on whose land it flows, although a lower proprietor is thereby deprived of its use."
>
> Broadbent v. Ramsbotham, 11 Exch. 602;
> Ennor v. Barwell, 2 Giff. 410.
>
> "The fact that surface water has flowed from the land of one man on to that of another for more than twenty years will not prevent the former from draining his land so as to cut off the flow."
>
> Rawstron v. Taylor, 11 Exch. 369.
>
> "So the fact that water has flowed from a drain on higher ground for more than twenty years does not give the lower proprietor the right to the flow which the upper proprietor cannot cut off, if necessary for the purpose of his farming operations."
>
> Greatrex v. Hayward, 8 Exch. 291.

We agree, therefore, in answer to the fifth question asked by the Committee on Engineering, that there is no reason why the surface waters and storm waters cannot be collected for the use of the City of New York, even if those waters, when left to their ordinary flow, would pass through other States to the sea.

Question VI.

"Is it possible under the charter and other existing statutes for the City of New York to acquire certain desirable sources of water supply in Suffolk County?"

The powers of the present City of New York to acquire title by condemnation to streams, ponds, springs and other sources of water supply are as follows:

I. Such powers as the former City of New York possessed for this purpose under the Consolidation Act (Laws of 1882) and other statutory enactments, which powers have been preserved to the present City of New York by the Charter (Section 1615).

II. Such powers as were formerly possessed by the City of Brooklyn and the various localities in the Counties of Queens and Richmond which were recently consolidated with the City of New York.

III. Such additional and further powers as have been conferred upon the present City of New York by the Charter (Chapter 378, Laws of 1897).

First: As to the Powers Formerly Possessed by the City of New York.

It will be found upon an examination of the Consolidation Act and the various statutes subsequently passed relating to water supply for the City of New York, that prior to the passage of the present Charter the City of New York possessed no general power to acquire ponds, streams and other bodies of water by condemnation proceedings in the various parts of the State, but was confined in the exercise of such power to certain localities in Westchester County connected with the Croton watershed.

The only additional power it possessed was conferred by Chapter 512, Laws of 1883, which authorized the City of New York to lease certain sources of water supply in the Counties of Orange and Rockland.

Second: As to the Powers Possessed by the Former City of Brooklyn and the Various Other Localities Consolidated with the City of New York.

Neither the Act of 1854, consolidating the City of Brooklyn with Williamsburg and Bushwick, nor the charter of the City of Brooklyn, enacted in 1873, contain any provisions empowering the City of Brooklyn to acquire sources of water supply by condemnation.

The powers exercised by the City of Brooklyn in this respect seem to have been derived from the charters of the two corporations, the Williamsburg Water Works Company, incorporated by special statute, amended by act passed April 16, 1852, and the Nassau Water Company, incorporated under Chapter 333, Laws of 1855.

These two corporations were subsequently consolidated under the name of the Nassau Water Company, and the franchise, rights and property of the Nassau Water Company were subsequently purchased by the City of Brooklyn pursuant to Chapter 22, Laws of 1857.

The charters of these two corporations were practically identical in terms, and empowered them to "purchase, take and hold" any real estate necessary for the purpose of obtaining a water supply, and to "enter upon the lands of any person or persons and take water from any ponds, streams, springs," etc., without any restriction as to locality.

These powers, conveyed to the City of Brooklyn by the sale to it of the franchise of the Nassau Water Company, were further enlarged and confirmed by Chapter 396, Laws of 1859, and Chapter 652, Laws of 1870, and were continued in the City of New York by Chapter 1615 of the charter.

As to the powers of acquiring sources of water supply by condemnation, which were possessed by the various small localities in Queens and Richmond counties, consolidated with the City of New York, these do not seem to be specially pertinent to this inquiry.

Third; As to Additional Powers Conferred by the Charter Upon the Present City of New York.

These additional powers are conferred upon the City by section 42 of the charter, which authorizes the Municipal Assembly to acquire by condemnation or purchase additional water works to supply the city and its inhabitants with water; and section 472, which authorizes the Commissioner of Water Supply, with the approval of the Board of Public Improvements and the Municipal Assembly, to acquire additional sources of water supply throughout the State, by condemnation.

Section 471 provides that the Commissioner of Water Supply shall not contract with any person or corporation engaged in the business of supplying or selling water for private or public use or consumption, without the previous assent of the Board of Public Improvements, and provides that all contracts as to increased water supply shall be in accordance with the provisions and requirements of the charter.

No specific authority to make any such contract is conferred upon the Commissioner of Water Supply or any other official by section 471.

Section 474 authorizes the making of a contract with the City of Yonkers to supply water to the Borough of the Bronx.

These various powers for the acquirement of sources of water supply thus conferred upon or continued in the City of New York by the various sections of the charter seem, however, to be modified and limited by section 1619 of the charter, which reads as follows:

> "Section 1619. Nothing in this act contained shall be "deemed to repeal the provisions of chapter nine hundred "and forty-two of the laws of eighteen hundred and ninety-"six."

Chapter 942, Laws of 1896, enacts as follows:

Section one provides that whenever the Board of Supervisors of any county which does not contain an incorporated city, and is within forty miles of a city of the first class, containing over 800,000 and less than 1,000,000 inhabitants shall, by a majority vote of said board, to be duly entered upon the minutes of their proceedings, decide that certain streams and ponds within such county are necessary for the supply of pure and wholesome water to the people residing in such county, they shall direct a certificate to that effect to be filed with the Clerk of the county.

Section two prescribes the form of the certificate to be so filed.

Section three reads as follows:

> "Sec. 3. Whenever such certificate has been duly re-"corded, as provided by sections 1 and 2 of this act, it "shall not be lawful for any person, corporation or munici-"pality to enter into or upon such pond and streams, or "upon the land adjacent thereto and take water therefrom "for the purpose of supplying water to any city or county "other than to the citizens of the county wherein such cer-"tificate is recorded, except upon the written consent of a "majority of the Supervisors duly elected to said Board "of Supervisors under their hands and seals, certifying that "the said ponds or streams are no longer necessary for the "purposes for which such ponds or streams may have been "set apart as provided in the first section of this act."

Section four repeals all acts inconsistent with this act.

Section five provides that the act shall take effect immediately.

It is evident that this statute was intended to apply to the City of Brooklyn.

By the United States census of 1890 the population of the City of Brooklyn is fixed at 806,343. By the New York State census of 1892 the population of Brooklyn is fixed at 957,163.

The effect of this act is, clearly, that upon the filing of the certificate as provided for in sections one and two, the streams and ponds referred to in such certificate are exempted from condemnation for all time, and cannot be acquired by any person, corporation or municipality, except under the conditions set forth in section three of a formal declaration by such Board of Supervisors that such ponds and streams are no longer necessary for the purposes for which they have been set apart.

It would seem, therefore, that this statute is a bar to the acquirement by the City of New York of the sources of water supply in Suffolk County as to which the inquiry is made, Suffolk County being admittedly within forty miles of the City of Brooklyn, provided the Board of Supervisors of Suffolk County have filed the certificate in the manner and form provided for in the act.

It follows, therefore, that the interrogatory must be answered in the negative, that the City of New York has no power to acquire by condemnation or purchase the sources of water supply in Suffolk County, as to which inquiry is made, save by co-operation with the Board of Supervisors of Suffolk County and the formal abandonment by them of such sources of water supply for local purposes.

Respectfully submitted,

ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE,
Committee on Legislation.

OPINIONS.

I: Rights of Oyster-Growers to Fresh Waters Falling into the Sea.

II: Right of City of New York to Construct an Aqueduct Through the State of New Jersey.

III: Exemption of Water-Supply Bonds from the Debt Limit.

IV: Power of the City of New York to Acquire Water Rights Now Held by Corporations or Private Parties.

NEW YORK, January 4, 1900.

GENTLEMEN:

You have submitted to us by letter to our Chairman, under date of December 28, 1899, the following questions, to which we return the following answers:

Question I.

> "Have the oyster growers upon the coast of this State equitable or statutory rights to the fresh waters naturally falling into the sea? If so, what is the extent of these rights; and are they sufficient to prevent the diversion of such fresh waters for the purposes of municipal water supply?"

We beg to advise you that, in our opinion, the oyster growers have no rights which cannot be condemned by the City under its right of eminent domain contained in the charter. This is subject, however, to the answer to the fourth question below.

Question II.

> "Can the City of New York construct an aqueduct through the State of New Jersey to convey water derived from the upper Delaware or other sources not within the State of New Jersey?"

We beg to advise you that the City of New York, if it acquires by purchase the property through which an aqueduct is built, can construct and maintain such aqueduct to convey waters for the use of the City. This right is, of course, subject to two considerations.

1st: That the City of New York must have the right to the use of the waters in question; and

2nd: Such an aqueduct is constructed subject to the right of the State of New Jersey to condemn the land for any public use of that State. We consider it highly improbable, however, that lands used for the purpose of an aqueduct would be condemned by the State of New Jersey for any public use of that State.

Question III.

> "Whether there is any statute or constitutional provision exempting water supply bonds or indebtedness from the debt limit?"

We beg to advise you that Section 10 of Article 8 of the Constitution of the State of New York, as revised by the Constitutional Convention of 1894, provides that no county or city shall be allowed to become indebted for an amount exceeding ten per cent. of the assessed valuation of the property subject to taxation; but the section further provides as follows:

> "Nor shall this section be construed to prevent the issue of bonds to provide for the supply of water; but the term of the bonds issued shall not exceed twenty years, and a sinking fund shall be erected on the issuing of said bonds for their redemption, by raising annually a sum which will produce an amount equal to the sum of the principal and interest of said bonds at their maturity. All certificates of indebtedness or revenue bonds issued . . . after incurred by any portion or part of a city, if there shall be any such debt, shall be included in ascertaining the power of the city to become otherwise indebted."

We are of the opinion, therefore, that the City of New York can become indebted for a water-supply by the issuance of bonds, whose term shall not exceed twenty years, accompanied by a proper sinking fund.

(See Title 22 Charter, Sec. 169.)

Question IV.

"Can the City of New York acquire (by right of eminent domain) water-rights now held by corporations or private parties, but not necessarily required by them for supplying water to communities, under existing contracts?"

We beg to advise you that the Charter of the City of New York, by Section 472, gives to the Commissioner of Water Supply power to determine what supplies are necessary for the City, and that after certain proceedings have been gone through, it shall be lawful for the City of New York to acquire any real estate necessary to acquire the sole and exclusive property in such source or sources of water-supply; but by the same section it is provided that the Commissioner

> "shall not have power to acquire or to extinguish the property rights of any person or corporations in or to any water rights that, at the time of the initiation of the proceedings for condemnation, were *in whole or in part* devoted to the supply of the water-works of the people of any other city, town or village of the State or to the supply and distribution of the water to the people thereof . . ."

We are of opinion, therefore, that the City cannot condemn water-rights devoted in whole or in part to the supply of other municipalities. But we suggest that the courts might say that the rights must be actually used for such purposes. The purpose of the proviso seems to us to be to protect the water supply of other municipalities. We prefer, however, not to pass definitely and finally upon this question until fuller information as to the conditions is laid before us.

Respectfully submitted,

ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE,
Committee on Legislation.

OPINIONS.

I: Would a Salt-Water Fire-Pipe System be Under Control of Water or Fire Department?

II: Would Present Labor Law Apply to Work Done For or By the City Outside the City Limits?

January 19, 1900.

To the Executive Committee:

GENTLEMEN:

At the last meeting of your committee certain questions asked by the Engineering Committee were referred by you to the Committtee on Legislation for their opinion. These questions were as follows:

Question I.

> "In case a pipe system for extinguishing fires by use of "salt water, pumped by fireboats, is introduced, would same "be under control of Water or Fire Department?"

We beg to report that there is nothing in the charter to indicate that a supplemental system of this kind was contemplated by the framers thereof, and it is reasonably certain that if this method were resorted to, it would be the subject of special legislation. Under the statutes, as they stand, however, we are of opinion that any pipes which are laid and any hydrants connected therewith would be under the control of the Water Department, while the Fire Department would have control of the fireboat. Section 469 of the charter gives the Commissioner of Water Supply control "of all structures and property connected with the supply and distribution of water for public use, except the same shall be owned by private corporations, including all fire and drinking hydrants and all water meters." Section 479 provides "The Commissioner of Water Supply is charged with the preservation and repairs of . . . mains, pipes, pipe-yards and property of every description belonging to the water works, and shall have the construction of such new works and the purchase and laying down of such mains and pipes as may be authorized in accordance with the law."

The chapter of the charter relating to the Fire Department (Chap. 15) gives that department no control of any kind over pipes and mains, except that it is authorized to prevent obstructions to the use of fire hydrants (Section 750). That department (the Fire) is required to "perform all duties for the government, management and maintenance of the Fire Department of the city and the premises and property thereof," and all real estate, fire apparatus, hose, implements, tools, bells and bell towers, fire telegraph and all property of whatever nature in use by the firemen or Fire Department of the city belonging to said city, shall be in the keeping and custody of the Fire Department and for the use of said department." (724). This undoubtedly vests the Fire Department with the control of the fireboats, but the expressions "fire apparatus," "implements" and "all property of whatever nature" are not now construed as giving that Fire Department control over the water mains, and as the method suggested in the question would be carried out by means of additional water mains, we think that it would be regarded and treated in the same way as our existing water mains.

Question II.

> "Would the present Labor Law, as construed by the City authorities, which governs the time, wages, etc., of men employed on public works for the City of New York, within such municipality, apply to contracts for work done for or by this City outside of the City limits; such as aqueducts, etc?"

We answer this question in the affirmative. Section three of the Labor Law, as amended by Chapter 567, of the Laws of 1899, provides specifically that the eight-hour law shall apply to all municipal contracts. It is provided by this section that the wages to be paid for a day's work "shall not be less than the prevailing rate in the same trade or occupation in the locality within the State where such public work on, about or in connection with which such labor is performed, or its final or completed form is to be situated, erected or used."

We are of the opinion that under this clause, work done outside of the County of New York would be paid for at the rate prevalent in the county where the work was done, and not at the New York County rate.

Respectfully submitted,

ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE,
Committee on Legislation.

OPINION.

I: Obligation of City to Accept Water Under Ramapo Contract.

New York, February 9, 1900.

To the Executive Committee:

Gentlemen:

By a resolution of your Board, passed at a meeting of the Committee held on February 2, 1900, the proposed Ramapo contract was referred to a special committee to frame questions to submit to the Committee on Legislation, outlining the legal objections to the proposed contract. The Legislative Committee, after a somewhat lengthy investigation of the proposed Ramapo contract, would respectfully report that so large interests are involved that it seems unwise on our part to take up all of the legal objections that might be raised to this contract. This subject is now before the courts in various litigations, and is of such vital importance that it is bound to come before the highest courts in the State. The questions involved in these litigations include the constitutionality of the statute under which the Ramapo Company proposes to contract with the City, the character of the contract, as to whether or not it is an option, the right of the Ramapo Company to make any contract because of failure to exercise corporate powers, the contention being that the company is legally dead, and other questions whose determination will settle the right of the Ramapo Company to make any contract whatever with the City.

We have considered one question, however, which was under discussion at the last meeting of the Committee, as to whether the proposed Ramapo contract is an option. We wish to report that Mr. Justice Gildersleeve, in his opinion at Special Term on December 13, 1899, in the case of Charles E. Keator v. William Dalton, as Commissioner, etc., said:

> "The allegation of the complaint that the contract is a wasteful one is not the statement of a fact. No facts are stated showing ground for apprehension of future injury.

The contract is before the court, and a careful perusal shows it to be quite harmless. It is a simple option. By its terms the Ramapo Water Company is to supply water, provided the City needs it. If the City does not need water, she need not take it. It really confers upon the City a privilege of which she may avail herself, if she wishes to do so. No waste of the City's estate is likely to result from such a contract. The contract itself refutes such an allegation."

The members of the Committee are, however, of the opinion that the language used by the learned Justice is not borne out by the wording of the proposed contract. There are mutual obligations contained in said contract. The City agrees to accept, receive, and pay for, such water *as it may require.* In case the City should hereafter require more water, then it is bound to take that water from the Ramapo Company at the stipulated price, according to other conditions of the contract. The meaning of the words "*as it may require*" is so indefinite, that it furnishes one of the most potent arguments why the proposed contract should not be adopted. Respectfully submitted,

ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE,
Committee on Legislation.

OPINIONS.

I: Control of Waters Flowing From New Jersey Into New York.

II: Acquirement of Land in New Jersey.

III: Control of Drainage Basin in New Jersey.

April 6, 1900.

To the Executive Committee:

GENTLEMEN:

The following resolution is submitted by the Engineering Committee to the Legislative Committee:

> "That the Legislative Committee be requested to advise this Committee as to the legal position of the suggested Wallkill Reservoir in the State of New Jersey as shown on the accompanying map, as regards:
>
> "I: Can the City take into this reservoir water now running from the State of New Jersey into the State of New York?
>
> "II: Can the City acquire land in the State of New Jersey except by purchase?
>
> "III: Can the City acquire any power of preserving drainage basin from pollution in the State of New Jersey as shown on the map submitted, except by purchase?"

To these questions we beg to reply as follows:

Question I.

We are of opinion that the City, under the right of eminent domain, could take the waters running into the State of New York after they reach the State of New York, but that the City would have no right to interfere with the flow of waters in the State of New Jersey.

Question II.

We are of opinion that the City cannot acquire land in the State of New Jersey for the purposes of this reservoir, except by purchase.

Question III.

We are of opinion that the City cannot acquire any power of preserving drainage basin from pollution in the State of New Jersey, except by purchase.

Our reasons for this opinion are set out in full in our report to your Committee, dated December 21, 1899.

Respectfully submitted,

ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE,
Committee on Legislation.

OPINION.

I: Compensating Reservoirs As a Means of Avoiding Payment of Damages to Lower Riparian Owners.

March 9, 1900.

To the Executive Committee:

GENTLEMEN:

At the last meeting of your committee we reported the receipt of a letter from the Engineering Committee, and asked for further time in which to consider the questions referred to therein. We have examined these questions relating to compensating reservoirs, and accordingly make the following report:

It appears that one of the plans proposed by the Engineering Committee is to supply the City of New York with water from the Hudson River in the Adirondacks. It is proposed to build a reservoir of sufficient size to hold the flood-waters of the stream, and subsequently to deliver the water to the lower riparian owners at an even rate of flow. By such compensating reservoirs the normal flow of the river will be obtained throughout the year, and the lower riparian owners will be protected against freshets and droughts, and will receive an even flow of water the year round.

In case the City should construct such reservoirs as to deliver to the lower riparian owners throughout the year substantially the normal flow of the river, the Engineering Committee asks whether such construction will relieve the City from the payment of damages to the lower riparian owners.

We will assume for the purpose of this opinion that no actual damage can be shown by the lower riparian owners, by reason of the building of the reservoir. Even upon this assumption, we are of the opinion that the lower riparian owner could enjoin the City from obstructing the flow of water, and that the City would be compelled to condemn the water-rights of the lower owners and pay therefor substantially the full value of those rights, as long as the city was under no legal obligation to furnish a uniform supply to the lower owner, the right to the use of the entire stream would have to be condemned.

We reach this conclusion with considerable hesitation, and base it entirely upon authority, for we feel that the reasoning of the court is far from satisfactory.

The leading case in this State is Smith v. The City of Rochester, 92 N. Y. 463; on second trial, 38 Hun. 612, opinion affirmed, 104 N. Y., 674.

In that case the City of Rochester, under legislative grant, took for the purpose of its water-supply two ponds. The plaintiff was the owner of a mill upon Honeoye Creek, the outlet of Hemlock Lake, one of the ponds taken by the city. Upon the agreed facts of the case it appeared that the waters flowing through the creek were sufficient for the plaintiff's use in propelling his mill except during the dry season, and that during the dry season the plaintiff had been furnished by the city with a flow of water from another pond, by means of bulkheads and gates, giving a more uniform supply of water than by the natural flow. It was also agreed that the city had erected the bulkheads and gates for the express purpose of supplying the plaintiff with a more uniform supply of water, and that it proposed to continue such supply. It was also stipulated that the plaintiff had not suffered any damages because of the interference of the defendant with the waters of the pond.

Upon this state of facts, the trial Judge, the General Term, and the Court of Appeals were of the opinion that the plaintiff was entitled to an injunction restraining the city from diverting the flow, though no pecuniary damages were shown.

The argument in brief is this: The plaintiff is entitled to the flow of the creek in its usual volume. His right is to the flow, not only in its accustomed channel, but from its natural sources. This right is absolute, and the defendant cannot change it without the consent of the plaintiff and defend upon the ground that it is giving a full equivalent. Therefore the Court directed that an injunction issue unless the defendant condemn the plaintiff's right.

In Neal v. The City of Rochester, 156 N. Y. 213, upon similar facts the Court held that it was no defence to the city that it was furnishing the plaintiff (a lower riparian owner) with an equivalent flow, because this was a gratuitous act of the city, and the plaintiff had no legal right to compel its continuance.

Of course the city could make such a contract with a lower owner, but this is only saying that it may obtain this right by contract instead of by condemnation.

These cases established the principle that the lower riparian owner can prevent the erection of compensating reservoirs unless the city condemns the right of such owners. The fact that the injury to the lower owner is apparently nominal is not in itself sufficient to prevent such owner from obtaining injunctive relief. His right to the flow of the water is absolute and cannot be taken away except upon condemnation, and upon condemnation proceedings it would be necessary to determine all damages which he might suffer by reason of the diversion of the water; the fact that the city was furnishing a uniform supply by compensating reservoirs was no protection to it, as the lower owner would have no right to compel the city to continue the supply.

Respectfully submitted,

ARTHUR J. BALDWIN.
CHARLES L. GUY.
JOHN M. PERRY.
HENRY W. GOODRICH.
JOSEPH G. DEANE.

Committee on Legislation.

OPINIONS.

Underground Waters in Suffolk County.

To the Executive Committee:

GENTLEMEN:

At the meeting of your Committee held on Friday, January 19, the question suggested by Mr. North was referred to us for our opinion. The question as submitted is as follows:

Question.

> "The report of the Committee on Legislation of Dec. 21, 1899 (page 463), recites Chapter 942, Laws of 1896, in which is found: 'To enter into, or upon such pond and streams, or upon the land adjacent thereto and take water therefrom. . .'
>
> "Would that phraseology apply to ponds and streams that are entirely underground?
>
> "There are ponds or deposits of water not only under the surface of Long Island but under an impervious substratum. Can such ponds or streams be taken by this City, or are they covered by Chapter 942 of the Laws of 1896?"

In answering this question we beg to call your attention to the peculiar wording of Chapter 942 of the Laws of 1896. That chapter provides:

> "Whenever the Board of Supervisors . . . decide that certain streams and ponds within such county are necessary for the supply of pure and wholesome water . . . the said Board shall direct a certificate to that effect . . . to be recorded in the office of the clerk of said county. . . ."

Sec. 2 of the law provides that the certificate mentioned in the preceding section shall contain the name of the pond or stream, a description of the same, where located, the riparian owners, etc.

Sec. 3 of the law then provides that whenever such certificate has been made and recorded, it shall not be lawful for anyone to take water from such stream for the purpose of supplying water to any city outside of the county.

We are of the opinion, therefore, that Sec. 942 of the Laws of 1896 does not apply to streams of water underground unless such streams or ponds have been designated by the Board of Supervisors, in accordance with the act, as streams and ponds that are necessary for supplying the inhabitants of the county with pure and wholesome water.

Respectfully submitted,

(Signed)
ARTHUR J. BALDWIN,
CHARLES L. GUY,
JOHN M. PERRY,
HENRY W. GOODRICH,
JOSEPH G. DEANE.

SECTION IV.

REPORT AND OPINIONS OF THE COMMITTEE ON LEGISLATION.

PART III: APPENDICES.

THE PROPOSED RAMAPO CONTRACT, OFFICIAL ACTION THEREON AND THE CONTROLLING STATUTES.

CONTENTS OF APPENDIX A.

THE PROPOSED RAMAPO CONTRACT, OFFICIAL ACTION THEREON AND THE CONTROLLING STATUTES.

[At a meeting of the Board of Public Improvements, held August 9, 1899, Water Commissioner Dalton gave notice that at the next meeting he would present for approval by the Board a proposed contract for supplying the City with water. The proposed contract, Commissioner Dalton's recommendations, and the subsequent action of the Board of Public Improvements thereon, are set forth by the following abstract from the official record, to which is appended the text of the Laws cited as authority for the contract.]

I.

REPORT OF COMMISSIONER DALTON RECOMMENDING THE RAMAPO CONTRACT AND ACTION THEREON.

[*Abstract from Proceedings of Board of Public Improvements, August 16, 1899.*]

The Board of Public Improvements of the City of New York met at the office of the Board, No. 21 Park Row, on Wednesday, August 16, 1899, at 2 o'clock P. M., pursuant to notice.

The roll was called and the following members were present and answered to their names:

The Comptroller, the Commissioner of Water Supply, the Commissioner of Highways, the Commissioner of Street Cleaning (Deputy Commisioner Gibson), the Commissioner of Sewers (Deputy Commissioner Donohue), the Commissioner of Public Buildings, Lighting and Supplies; the Commissioner of Bridges, the President of the Borough of Manhattan, the President of the Borough of the Bronx, the President of the

Borough of Queens, the President of the Borough of Richmond and the President of the Board.

* * * * * *

The following report from the Commissioner of Water Supply was read:

DEPARTMENT OF WATER SUPPLY,
NEW YORK, August 9, 1899.

Hon. Maurice F. Holahan, President, Board of Public Improvements:

DEAR SIR—The present conditions of the water-supply of Greater New York, and those which confront us in the near future, impose on this administration the imperative duty of taking prompt and decisive action to remedy existing deficiencies and to secure to the people an adequate supply of pure and wholesome water, such as a great city requires for the preservation and promotion of the public health, for the fullest possible protection of property and lives from the ravages and dangers of fire, for the support and encouragement of industries, and for domestic necessities and comfort. The duty thus imposed upon me as Commissioner of Water Supply, and upon your Board as the municipal body which has the power to authorize me to take the necessary remedial measures, cannot safely be put off.

Although the conditions to which I refer have in part or in whole been set forth in my official reports and communications to his Honor, the Mayor, and published in the "City Record" and printed in documents, I deem it proper to present herewith a concise statement of the situation:

Needs of Brooklyn and Queens.

The full normal capacity of the public water-supply of the Borough of Brooklyn is 93,000,0000 gallons per day for a population now estimated conservatively at 1,200,000. It has so remained for more than five years without additions or improvements, while the population and the demands on the water service have been constantly growing. About three-fifths of the supply is obtained from flowing streams and from ponds; the other two-fifths, or about 40,000,000 gallons per day, has to be pumped out of the soil from driven wells. The objections to a water-supply for a great city population from deep wells are too well-known to need reiteration here. The entire supply, even that from the flowing streams and ponds, has to be pumped to a height of 170 feet into the Ridgewood reservoir for distribution through the water mains, and some of it an additional height of 50 feet into the Mount Prospect reservoir, and 80 feet more into the Mount Prospect tower in order to gain sufficient pressure to deliver the water in houses on high ground.

If the people of the Borough of Brooklyn are to be supplied with water at the same rate per capita as the people of the Boroughs of Manhattan and the Bronx, they would now need a daily supply of 150,000,000 gallons. This would require an immediate addition of 57,000,000 gallons per day from new sources, and if the undesirable and unreliable supply from driven wells is to be eliminated we would have to obtain 97,000,000 gallons per day to bring the Brooklyn water-supply up to the standard of the supply in Manhattan and the Bronx.

In the Borough of Queens, where the City owns three pumping-stations in Long Island City, one at College Point, one at Flushing and one at Whitestone, with systems of distributing mains, the conditions are even worse. The entire supply is obtained from deep wells, some of which are in such close proximity to the shore of the East River or Long Island Sound that the pumping of water from them has to be carefully limited to prevent the drawing of an admixture of salt water, which would render the entire supply unpotable and unfit for use. Some of the other wells are in surroundings where there is a constant increase in population and buildings which will in a short time compel the abandonment of the wells in consequence of pollution from house drainage. The wells and plants are now worked to their maximum capacity, producing a supply of 3,350,000 gallons per day. This supply is manifestly and absolutely inadequate even for the present population and number of water consumers, much less the extensions of the public water service into new streets and territory for which requests are constantly received from property-owners. It would be profitable for the City and highly advantageous to the population in the water districts of Long Island City, College Point, Flushing and Whitestone if we were in a position to at once increase the daily water-supply to five or six million gallons, and have the facilities to continue increasing it so that we could encourage instead of retarding private enterprise and investments in household property by responding to all reasonable demands for extension of the water service, and giving assurance that the water-supply shall be sufficient for domestic and industrial uses, for fire protection and for the protection of the public health.

In accordance with these views I estimate the present necessities for public water-supply in the Borough of Queens at 6,000,000 gallons per day. When the projects for connecting the Borough with Manhattan Island by bridges are carried out, the population within the present public water districts, Long Island, College Point, Flushing and Whitestone, will increase at a much larger ratio than in any other section of Greater New York, and the demands for water-supply will increase in proportion. Therefore, in the estimate which I give below I assume the needs of water-supply for these water districts at 6,000,000 gallons per day at the present time, and the rate of annual increase required at 20 per cent.

Only Five Years' Supply for Manhattan and Bronx.

It is a mistaken idea or theory which many people may entertain that the Boroughs of Manhattan and the Bronx are not in need of prompt action and measures to increase the water-supply, and more especially the pressure and elevation at which water can be delivered in the houses for extinguishing fires. While the entire supply from the Croton, Bronx and

Byram watersheds comes into the City reservoirs by gravity or natural flow, the elevation at which it can be delivered in houses from the distributing mains is limited to 119 feet above mean-tide, and in many localities the elevation of delivery is less. As early as 1870 it became necessary to resort to steam pumping machinery to deliver the water in houses on higher grounds, beginning with a small pumping station at Highbridge, with a daily capacity of 2,500,000 gallons. The growth in population and buildings in the high-service districts has been such that up to date the capacity of the high-service supply had to be increased to 55,000,000 gallons per day by the establishment of two additional pumping stations, and the purchase and erection of additional pumping machinery. The demand for high-service supply continues to grow at a constantly increasing rate, so that this Department is compelled to make, and does make, plans and preparations from time to time to increase the capacity of the pumping machinery.

In the Borough of the Bronx there is as yet no high-service, and the consequence is that the Department is unable to properly supply houses on University Heights, Morris Heights, Woodlawn Heights and other elevated sections of the Borough, giving rise to many and justifiable complaints that the house-owners and residents in these locations are unfairly treated and neglected as to their rights for a fair water-supply.

In less than five years from now the water-supply for Manhattan and the Bronx will be deficient in quantity, as well as in pressure or in elevation of delivery. The average daily consumption for the past six months is 265,000,000 gallons, and the maximum during the hot days of June and July was 286,000,000 gallons, which is an increase of 30,000,000 gallons over the maximum consumption last year, or nearly twelve percent. The combined capacity of the old and new Croton Aqueducts and the Bronx River conduit, which are now the only means of conveying water to these boroughs, is 400,000,000 gallons per day. Therefore, at the present rate of increase in consumption the limit of capacity of the present water system will be reached in four years or less, and on an increase of ten per cent. per annum it will be reached in less than five years.

Summary of Supply and Consumption.

The following figures show in the most concise form the present rate of supply and consumption of water in the four boroughs, and the increase which will be needed in four years and in ten years from this date, calculated at ten per cent. per annum (except for the Borough of Queens), which is a very conservative estimate, amply supported by past experience:

Borough of Brooklyn.

	Gallons.
Present supply and consumption	93,000,000
Increase required in four years (1903)	43,161,000
Increase required in ten years (1909)	168,218,000

Boroughs of Manhattan and the Bronx.

	Gallons.
Present supply and consumption	265,000,000
Increase required in four years (1904)	122,986,000
Increase required in ten years (1909)	422,341,000

Borough of Queens.

	Gallons.
Present supply, 3,350,000 gallons; supply actually needed	6,000,000
Increase required in four years (at 20 per cent. per annum)	11,450,000
Increase required in ten years	53,000,000
Total increase required in four years	177,597,000
Total increase required in ten years	640,559,000

Petitions for Increase.

Treating on needs for more and better water-supply for the four Boroughs as a whole, or each one separately, I can say that this is not the first presentation of the urgent necessity of prompt action to secure such increase.

As I have already stated in this communication, the official reports of the Department of City Works of Brooklyn for several years prior to 1898 are replete with evidence that the water system of that Borough needs expansion and improvement.

In respect to the Boroughs of Manhattan and the Bronx, your Board received in June of last year a communication or petition from the New York Board of Fire Underwriters making a most forcible appeal for a larger water-supply, which can be brought to the City at such elevation or under such pressure that it can be delivered through the distributing mains and in houses to the top story of every building except the very high office and business buildings, without the necessity and expense of pumping either by the City at the high-service stations or by the owners or tenants of buildings. The demands made in that communication or petition are summarized as follows:

"Protection against fire throughout the City.

"A more efficient supply to the modern high buildings, which represent large and rapidly increasing values.

"A general supply to all buildings of ordinary height without private pumping; and

"Pure mountain water in sufficient quantity to prevent scarcity in case of accident to the present system of reservoirs and aqueducts."

Petitions of the same purport and the same urgency were presented to the Commissioners of the Sinking Fund in September, 1895, from fire underwriters, real estate owners and agents, bankers, hotel keepers and others, with resolutions of the Board of Trade and Transportation and the Chamber of Commerce.

It must be borne in mind that these petitions, which relate more particularly to the water-supply of the Boroughs of Manhattan and the Bronx, though they have the intention and object of securing better water service for the entire Greater New York, have been presented since the acquisition of a large additional supply through the new Croton Aqueduct, which came into use in July, 1890.

Prior to that, in 1883, when the plans for the new Croton Aqueduct had been made and its construction assured, a Merchants' Committee of which such prominent citizens as Cornelius N. Bliss, William L. Strong, John Claflin, Charles S. Smith and William E. Tefft were members, appointed at a mass meeting of business men, petitioned the Legislature for the enactment of a law that would enable the City to obtain by contract a supply of pure and wholesome water from the mountain streams and lakes west of the Hudson River to supplement the Croton system. These eminent and representative citizens of New York evidently foresaw the inadequacy of the Croton, Bronx and Byram River systems to supply the future needs of the old City of New York, now Boroughs of Manhattan and the Bronx, and that these systems would always lack the element of giving sufficient elevation of delivery of the water to furnish at all times sufficient pressure for the extinguishment of fire and to do away with private pumping in houses.

Personal Inspection of Proposed Source.

These petitioners pointed to the mountainous region west of the Hudson River as the best, most available, most reliable and most economical source of water-supply for the future needs of the City for years to come, and to the superior quality of the water which can be obtained from that region, as compared with the water from all the present sources of supply, and from other sources which are practically available.

I find these views confirmed by the judgment of eminent engineers. For the purpose of making some personal observations and obtaining practical knowledge of the conditions and capacities of the available watersheds in the hills and mountains west of the Hudson River, I made a tour of examination, in which I was accompanied by you, as President, and representatives of the Board of Public Improvements, and four engineers of high standing, including the Chief Engineer of this Department and the Chief Engineer of your Board.

The territory which we visited and examined covers part of the district known as the Highlands of the Hudson, and part of that which is generally described as the Catskill Mountains. The Highlands district may for convenience be called the Fort Montgomery Watershed. The section of the Catskill Mountains which we visited and examined embraces the Valley of Esopus Creek, the upper water of Schoharie Creek and the head waters of the east branch of the Delaware River. It presents the very great advantage of a large number of natural sites for storage reservoirs which can be made available with comparatively small cost for the construction of dams, sluices, etc.

Description of Sites Proposed.

The following is a brief description of the reservoir sites which we examined, commencing at the southern end of the watersheds.

The Fort Montgomery Reservoir site is about forty miles from the City, and two miles west of the Hudson River. It has an elevation of 400 feet above tide level, will flood about 150 acres in area, and has a watershed of about 45 square miles.

The Popolo Reservoir site has an elevation of 500 feet above tide, and an area of about 250 acres.

The Mine Pond, five miles from the Hudson, has a natural flood area of ten acres, 600 feet above tide.

Lake Popolopen, five and one-half miles from the Hudson, is more than two miles long and one thousand feet wide, with an elevation of 650 feet above tide.

Lake Hill Reservoir site can be flooded to an area of 300 acres at 1,050 feet elevation above tide.

Coal Brook Reservoir, in the Esopus Valley, can be made to contain 15,000,000,000 gallons of water at an elevation of 675 feet.

The Olive Reservoir site can be made to impound 7,000,000,000 gallons.

Statement of Quantity Available.

The aggregate area of the watersheds referred to is over 1,400 square miles. Official records, kept for the last twenty-six years, show that the rainfall in this region averages fifteen per cent. greater than the rainfall in the Croton watershed. The population averages not more than 10 to the square mile. The geological and topographical features assure a larger yield, or percentage of yield, than could be obtained for a potable water supply in a less mountainous, more populated and more agricultural territory, such as the Croton watershed.

All these conditions confirm the estimate that these watersheds are capable of furnishing ultimately a daily water-supply of 900,000,000 gallons of the purest quality which can be obtained anywhere in the State of New York.

Other Sources Inferior.

Other sources for an additional supply have been suggested from time to time, none of which present the same combination of amplitude, reliability, excellence of quality of the water, economy of cost, susceptibility of gradual development by gradual increase of the supply to be obtained in conformity with the growing needs of the City.

From the Ten Mile River in the Housatonic watershed a daily supply of 110,000,000 gallons might be obtained. If this supply was led into the Croton aqueducts it would fail to give the much needed increase of pressure and elevation in the delivery of the water. To obtain a higher elevation of delivery from this source a new aqueduct or conduit would have to be built from that watershed to the City at a cost of $40,000,000 or more. The water would be inferior in quality, because the watershed contains a great number of factories and dwellings, has a large population which is constantly increasing, and gradual pollution of the water would certainly ensue.

Lake George, Lake Ontario and Lake Champlain have been suggested as practically inexhaustible sources of supply. A supply from Lake George would flow by gravity to tide level at New York, where it would have to be pumped to the required elevation. The construction of the necessary work to obtain a large supply would cost not less than $200,000,000. A supply from Lake Champlain would flow by gravity to Troy, where it would have to be pumped 250 feet high in order to reach tide level at New York, and then again pumped to required elevation.

A supply from Lake Ontario would flow by gravity to Albany, where it would have to be pumped 230 feet high in order to flow by gravity to tide level at New York, where it must again be pumped to the required elevation.

To convey a water-supply from any one of these three lakes would require the building of tunnels, respectively 10, 56 and 50 miles in length, to pass the intervening ridges of hills, or immense pumping machinery to raise and pass the water over the ridges.

A gravity supply could be obtained from the Adirondacks under pressure equal to that to be obtained from the watersheds west of the Hudson, but the necessary works of construction would probably cost not less than $500,000,000, and could not be completed in less than twelve years.

The facts again demonstrate the superiority of the watersheds west of the Hudson as a source of water-supply for the City of New York.

Questions of Time.

I now come to the question of cost, and of the time within which a large addition to the water-supply can most speedily be obtained. Both of these questions are of paramount importance in the consideration of the subject.

I will first deal with the question of time, taking it for granted that the watersheds of the Hudson Highlands and the Catskill Mountains, as above described, will be chosen as the source of supply.

If the City were to undertake acquisition of the necessary lands and water rights, and the construction of the dams, reservoirs, tunnels and conduits to convey the water to the distributing mains in the city, it would have to go through the process:

First.—Obtain authority for the necessary bond issues through the Board of Estimate and Apportionment and the Municipal Assembly.

Second.—Employ a large corps of engineers, surveyors and draughtsmen to make detailed surveys and maps of every parcel of land, every millright and right-of-way.

Third.—File copies of these maps in the office of the County Clerk of each county included in the watershed and along the conduit which is to convey the water to the City and in the several offices in the City where the law requires such maps to be filed.

Fourth.—Apply to the Supreme Court for the appointment of Commissioners of Appraisal to determine the damages to be paid for the taking of lands, etc., or obtain the lands, water rights and rights-of-way by negotiations and purchase with and from each individual owner, and then only with the consent and approval of the Comptroller.

Fifth.—Employ engineers to make detail plans and estimates of construction, so as to be prepared to advertise for proposals from contractors to do the work.

Sixth.—Advertise the contracts for public letting, make awards to the lowest bidders at public letting, provided they furnish satisfactory sureties to the required amounts.

Seventh—Take the risk that the contractor or contractors to whom the work is awarded are dilatory and slow in the performance of the work, or otherwise violate the conditions of their contract, or totally abandon their works of contracts, or compel the City to declare the contracts abandoned, and to resort to readvertisement and reletting to new contractors with the same risk.

The records of the public works of the City are full of illustrations of the delays which seem to be inseparable from the prosecution of large public improvements of the magnitude of the one which is the subject of this communication. I have shown in the foregoing part of this communication that the Boroughs of Brooklyn and Queens are in need of additions to their water-supply even at this day, and that the Boroughs of Manhattan and the Bronx will need additional water-supply before the expiration of five years. I have the conviction, based on past experience in city affairs, that under the most favorable circumstances the City could not accomplish the completion of the necessary works of construction, and all the other incidental measures, in a shorter period than seven years. An example of this may be found in the time which elapsed between the creation of the Board of Aqueduct Commissioners, in June, 1883, and the completion of the new aqueduct, so that it could be brought into use in July, 1890.

The Question of Cost.

If the City undertakes the work itself it must build so that the addition to the water-supply shall be assured for a series of years after the completion of the works, which means that it must build reservoirs and conduits of sufficient capacity to guarantee an additional supply of not less than 600,000,000 gallons per day, and must be ready to make bond issues to an amount of not less than $70,000,000, and possibly $100,000,000. This great municipality is confronted with a financial condition which makes such bond issues for water-supply purposes alone impossible unless it be done with the exclusion of all other necessary public improvements which are payable from bonds, such as parks, school houses, bridges, etc., etc.

These considerations as to cost and time lead me to the presentation of the recommmendation which I will now make, and in making it I desire to again emphasize the seriousness of the situation, which makes time precious and prompt action imperative.

Proposed Contract Recommended as Advantageous.

It is not necessary that the City commit itself to a bond issue in this case, or that it shall incur any expenditure. Private capital stands ready to construct the works and furnish the water without obligation or cost to the City, except to pay for the water when delivered. A proposal has been presented by a responsible company to furnish the needed water-supply at a pressure due to an elevation of three hundred feet, or more if desired, above tide level. By act of the Legislature this company is authorized to contract with the City of New York to furnish such a water-supply. The proposal is to deliver to the City, at its northern limit, not less than 200,000,000 gallons of water per day within five years from the date of the acceptance of the proposal, at $70 per million gallons. The company has taken all necessary legal steps to secure this water-supply, and such additions to it as the City will need, above 200,000,000 gallons per day, as the watersheds of the Hudson Highlands, and part of the Catskill Mountains, already described, can yield. I am satisfied of the competency and reliability of the company to carry out this proposal, and I am also satisfied that under the existing conditions, as herein stated, it will be advantageous to accept the proposal. The lowest rate at which this City sells water to consumers by measurement is the Brooklyn meter rate of 7½ cents per one hundred cubic feet, or $100 per million gallons. This leaves a quite sufficient margin between the price asked by this water company and the lowest rate charged by the City to consumers, to more than pay for the cost of distributing the water to consumers through the mains and collecting the water rents.

The Company is not seeking a municipal franchise. It does not propose to sell water to the residents of this City. It will deliver the water to the City, and the City will distribute it through its mains in the same manner as the public water-supply in the several Boroughs is now distributed, and the City will collect the water rents as heretofore.

I submit herewith for approval by your Board a contract with the Ramapo Water Company, on the basis of the Company's proposal, and approved as to form by the Corporation Counsel.

Very respectfully,

WILLIAM DALTON,
Commissioner of Water Supply.

The Commissioner of Bridges moved that the matter be laid over for four weeks, which motion was lost by the following vote:

Affirmative—The Comptroller, Commissioner of Street Cleaning, Commissioner of Bridges, Commissioner of Public Buildings, Lighting and Supplies, President of the Borough of Queens and President of the Borough of Richmond—6.

Negative—Commissioner of Water Supply, Commissioner of Highways, Commissioner of Sewers, President of the Borough of Manhattan, President of the Borough of the Bronx and President of the Board—6.

A motion to lay the matter over for three weeks was lost by the following vote:

Affirmative—The Comptroller, Commissioner of Street Cleaning, Commissioner of Bridges, Commissioner of Public Buildings, Lighting and Supplies, President of the Borough of Queens and President of the Borough of Richmond—6.

Negative—Commissioner of Water Supply, Commissioner of Highways, Commissioner of Sewers, President of the Borough of Manhattan, President of the Borough of the Bronx and President of the Board—6.

At the suggestion of the President of the Board the matter was laid over for two weeks, pending a report from the Comptroller; the Commissioner of Highways and the Commissioner of Water Supply voting in the negative.

II.

THE PROPOSED RAMAPO CONTRACT.

Agreement made this day of , 1899, by and between the Ramapo Water Company, a corporation of the State of New York (hereinafter called the Water Company), party of the first part, and the City of New York, a municipal corporation, by William Dalton, the Commissioner of Water Supply of said corporation (hereinafter called The City of New York), as authorized by chapter 378, sections 415, 457 and 471 of the Laws of 1897, party of the second part.

Whereas, The said water company was duly incorporated on or about the 12th day of September, 1887, under and in pursuance of the act of the Legislature of the State of New York, passed on the 17th day of February, 1848, entitled "An Act to authorize the formation of corporations for manufacturing, mining, mechanical or chemical purposes," and of the several acts of the said Legislature amendatory thereof; and

Whereas, The said water company is authorized and empowered by law, and more particularly by the provisions of chapter 985, Laws of 1895, entitled "An Act to limit and define the powers of the Ramapo Water Company," passed on the 11th day of June, 1895, to acquire such lands and waters along the sheds of the Ramapo and along such other watersheds and their tributaries as may be suitable for the purpose of accumulating, storing, deducting, selling, furnishing and supplying water for domestic and municipal purposes to any city, town and village, and may contract with any corporation in this State, public or private, to furnish water for the purposes mentioned; and

Whereas, The said water company has proposed to supply the City of New York with water from streams and lakes and their tributary watersheds in the State of New York, west of the Hudson River, to be delivered at a pressure at the place of delivery due to an elevation of 300 feet above the mean tide level; and

Whereas, The City of New York is authorized, under the provisions of chapter 958, section 3, Laws of 1895, to enter into a contract with said water company to furnish water for domestic and municipal purposes to said city for any length of time that may be deemed advisable; and

Whereas, The said Commissioner of Water Supply has duly examined into the sources of the water-supply so proposed to be furnished by said water company, and has selected the Esopus and its tributary and connecting watersheds, and has determined that the supply from those sources will be adequate, and that water supplied from these sources will be pure and wholesome; and, being drawn from mountainous and rocky areas very sparsely populated, is and will remain and continue to be free from contamination and pollution, and has determined that said water company is duly authorized by law to do whatever is necessary to enable it to furnish and deliver to the City of New York and to its inhabitants the quantity of water which the said water company hereafter agrees to furnish and deliver, at a pressure at the place of delivery due to an elevation of 300 feet mean tide level; and

Whereas, Preliminary to the execution of this contract the provisions of this contract in all its details in form and substance as herein provided were submitted to the Board of Public Improvements of the City of New York, and the assent of said Board, after such submission to it, was given by resolution to the execution of such proposed contract as so submitted;

Now, therefore, this agreement witnesseth, that in consideration of the mutual covenants herein contained, and of one dollar ($1) in hand paid by each party hereto to the other party hereto, the receipt whereof is hereby acknowledged, and in consideration of the construction by the said water company of the dams, reservoirs, conduits and pipe lines necessary to carry out the covenants and conditions of the said water company herein contained, the parties hereto have covenanted, promised and agreed and hereby covenant, promise and agree, the party of the first part for itself, its successors and assigns, and the party of the second part for itself and assigns, as follows:

1. The said water company, the party of the first part, will furnish, supply and deliver, by a gravity system of transmission, at its own cost and expense, water to be taken from the Esopus and its tributary and connecting watersheds west of the Hudson River and in the State of New York, to the party of the second part, the City of New York, at the time and place, and in the manner and under the conditions hereinafter specified, and will acept as full compensation therefor the sum of seventy dollars ($70) for each and every million gallons of such water so delivered.

2. The said water company hereby covenants and agrees that the water so furnished, supplied and delivered shall not be drawn from any stream or lake the surface of which is at an elevation of less than four hundred and twenty feet above mean tide level, and that such water shall be of greater purity than the water supplied to the City of New York from the Croton and Long Island watersheds, as shown by the average of the analyses of the water from these sheds taken from the distributing reservoirs within the cities, which have been made under the direction of the Health Officers of the City of New York and of the City of Brooklyn during the past year, as shown by the public record as compared with the average of the analyses for a like period of the water to be furnished by the party of the second part, taken at the point of delivery to the City to be made by the Health Officers of the City of New York or by the Commissioner of Water Supply of said City.

3. The said water company further covenants and agrees to furnish, supply and deliver to the City of New York two hundred million (200,000,-

000) gallons of such water, at a pressure due to an elevation of 300 feet above mean tide level on and during each and every day for the period of forty years, from and after the first day of , in the year 1902. Subject, however, to the right of the City of New York (through its Commissioner of Water Supply or his successor in office or position) to reduce the quantity of supply to such number of gallons as to his judgment may be required, upon notice thereof to the party of the first part, except as hereinafter otherwise excepted, conditioned and provided; and to deliver such water to the party of the first part at the northern boundary line of the City of New York at the point of intersection thereof with the new Croton Aqueduct.

4. The said water company hereby covenants and agrees that it will construct, maintain and operate all such reservoirs, conduits and pipe lines, as may be necessary to accumulate, store, furnish, supply and so deliver such water without cost or liability to the City of New York other than the payment of seventy dollars ($70) for each and every million gallons of such water so furnished, supplied and delivered, as herein provided.

5. The City of New York, in consideration of the covenants, promises and agreements of the said water company herein contained, covenants and agrees to accept and receive such water as it may require, not exceeding two hundred million (200,000,000) gallons of such water so delivered by the said water company, on and during each and every day from and after the first day of , in the year 1902, and the City of New York hereby covenants and agrees to pay, in regular quarterly payments, to the said water company, its successors and assigns, the sum of seventy dollars ($70) for each and every million gallons of such water so delivered not exceeding 200,000,000 daily.

6. The City of New York agrees to authorize, and does hereby authorize, the said water company to act as the agent and representative of the City of New York, so far as it may lawfully do so, in doing whatever may be necessary for the fulfillment of this contract; provided and conditioned that the City of New York shall not incur, or be or become liable for, any cost or expenditure on account thereof or in connection therewith.

7. It is hereby agreed by and between the parties hereto that the agreement of the said water company to furnish, supply and deliver to the City of New York, and of the City of New York to accept, receive and pay for, not exceeding two hundred million (200,000,000) gallons of water on each and every day from and after the first day of , 1902, as hereinbefore expressed, are made subject to and conditioned upon the further understanding and agreement, hereby made by and between the parties hereto, that, in consideration of the promise of the said water company, hereby given, to expedite and hasten the completion of its work so as to enable it to deliver such water, or a part thereof, prior to that date, the City of New York hereby agrees to accept, receive and

pay for, as hereinbefore provided, that quantity of water, or any part thereof, so required, whenever such water shall be furnished and delivered by the party of the first part prior to said date upon the condition that the said water company shall notify the said Commissioner of Water Supply, that it will deliver that quantity of water, or a part thereof, during the next ensuing year, giving in such notification the quantity to be delivered and the date or dates upon which the delivery of the quantity or quantities, if the quantity to be delivered daily is to be increased during the year, will commence; such notification to be so given not less than thirty days prior to the beginning of the year during which the delivery of such quantity of water, or a part thereof, shall be so commenced.

8. It is hereby agreed by and between the parties hereto that the time herein fixed for the delivery of such water as herein provided may be deferred, at the option of the said water company, for a period equal to the time during which the said water company shall be delayed or interfered with in the construction of the works necessary for the delivery of such water, by any injunction or legal proceeding, or by strikes of workmen, or by any other cause of delay not within the power of the said water company to remedy or overcome.

9. It is further understood and agreed by and between the parties hereto that the failure to deliver such water, or any part thereof, at any time after the commencement of such delivery, caused by an accident or injury to the works of the said water company, shall not invalidate this contract, provided such injury, or cause of failure, shall be repaired or removed by the said water company as soon as may be practicable, and that if the said water company cannot, by reason of such accident or injury, deliver the full quantity of two hundred millions (200,000,000) gallons daily, the City of New York shall pay only for the quantity of water that can be delivered.

10. It is hereby further agreed by and between the parties hereto, that this contract may be modified, altered or amended hereafter, in such mannr as the parties may deem to be necessary or desirable.

11. The said water company covenants and agrees that no laborer, workman or mechanic whom it may have in its employ, or in the employ of its sub-contractor or other person doing or contracting to do the whole or part of the work contemplated by this contract, shall be permitted or required to work more than eight hours in any one calendar day, except in cases of extraordinary emergency caused by fire, flood or danger to life or property; and it is further covenanted and agreed that each such laborer, workman or mechanic employed by said water company, its sub-contractors or other person in, about or upon such public work, shall receive such wages as are provided for by Chapter 415 of the Laws of 1897 as amended by Chapter 567 of the Laws of 1899; and it is further covenanted and agreed that upon the failure to comply with the provisions of Section 3, of Chapter 567, of the Laws of 1899, this contract shall be void and of no effect.

The said water company shall furnish a bond to the amount of one hundred thousand dollars ($100,000) for the faithful performance of the above agreement.

In witness whereof, the parties hereto, by their duly authorized officers have respectively signed the corporate seals of the parties hereto and fixed the corporate seals of the parties hereto, the day and the year first above written; and have duly executed this agreement in triplicate, one part of which is to remain with the Commissioner of Water Supply, one part to be filed with the Comptroller of the City of New York, and the third to be delivered to the party of the second part.

Signed and sealed in the presence of:

Approved as to form.

JOHN WHALEN, *Corporation Counsel.*

City of New York and County of New York, ss.:

On the day of , 1899, before me personally came William Dalton, to me known and known to me to be the Commissioner of Water Supply of the City of New York, and the person described in and who executed the foregoing instrument, and who acknowledged to me that he executed the same as such Commissioner of Water Supply of the City of New York and County of New York, ss.:

On this day of , 1899, before me personally came to me known and known to me to be the person described in and who executed the foregoing instrument and who acknowledged to me that he executed the same for the purpose herein mentioned.

III.

OFFICIAL PROTEST OF COMPTROLLER COLER.

[*Abstract from Proceedings of Board of Public Improvements, August 30, 1890.*]

* * * * * *

The hearing in the matter of the proposed contract with the Ramapo Water Company was then opened, and the Comptroller presented the following reports:

DEPARTMENT OF FINANCE,
August 29, 1899.

To the Board of Public Improvements:

GENTLEMEN—At a meeting of this Board held August 16, 1899, the Commissioner of Water Supply presented a report urging the approval of a contract with the Ramapo Water Company to supply the City of New York with 200,000,000 gallons of water daily, at the rate of $70 per million gallons.

The questions involved in the execution of such a contract were of the utmost public importance; for, apart from the enormous expenditure contemplated thereby, about $200,000,000 during the forty-year term of the contract, to resort to a private company for the future needs of the City meant the reversal of a consistent policy of municipal ownership which has for many years governed all the large cities of this country.

When this matter was thus brought to the attention of the Board a motion was made to defer action for four weeks, in order that a reasonable opportunity might be had for investigation and discussion.

This motion was lost by a tie vote.

A similar motion to defer action for three weeks was likewise lost by the same vote. Finally, a delay of two weeks was granted to enable the Comptroller to present a report on this supremely important subject.

During the two weeks just elapsed I have endeavored, with the utmost diligence, to obtain all the facts essential to the forming of an intelligent judgment on the proposition pending before the Board. In addition to the regular engineering force of my department I have employed experts of national reputation to examine into, not only the present and future needs of the City in respect to its water-supply, but also the ability of Ramapo Water Company to supply water from the watershed alleged to be within its control.

The time allotted has proved altogether inadequate for the purpose. Monstrous as this proposition appears to me, it has been urged seriously, and it is my desire to treat it with all the seriousness due to its overwhelming importance.

To do this involves an examination which, if conducted with proper care and thoroughness, cannot possibly be completed in any such brief periof of time.

* * * * * *

The fact that actions brought by taxpayers at present enjoin this Board from approving of this contract may seem to render a request for additional time unnecessary, but I have, nevertheless, thought it proper to advise the Board of the progress thus far made, and of the conclusions to which the partial reports of my engineers inevitably point. In stating these conclusions I do not expect the Board to accept them without due consideration of the data upon which they are based; rather, it is my intention to state that as an attorney would open a case, confident that the evidence to be offered will abundantly sustain the claims hereby made.

Briefly, then, I expect to prove to the satisfaction of this Board:

First—That the supplying of water to large cities by private companies has everywhere throughout the civilized world proved a failure, as compared with municipal ownership of the water-supply.

Secondly—That the proposed contract with the Ramapo Water Company would result in the City paying an excessive price for water, and that at the end of forty years the City would have nothing to show for an expenditure of about $200,000,000, and would gradually become more and more dependent on the mercy of private interests, grown enormously powerful by the aid of the municipal treasury.

Thirdly—That if the contract with the Ramapo Water Company were entered into it would still be necessary for the City to expend a very large amount of money to utilize the water thus supplied.

Fourthly—That the Ramapo Water Company could not be ready to supply the water contracted for within the time specified in the contract, and that the bond required from that company is entirely inadequate to protect the City from loss if provision is to be made in the meantime for the distribution of such water in the several Boroughs of the City.

Fifthly—That the charter of the Ramapo Water Company is void and voidable, and that it is not competent to enter into the contract in question.

Sixthly—That the statements as to the future requirements of the City as to water have been grossly exaggerated in the report of the Commissioner of Water Supply.

Seventhly—That the water-supply of the Boroughs of Manhattan and the Bronx will be sufficient for many years to satisfy the population of those Boroughs, and that with proper prevention of waste the Croton

Watershed and the adjoining territory can provide a large surplus for the use of the other Boroughs.

Eighthly—That the legitimate sources of water-supply on Long Island for the Borough of Brooklyn have been by no means exhausted.

Ninthly—That the Board of Public Improvements are not empowered by law to authorize the execution of the contract in question, and that the approval of that Board would not enable the Commissioner of Water Supply to enter into such a contract.

Tenthly—That the City of New York is in a position to expend by the issue of bonds the necessary money to provide for the extension of its water system.

The last point being of a financial rather than of an engineering nature, there is no reason why I should not immediately state my views to the Board.

It has not been claimed that the City would be unable to issue bonds to provide for an extension of its water system; since, indeed, the Constitution expressly permits the issue of such bonds in excess of the limitation otherwise prescribed for municipal indebtedness. The claim has been made, however, that if the necessary bonds were to be issued for this purpose the City would be prevented by constitutional provisions from issuing bonds for other highly necessary purposes.

The present debt of the City is within the constitutional limit thereof by more than twenty-two million dollars.

At the next election an amendment to the Constitution is to be voted on, which, if adopted, will add nearly thirty millions of dollars more to the debt-incurring capacity of the City. As this amendment has been favored by both the principal political parties of the State, there would seem to be no reason to doubt its passage. Assuming its adoption, the City will enter upon the fiscal year 1900 with the power to issue $50,000,000 of bonds for new liabilities not now contracted for.

In addition to this the revenues of the Sinking Fund will amount to more than $13,000,000 in 1900, and will steadily increase after that year. This figure, therefore, represents the amount by which new bonds can be annually issued without any increase of the City's net debt.

In order to judge the ability of the City to enter into any large scheme of public improvement it is necessary not only to know the estimated cost thereof, but also the period of time within which payments will be required. Both of these elements cannot now be said to be definitely known—no more to the Commissioner of Water Supply, I believe, than to myself. I hope to be able to throw light on this highly important question when the complete reports of my engineers are presented. In the meantime, however, attention may properly be called to the following facts:

Prior to the construction of the new Croton Aqueduct, with its appurtenant dams and reservoirs, the water-supply of the City amounted to 114,000,000 gallons daily.

By the construction of the new aqueduct that supply has been increased to 265,000,000 gallons daily.

The expenditure required for that purpose has amounted (to August 29, 1899) to $40,059,581.16, but that expenditure has extended over a period of sixteen years. The average annual issue of bonds has been only $2,293,-823.53, and the largest amount of bonds issued in any one year has been $4,500,000.

If the present Aqueduct Commission were to proceed to develop other additional sources of water-supply, it might be possible to proceed with greater speed than has been displayed in the past; but it cannot be doubted that the prosecution of such a work would necessarily extend over a considerable number of years, and that the payments required to be made by the City could be easily met as occasion required.

It seems to me that the ability of the City to proceed along the time-honored and amply justified lines of municipal ownership is the only question involved in this discussion worthy of serious argument; for, if that be granted, the objections to handing the City Treasury over to private interests become absolutely unanswerable.

In the light of the figures herein stated, I think it will be extremely difficult to disprove the City's ability to supply its own water, and in view of the fact that, by common consent, an adequate water-supply is a public need entitled to precedence over all other public improvements, it would seem that the burden of proof is on those who deny that the City is able to perform its most important governmental function.

Respectfully,

BIRD S. COLER, *Comptroller.*

IV.

CONTROLLING STATUTES RELATING TO THE CITY'S WATER SUPPLY.

Board of Public Improvements: Power with Respect to Certain Subjects.

Chapter 378, Laws of 1897.

Section 415. The Board of Public Improvements shall have power over the following subjects:

* * * * * *

7. Water rents, superintendence of water supply of private water companies, contracts for water-supply with private companies or other municipalities.

Commissioners: Power with Respect to Contracts.

Section 457. The Commissioners at the head of each of said departments shall prepare and execute all contracts authorized by the Board of Public Improvements, or by said Board and the Municipal Assembly for his department, and shall make and cause to be made all surveys, maps, plans, estimates and drawings of all works relating to his department, and shall preserve the same in the main office of the department, and shall make an annual report of the business and transactions of his department to the Mayor.

Powers of Commissioner of Water Supply and Board of Public Improvements as to Water Contracts.

Section 471. It shall not be lawful for the Commissioner of Water Supply to enter into any contract whatever with any person or corporation engaged in the business of supplying or selling water for private or public use and consumption, unless preliminary to the execution of the contract, the assent of the Board of Public Improvements after submission to it of the proposed contract in all its details, shall be given by resolution to the execution of such contracts as submitted, and it shall not be lawful for the said City of New York or for any department thereof, to make any contract touching or concerning the public water-supply, and especially the increase thereof, with any person or corporation whatsoever, save in accord with the provisions and requirements of this act, which said provisions and requirements are hereby declared to establish the exclusive rule for the making of such contracts.

City's Power to Condemn or Acquire Water Rights.

Sec. 472. The Commissioner of Water Supply, with the approval of the Board of Public Improvements, shall have power throughout the State of New York to select and to determine all sources of water supply that may be needed for the supply of the public water works of said City, and for the supply and distribution of water in said City. Any sources of water so selected and determined by him shall be deemed necessary for the public use of the City of New York, and thereupon, with the approval of the Board of Public Improvements and of the Board of Estimate and Apportionment, together with the authority of the Municipal Assembly expressed by its resolution or ordinance, it shall be lawful for the City of New York to acquire by condemnation any real estate or any interest therein that may be necessary in order to acquire the sole and exclusive property in such source or sources of water supply, and to wholly extinguish the water rights of any other person or corporation therein, with the right to lay, relay, repair and maintain conduits and water pipes with the connections and fixtures on the lands of others, the right to intercept and to direct the flow of waters from the lands of riparian owners, and from persons owning or interested in any water, and the right to prevent the flow or drainage of noxious or impure matters from the lands of others into its reservoirs or sources of supply, provided that he shall not have power to acquire or to extinguish the property rights of any person or corporation in or to any water rights that, at the time of the initiation of proceedings for condemnation, were in whole or in part devoted to the supply of the water works of the people of any other city, town or village of the State, or to the supply and distribution of water to the people thereof, or to take or use the water from any of the canals of the State, any canal reservoirs, or waters used exclusively as feeders for canals, or from any of the streams acquired by the State for supplying the canals with water. It shall be the duty of the corporation counsel to take the necessary legal proceedings, as provided in this act, for such improvement, upon the request in writing of the said Commissioner of Water Supply. In the ascertainment of the compensation for any property or property rights so acquired, such compensation shall be based upon the actual values of the property or the interest acquired therein at the time of its taking, and there shall not be taken into consideration any prospective or speculative value, based upon the possible, probable or actual future use of such property or property rights, if the same had not been acquired by the said City of New York for the public use.

The Commissioner of Water Supply is hereby authorized to examine into the sources of water supply of any private companies supplying the City of New York or any portion thereof or its inhabitants with water, to see that the same is wholesome and the supply is adequate, and to establish such rules and regulations in respect thereof as are reasonable and necessary for the convenience of the public and the citizens; and the Board of Public Improvements may exercise superintendence, regulation and control in respect to the supply of water by such water companies, including rates, fares and charges to be made therefor, except that such rates, fares and charges shall not, without the consent of the grantee, be reduced by the Board of Public Improvements beyond what is just and reasonable; and in case of a controversy the question of what is just and reasonable shall be finally determined as a judicial question on its merits by a court of competent jurisdiction.

ACTION OF THE MERCHANTS' ASSOCIATION ON BEHALF OF PROPOSED LEGISLATION RELATING TO CITY'S WATER SUPPLY.

CONTENTS OF APPENDIX B.

ACTION OF THE MERCHANTS' ASSOCIATION ON BEHALF OF PROPOSED LEGISLATION RELATING TO CITY'S WATER SUPPLY.

I.

RECOMMENDATIONS BY GOVERNOR ROOSEVELT.

In the message of Governor Roosevelt to the Legislature, transmitted January 1, were recommendations for legislation in relation to the water supply of this city. These recommendations were later embodied in the Fallows Bill, the Demarest Bill and Morgan Bill, each of which covered different parts of the question.

January 11 Hon. F. P. Demarest of Rockland County introduced Assembly Bill No. 37, entitled, "An Act to Repeal Chapter 985 of the Laws of 1895"; said Chapter 985 being "An Act to Limit and Define the Powers of the Ramapo Water Company." It was opposed as of doubtful constitutionality, and was defeated by an adverse vote in the Assembly.

January 16 Hon. E. H. Fallows introduced Assembly Bill No. 181, amending Section 471 of the City Charter in such manner as to deprive the Water Commissioner and Board of Public Improvements of exclusive jurisdiction over water contracts.

Action by the Committee on Water Supply.

The sufficiency of these measures was carefully considered by the Committee on Water Supply and its Sub-Committee on Legislation. At a meeting January 19, the propriety of action by the Committee in the matter of legislation relating to the water supply of this City was discussed at much length. It was the sense of the Committee that legislation intended solely to protect the City against a compulsory contract and to clothe it with the powers necessary to municipal ownership, was necessary and might properly be promoted. The following action was therefore taken:

> RESOLVED: That in the opinion of this Committee the City of New York should be clothed with all the powers necessary to enable it to own and control its own water supply:
>
> That the Legislation Committee be instructed to draft such changes in existing laws as may be necessary to accomplish that purpose:
>
> That this Committee recommends that when such bills have been drafted and are approved they be promptly introduced into the Legislature, and be furthered in their progress through the Legislature in every legitimate way which the Merchants' Association can utilize.

The Morgan Bill Prepared by the Committee on Legislation.

The Committee on Legislation had on January 4 reported their opinion that under Section 472 of the City Charter the City cannot condemn water rights devoted in whole or *in part* to the supply of other municipalities. (See page 469.)

It was the unanimous opinion of the members of the Committee on Water Supply that this proviso in Section 472 would enable private companies to debar the City from practically every available watershed, and thereby compel it to resort to contract as the only practicable means for obtaining an increased water supply. An examination of the County Records in every county of the State showed that the Ramapo Water Company had acquired many water rights in nearly all the counties in the Hudson Valley and also in part of the Mohawk and Delaware Valleys, and that these rights might be exerted to entirely preclude the City. The Committee on Legislation therefore drafted an amendment to Section 472 of the City Charter, intended to restore to the City full power to condemn all private water rights by eminent domain; and exempting only water rights actually used by or necessary for the public water supply of other municipalities. It was presented in the Assembly by Hon. J. H. Morgan and known as the Morgan Bill.

The full text of Section 472 is printed on page 508. The changes proposed were as follows:

Statute of 1897.	*Proposed Amendments.*
Sec. 472. . . . Provided that he [the Commissioner of Water Supply] shall not have power to acquire or to extinguish the property rights of any person or corporation in or to any water rights that, at the time of the initiation of proceedings for condemnation were in whole or in part devoted to the supply of the water-works of the people of any other city, town or village of the State or to the supply and distribution of water to the people thereof. . . .	Sec. 472 . . . Provided that he [the Commissioner of Water Supply] shall not have power to acquire or to extinguish the property rights of any person or corporation in or to any water rights that are in actual use at the time of the initiation of proceedings for condemnation, or which in the opinion of the court on such proceedings may reasonably become necessary for the supply of the water-works of the people of any other city, town or village of the State, or for the supply and distribution of water to the people thereof. . . .

The Morgan Bill was retained in Committee without action for many weeks. It was twice amended in conformity with suggestions made by party leaders and Governor Roosevelt. In its final form it gave the City all needed powers of condemnation as recited above, in specified counties from whence the needed supply must be drawn, as follows:

> . . . Within and throughout the counties of Essex, Hamilton, Warren, Fulton and Saratoga; or within and throughout the counties of Albany, Schoharie, Greene, Delaware and Ulster; or within and throughout the counties of Orange and Rockland. . . . Nothing in this section contained shall be deemed in any manner to limit or affect the rights, property-rights, power or jurisdiction now possessed by the City of New York in relation to the possession, maintenance, operation or completion of its present water system.

The Fallows Bill became law; the Demarest Bill was defeated by an adverse vote in the Assembly, because of doubtful constitutionality; and the Morgan Bill was withdrawn in the last week of the session, for the reason that it seemed to endanger the success of the Fallows Bill, whose passage was essential.

Much arduous work was done at Albany by the members of the Committee on Water Supply, who attended the various hearings and made several arguments.

II.

MEMORIAL IN SUPPORT OF ASSEMBLY BILL NO. 759 FROM THE MERCHANTS' ASSOCIATION OF NEW YORK.

NEW YORK, February 19, 1900.

To the Honorable Committee on Cities of the Assembly of the State of New York:

Your memorialists, comprising about 1,400 business and manufacturing firms of New York, representing more than 100 different lines of trade, and employers of very large numbers of wage-earners, respectfully petition that you will report favorably Assembly Bill No. 759 (The Morgan Bill) for the enlargement of the powers of the City of New York in condemning water-rights in order to obtain a sufficient and proper water supply for the City.

The powers of the City of New York to condemn water-rights for the purpose of obtaining a water-supply for the City are contained in Section 472 of the present Charter of the City of New York. By the provisions of this section the City is forbidden "to acquire or to extinguish the property rights of any person or corporation in, or to any water-rights that at the time of the initiation of the proceedings for condemnation, were in whole or in part devoted to the supply of the waterworks of the people of any other city, town or village of the State, or to the supply and distribution of water to the people thereof."

It will be seen that the letter of this act precludes the City of New York from taking by condemnation any of the surplus waters of any watershed which is devoted, even in small part, to the water-supply of any other city, town or village of the State, but it does not preclude the City of New York from purchasing the waters belonging to such rights from private companies which already have by statute the right to acquire and sell such waters. Therefore, the prohibition against the City of New York of Section 472 does not protect the sources of an increased water-supply of other cities, towns and villages throughout the State. The necessary result of this section, if construed strictly in accordance with its letter, will be to force the City of New York to contract with some private company for the supply of water which even at present is urgently needed for one or more of its boroughs. If the City of New York is obliged to enter into such a contract, as the law relative to the incorporation of waterworks companies now stands, namely, Chapter 566, Laws of 1890, Article 7, amended by Chapter 617, Laws of 1892, the watershed which may be necessary even at the present time for the supply of another city, town or village of the State will receive no protection, inasmuch as this law authorizes such water companies to acquire land, intercept and divert the flow of waters without any limitation except that they are prohibited from taking water from canals, canal reservoirs or streams used by the State for the purpose of supplying the canal.

The purpose of Assembly Bill No. 759 is to enlarge the powers of New York to condemn water-rights so as to permit the City to take the surplus of any watershed which is not actually used and necessary for the supply of the waterworks of the people of any other city, town or village of the State. That bill, therefore, inasmuch as it permits New York to act in acquiring its water supply independent of any private water company, actually affords the water-supply of the various cities, towns or villages of the State a greater protection than is accorded to them under the present, law, since it prevents the City, in condemning land, from condemning water-rights which the actually used and necessary for the supply of such city, town or village of the State, whereas, under the present law, it is forced practically, in order to increase its supply, to enter into a contract with a private company, which is not limited at all in the exercise of its powers of condemnation. This is true because a large proportion of the watersheds of the State of New York are already devoted, at least in part, to the supply of some other city, town or village.

The reasonableness of the grant of such powers as are given by Assembly Bill No. 759 to the City of New York is seen at once when it is remembered that:

1: Every village in the State of New York organized under the "General Village Law," Chapter 414, Laws of 1897, Section 223, may acquire "by purchase, if it can agree with the owners, or otherwise by condemnation, any land, streams, water or water-rights necessary for such (water) system;"

2: As has already been pointed out, waterworks companies under the general law relative to their incorporation, Chapter 566, Laws of 1890, Article 7, Section 84, as amended by Chapter 617, Laws of 1892, have power "to acquire land, intercept and divert the flow of waters;" and

3: The charters of several cities in the State grant to the authorities of such cities similar powers. Thus, for example, the Legislature in providing for a Water Board in the City of Hornellsville authorizes the board so created (Laws of 1899, Chapter 645, Section 3) "to acquire, condemn, construct, maintain, control and operate a system of waterworks to furnish the City of Hornellsville and its inhabitants with water," and the Water Board is authorized under Section 4 to accomplish such acquisition either by purchase or eminent domain. Similar provisions are contained in an act amending the Charter of Lansingburgh (Laws of 1899, Chapter 7, Section 16) by which the Water Commissioners of that corporation "may from time to time acquire such additional lands, water and water-rights as they deem necessary for the purpose of improving, enlarging or extending the water or sewer system" of such corporation.

In all cases to which attention has been called there is no limitation upon the power of condemnation similar to that which is imposed by Section 472 of the Greater New York Charter upon the powers of condemnation of the City of New York. It is further to be noted that all of the acts to which attention has been directed, with the single exception of the general act relative to the incorporation of waterworks companies, were passed either at the same time with the Greater New York Charter or subsequent thereto. These latter acts show, therefore, that the policy of the Legislature, as seen in its latest legislation, is to grant to municipalities the widest powers of condemnation in order that through their exercise a proper water supply may be obtained. New York appears to be the only one of the municipal corporations to which reference has been made which has not been treated in this manner.

It will be noticed, further, that the act of 1892 referring to private waterworks companies contains a limitation upon the powers of condemnation of such companies, similar to one upon the powers of the City of New York, namely, the prohibition to take water from canals, canal reservoirs or streams used by the State for the purpose of supplying the canal. The question at once presents itself, why was it necessary to impose upon the City of New York a limitation upon the power of condemning land for waterworks purposes which it was not deemed necessary to impose upon either private waterworks companies, the villages or the cities of the State to which reference has been made? Does this not seem an unfair discrimination against the City of New York?

It is extremely necessary that the powers of the City of New York to obtain an adequate water-supply shall be extended at the session of the present Legislature. It is not necessary to do more than to point out the fact that the necessary increase in the water-supply of New York cannot be obtained in a period of less than two to three years. If, as has been suggested at the hearing before the Committee, the determination of this question is left to the Commission for the Revision of the New York Charter which it is proposed to appoint, New York will be delayed a year, and perhaps two years, in increasing its water-supply.

That an immediate increase of its water-supply is necessary is seen from the experience of the Borough of Brooklyn during the present winter. Almost every official communication of the water authorities of the former city, now the Borough of Brooklyn, for the past few years has emphasized the necessity of an immediate increase of the supply of that portion of the City of New York. Prior to its consolidation with Manhattan this need of immediate increase was more than once dwelt upon by the messages that were sent to its Common Council by the Mayor. Since consolidation the public authorities of the greater city have also dwelt upon the necessity of an increase in the supply of water for the Borough of Brooklyn, and especially within a very recent time, when a water famine threatened Brooklyn.

The recent scarcity of water in the Borough of Brooklyn and the desire to provide for the needs of the other boroughs in the near future resulted in the proposition that the City of New York should enter into contract for water with the Ramapo Water Company, whose powers of condemnation are greater than those of the City of New York, and whose powers of contract and condemnation are greater than those of any other private water company in the State. That company, therefore, possessing such powers may take such action as might be disadvantageous to the other cities, villages and towns of the State.

The proposition to make this contract with the Ramapo Water Company led to the organization of the Committee on Water Supply of the Merchants' Association of New York. The investigation which is being conducted by this Committee has been admitted by the only critic of the bill at the hearing before your Honorable Committee to be both thorough and impartial. This investigation was undertaken with the entire approval of the Board of Public Improvements of the City of New York, which by a unanimous vote delayed all action on the proposed Ramapo Water contract with the City of New York until the 22d day of February, which period was extended until the 30th day of April, 1900.

It is hardly necessary to call the attention of your Honorable Committee to the fact that the action which we have requested from you will not in any way reverse or modify the determination recently reached by the Legislature of the State of New York with regard to the powers of the City of New York to acquire water-rights in Suffolk County. Chapter 942, Laws of 1896, prevents the acquisition of any water-rights in that county by the City. This prohibition was maintained by Section 1619 of the Greater New York Charter, which will be in no way changed by the passage of Assembly Bill No. 759.

The Committee on Water Supply of the Merchants' Association is not prepared to state at this stage of its investigations what it will ultimately determine to be the wise policy for the City of New York to adopt, whether that of municipal ownership or that of contract with private water companies. All that such Committee is now seeking to do is to assure the City of New York a position as favorable as that which is now occupied by private water companies and municipal corporations throughout the State, in order, if it should be concluded that the policy of the City should continue to be what it is now, namely, that of municipal ownership, that the City may be able to continue that policy, which in the past has approved itself to the minds of the citizens, and which an investigation of the subject will show is becoming more and more general, not only in this country, but in Europe.

All citizens of the Empire State realize that the commercial supremacy of New York City is at times threatened by Western rivals, and that there are indications to-day that unequal burdens rest upon the Metropolis of the Western Hemisphere which in certain directions are unquestionably impeding its development. The prosperity of the Empire State is intimately interwoven with the prosperity of the City of New York. A more liberal policy as to the acquiring of water has been adopted by other large cities of the country than, for some reason which it is not easy to discover, has been adopted as to New York. If such a liberal policy is not adopted with regard to the City of New York, it may perhaps be the case that New York will be obliged to enter into a contract with a private company for its water-supply, which will ultimately impose upon it a greater financial burden than it might be obliged to assume if it were enabled to own and operate entirely its own waterworks.

Briefly to resume, the intention of Assembly Bill No. 759 is to give to the City power to condemn water-rights which are not now used by a village, town or city, and which may not hereafter become reasonably necessary for the purposes of such municipality. It is further the intention of such bill that such necessity should in each case be determined as a question of fact by the Supreme Court.

By granting the powers of condemnation to the City of New York provided for in Assembly Bill No. 759, the Legislature will give New York City powers which, while not so great as those granted to other cities and private water companies, will at the same time enable the City to own its own water-supply if it shall be deemed proper to continue that policy.

The very recent Skaneateles cases (161 N. Y.) do not apply. It was therein held that a village could establish its own waterworks under the General Village Law, although a private water company was already supplying the inhabitants of such village. Such cases would be pertinent if Assembly Bill No. 759 becomes a law; but even then, New York City would be under larger restraint than is a village under the General Village Law, and the rights of all cities, towns and villages of the State would be carefully guarded.

We have shown that private water companies now have the right to enter upon the necessary sources of water-supply from which all cities, towns and villages in the State derive their public waters, to condemn the water-rights thereof, and to sell the waters to the City of New York for the private benefit of such companies; and that, by virtue of Section 472 of the City Charter, the City of New York may be compelled to buy those waters from such private companies. We, therefore, respectfully submit that the only effective measure of protection for such cities, towns and villages is to put New York in a position in which that municipality will be able to get its water supply without dealing with a private water company under such restrictions to be applied in the discretion of the Supreme Court, as will protect the rights of the other municipalities in the State; and we respectfully request that your Honorable Committee will favorably report Assembly Bill No. 759 immediately.

Very respectfully,

THE MERCHANTS' ASSOCIATION OF NEW YORK.

SECTION V.

COMMITTEE ON MUNICIPAL FINANCE AND PUBLIC POLICY.

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PART I.

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SECTION V.

COMMITTEE ON MUNICIPAL FINANCE AND PUBLIC POLICY.

PART I: REPORT OF CONCLUSIONS AND RECOMMENDATIONS.

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CONCLUSIONS AND RECOMMENDATIONS.

CONCLUSIONS AND RECOMMENDATIONS, COMMITTEE ON MUNICIPAL FINANCE AND PUBLIC POLICY.

To the Committee on Water Supply of the Merchants' Association,
M. E. Bannin, Esq., Chairman:

We were instructed to inquire:

Whether it is necessary or expedient for the City of New York to abandon its policy of municipal ownership of its water-supply, and resort to private contract:

Whether the proposed contract of the City with the Ramapo Water Company is in the public interest.

We have carefully studied the cost of the Croton system, so far as existing records admit, from 1832 to the present, and have separated the outlay into its elements. Tables I. to XI. show the financial results of the City's investments in the system, the cost of water at various dates, the water-revenues, and the profits therefrom.

We have also computed the cost and approximate revenue of a water supply during the ensuing forty years (the term of the proposed Ramapo contract), under municipal ownership and under the Ramapo contract. A comparison of these data shows the approximate deficits and profits to the City of each system and the relative financial advantages or disadvantages. These estimates and comparisons relating to future supply are exhibited in Tables XII. to XIV.

We have inquired into the City's ability to finance a new water system under the present limitations as to indebtedness.

We have also considered with care specific questions of public policy arising from the proposed contract. The experience of many other municipalities in the United States, Canada and the principal countries of Europe, and the tendency to municipal control has been studied, and is the subject of a special report. (Part II., page 584.)

We follow our conclusions with a summary statement of the reasons that led to them, and append analyses of sufficient fullness to show the conditions clearly. Some of the branches are discussed in separate special reports herewith.

I.

Summary of Conclusions.

From the data collected and analyzed under our direction we reach the following conclusions of fact:

1. The maximum cost of water per million gallons by the Croton system (obtained by dividing the total annual charge by the quantity delivered) was $54.20 in 1849.

2. The average cost per million gallons from 1866 to 1898, both inclusive, was $35.06. The data of consumption during some of the preceding years are lacking, and the average cost cannot be accurately computed prior to 1866.

3. The approximate average cost per million gallons in the year 1898 was $29.07, and in the period 1898 to 1910 (the latest date when the present system and the works now being constructed will be able to supply the City with sufficient water even if recourse be had to meters and other means of reducing waste), it will be under $25 and probably in the neighborhood of $20, owing to the great relative decrease of outlay and increase of consumption during the next few years.

4. The annual cost of distributing water to consumers is not less than $10 per million gallons at present; and

this expense should be added to the cost of delivering water at the City limits.

The relative cost, therefore, to the City per million gallons by the proposed Ramapo contract and by municipal ownership is approximately:

Contract Cost	$80.00		
Average City Cost, 1866–1898	35.06	*Excess Cost by Contract*	$44.94
Average City Cost, 1898–1910	25.00	" " "	55.00
City Cost, 1898	29.07	" " "	50.93

5. The City has received an average revenue of $52.87 per million gallons for all the water supplied by the Croton system since 1865.

6. The Croton system had yielded, up to the end of 1898, a net profit of $21,473,084. In the year 1898 it paid a net profit of $1,881,843. The ratio of profit is increasing rapidly, and the annual net profit will probably exceed $4,000,000, by 1910.

7. The relative profit by municipal ownership, and loss by the proposed Ramapo contract, is:

City System.

	1866–1898.	1898.
Average Revenue per Million Gallons	$52.87	$50.29
Average Cost per Million Gallons	35.06	29.07
Average Profit	$17.81	$21.22

Contract System.

Average Cost per Million Gallons	$80.00	$80.00
Average Revenue per Million Gallons	52.87	50.29
Average Loss	$27.13	$29.71

Comparison on Basis of 1898.

Profit by City System	$1,881,843
Loss by Contract System	2,635,128
Total Loss	$4,516,971

Comparison for Period of 40 Years, 1906–1945.

Poughkeepsie System and Ramapo Contract.

Supply—40,000,000 to 250,000,000 gallons daily.

Net Profit by City System....................	$48,338,259.53
Deficit under Ramapo Contract..............	60,241,811.32
Cash Loss............................	$108,580,070.87
Plus Value of Poughkeepsie System, all Bonds having been paid.........................	36,880,000.00
Cash and Property Loss to City..........	$145,460,070.87
Estimated Cash and Property Loss on Second System, Constructed by 1920, Capable of Supplying 250 Million Gallons Daily Additional	50,000,000.00
Final Loss by the Acceptance of Ramapo Contract	$195,460,070.87

The data for the foregoing conclusions of fact are found in Tables I. to XIV.

We have reached the following conclusions as to questions of opinion:

1. Existing conditions give no warrant for the abandonment by the City of New York of its policy of municipal ownership of its water supply. The City system is very profitable, and future conditions will be more favorable than the present. It will cost relatively less and earn relatively more than the present system. To substitute the contract system for municipal ownership would divest the City of an extremely valuable asset, deprive it of a large and increasing annual income and impose a heavy annual burden upon taxpayers.

The report of the Engineering Committee shows that the City can provide itself within a short time with an additional daily supply of 250 million gallons at a constructon cost for plant of $36,880,000. As a financial proposition the cost of this additional supply, together with all expenses for interest, maintenance and operation can be easily met out of the revenue from the additional supply without any increase in the present water rates. The same holds true of still further additional supply up to 1,500 million gallons daily, ample for an increase of the City's population to 18,000,000; as against these facts, every dollar paid by the City for its water supply in excess of $29.07 per million gallons deprives it of a dollar's profit at present rates and every dollar paid in excess of $50.29 must be taken directly from the pockets of the taxpayers.

We do not consider the proposed Ramapo contract worthy of a moment's favorable consideration on financial grounds.

2. It is urged that an increased water supply is imperative in the near future and that because of other financial demands upon the City's resources the additional water supply must be obtained through contract with the Ramapo Company or some other private corporation. We do not believe that a public utility of the enormous value of the water supply for the City of New York should be lost to the City and its taxpayers mulcted in millions of dollars every year for any reason whatsoever. The Constitution permits outlay for water supply to continue beyond the 10 per cent. debt limit. And if it should prove to be necessary temporarily to exceed that limit in order that the City may retain control of its water supply, such a course would be preferable to giving away this immensely valuable franchise on the plea that outlays for other public improvements must for a time stop or be seriously restricted. The City's water works are not a burden, but a source of profit. The realization of this fact, together with the strong popular disapproval of the unwise policy of giving away perhaps the most valuable of the City's assets, will shortly bring about a constitutional amendment recognizing that New York's profit-paying investment in its water works should not prevent expenditures for other municipal purposes—provided, in the meantime, the improvident action of the City authorities has not involved us in a contract with some private corporation to supply the City with water.

3. Within the last five years the Legislature has passed several acts, the effect of which is, on the one hand, to grant to the Ramapo Company excessive and unusual powers as compared with other water companies, and, on the other, greatly to restrict the powers of New York City in any effort to secure an additional water supply. New York is absolutely forbidden to condemn any water rights in Suffolk County. It cannot acquire or extinguish by condemnation the property rights of any person or corporation in, or to any water rights that at the commencement of the condemnation proceedings were in whole or in part devoted to the supply of the water works of the people of any other city, town or village, or to the supply and distribution of water to the people thereof.

These legislative restrictions upon the freedom of New York to acquire an adequate water supply are against the public interest. They seem only to give opportunity to take undue advantage of the City.

4. Statutes and resolutions authorizing the issue of bonds or outlays of City money may make it necessary for many separate accounts to be kept on the Comptroller's books, but this need not prevent the assembling of accounts relating to the same subject matter so as to present in clear, business-like fashion the facts as to the City's investment in its water works. The long and painstaking investigation into the expenditures and receipts of the City on account of the Croton and Bronx waters, undertaken by the committee with the helpful co-operation of the Comptroller and his assistants, made an important beginning toward the accomplishment of this result; and hereafter there should be no insurmountable obstacle to prevent in the Comptroller's quarterly and annual reports a simple and intelligent summary of the actual financial condition of the City's investment in its water works.

It should not require the training of an actuary, or of a professional accountant and a large expenditure of time for the citizen to ascertain such facts as cost of plant, amount of outstanding bonds, interest charges, expenses of maintenance and of operation, the sources and amount of revenue and other facts which will at once suggest themselves as essential alike to a proper knowledge of the financial condition and business methods of any large enterprise.

5. The official reports of the City's water supply lack important data necessary to any real knowledge by the citizen of the management and finances of that most important department of the City's business. For example, we find practically no data of any kind as to meters in any Annual Reports except the bare statement of number in use and aggregate revenue derived from water sold by meter measurement. The amount of metered water used for industrial and other purposes cannot be ascertained. Though several thousand meters have been added during the past three years, the amount of metered consumption has remained almost stationary. The length of pipe laid, with mention of its diameter, is returned without information as to its position. The locality of pipes of various diameters is noted without information as to length. Executed and unexecuted contracts, with costs and locations, are given without the length or size of the pipe laid or quantities of material delivered.

As a matter of fact there are practically no summaries of any sort for the City as a whole and the data by boroughs is meagre. We should expect to find, but do not, such important data as the size of the various drainage or collecting areas with monthly statistics of the rainfall at the most important reservoirs; the amount stored, utilized and wasted for each drainage area; chemical and physical tests of the most important supplies used in construction and operation; detailed operations and cost of the various pumping stations and of the street distribution, meter and accounting departments.

The foregoing are merely illustrations.

Some twelve or thirteen years ago the New England Water Works Association adopted a scheme for a statistical summary for water works reports which covers the subject very thoroughly. It has been used ever since by a number of cities, not confined to New England, and has the double advantage of meeting the wants of any given locality and of making comparisons with works in other cities both easy and valuable.

Furnishing water for the sanitary and productive necessities of the City of New York is a business in which not only the money invested, but the receipts, with the annual expenditures for maintenance, interest and the sinking fund, are counted in the millions. It should be conducted under the safeguards found necessary in all commercial enterprises. In no other way can either the knowledge be gained which constantly tends toward improvement and economy in management or the joint owner of the business be familiar with its financial status.

6. The revenues from the City's water works after meeting interest charges and the cost of maintenance and operation should be used to amortize bonds issued to establish the plant. The financial history of the City's water supply demonstrates that the surplus of receipts over expenditures at present rates is ample to amortize within a reasonable time any bonds which the City may issue to meet its need of additional water. Such bonds, therefore, as may be issued hereafter for this purpose should not be classed with bonds issued for other municipal purposes and the revenues from the additional supply should be pledged to the redemption of the bonds issued therefor.

II.

RECOMMENDATIONS.

I. The policy of supplying New York City with water by contract should be opposed by all lawful means.

II. The legislative obstacles to the continuance of the successful policy of municipal ownership by New York City of its water supply should be repealed by the Legislature.

III. The Legislature should clothe New York City with power to acquire by condemnation any water rights needed for its public water supply, excepting water rights actually used by or necessary for the supply of any other city, town or village.

IV. The constitutional requirement that the bonds issued by New York City for a water supply should be included in ascertaining whether the City can become indebted for other municipal purposes should be removed.

V. The Comptroller's quarterly and annual reports should contain a clear and business-like statement of the financial status of the City's investment in its water works.

VI. A carefully devised system of detailed, accurate and easily understood public records and reports should be substituted for the present inadequate and confusing methods of the Department of Water Supply.

VII. The financing by the City of any addition to its water supply should include the application of the surplus of the revenues over expenditures to the redemption of bonds issued to establish the plant.

The following pages contain the data upon which these conclusions and recommendations are based.

Respectfully submitted,

HORACE E. DEMING, *Chairman*,
SIMON STERNE,
F. W. HINRICHS,
DR. CYRUS EDSON,
DR. GEORGE B. FOWLER,
J. KENNEDY TOD,
ALBERT SHAW,
JACOB H. SCHIFF,
MILO R. MALTBIE,
RICHMOND MAYO-SMITH,

Committee on Municipal Finance and Public Policy.

NEW YORK, *July 31, 1900.*

SECTION V.

COMMITTEE ON MUNICIPAL FINANCE AND PUBLIC POLICY.

PART II: WATER-SUPPLY FINANCE.

CONTENTS OF SEC. V: PART II.

WATER SUPPLY FINANCE.

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WATER SUPPLY FINANCE.

I.

Cost and Revenue of the Croton System.

During a term of sixty-seven years, from January 1, 1832, to December 31, 1898, the City of New York made a capital investment of $86,359,562.09 for the construction of water works. It expended during that period for interest charges, maintenance and operation $66,544,245.38, the aggregate earnings were $88,-017,329.72, and the total net profit was $21,473,084.34.

An analysis of these results shows that for a period expenses exceeded revenues, that for another period the works were self-sustaining, and that for a considerable time the plant has been a financial investment of the very first class, having paid off all deficits incurred in the early years of its history and of late having annually yielded a large net profit. The water properties of this City now combine the most favorable conditions possible, namely, large and progressive earning power, minimum pro rata operating charges, decreasing capital charges, increasing consumption and assured demand.

Up to 1849 the City had invested $12,000,000 in a water plant, and the result was a heavy deficit. Another million added a little to the annual expense account, but more than doubled the earnings, producing a small profit, and stopping the further growth of a deficit, which in 1855 was nearly $6,000,000.

Between 1855 and 1881 the outlay of over $20,000,000 more piled up an enormous interest charge, but the earning power also increased, and by 1881 there was a surplus of about $1,000,000. The investment of some $33,000,000 was further increased by $4,000,000, and this increase of 12 per cent. in the investment was accompanied by about 20 per cent. increase in the capacity of the works. The gross yearly revenue increased in six years from $1,968,000 in 1883 to $2,729,000 in 1889. The period from 1885-1889, inclusive, earned a revenue from water rates of $12,676,558, netting a profit of $4,510,000, after paying between 5 and 6 per cent. interest on an investment of $37,382,000.

As the result of these successive investments, the Croton system had a daily capacity in 1889 (Table II.) of 115,000,000 gallons, and was earning an annual net profit of over $786,000, after paying all expenses of maintenance and operation and interest upon 62 millions of the outstanding bonds, more than 24 millions of additional bonds having been issued between 1885 and 1889 for new construction.

During this period, from 1885 to 1889, owing to the need of the City for water, the system was strained to the uttermost limit, and, indeed, was seriously injured, so that it has not since been considered safe to permit a daily flow of more than 90,000,000 gallons through the old aqueduct.

Present Conditions and Potential Earnings.

Anticipating that the maximum capacity of the Croton system, as it then existed, would be reached in 1889, the City commenced a third investment in waterworks in 1885. Between 1885 and the close of 1898 about $50,000,000 was invested in enlargement of the water system, which with a further outlay of about $15,000,000, will add from 260,000,000 to 290,000,000 gallons daily to the delivery capacity.

Comparing the annual charges of 1884, when the capital investment in the system of the second period was finished, with the annual charges for the year 1898, when the capital investment for the third period was completed, we find the excess of annual charges in 1898 over those of 1884 to be about $1,310,000.

In the year 1898 the reported annual delivery was 128,000,000 gallons per day in excess of the 115,000,000 gallons daily delivery of the completed Croton system of the second period, or a total daily delivery in 1898 of 243,000,000 gallons, from which the City derived a revenue of $50.29 per million gallons, $15.21 per million gallons less than the $65.50 per million gallons in 1889, although no change had been made in the water-rates. There is here a loss to the City for 1898 of $1,349,000.

This analysis shows that on the 31st of December, 1898, the City had a water-plant which represented a net investment by the City of $86,000,000. It was earning at that date, upon actual consumption, a net annual profit of $1,882,000, which profit, through increased consumption of water, is steadily growing, and will, when the consumption reaches the capacity of the present system, be increased to more than $4,000,000 yearly.

A brief outline of the three constructive periods of the Croton system will aid the study of its finances.

First Period (1832–1884).

The actual work was begun in 1833. The aqueduct was partially completed in 1842, when, on October 14, the Croton water was introduced into the City. The work on the aqueduct was not, however, fully completed until 1844, while High Bridge, over which the water was conveyed to Manhattan Island, was not finished until November, 1848.

The distributing system below the Harlem River was badly planned and experience proved that it had practically to be reconstructed in the succeeding years.

The financial results of the period ending in the year 1849 are to be found in the annexed tables. The maximum delivery capacity at that time was 13,140 million gallons yearly. In the year 1849, that quantity was delivered. The aqueduct had then cost $11,676,736.70 for construction and $52,492.05 for maintenance, a total disbursement, from 1832 inclusive, of $11,729,228.75. Its revenue was $278,811.72, and could not be increased without an increased investment and further extensions of the plant. The annual interest charges were $700,000; the annual maintenance charges $12,364. The deficit of that year was $433,442.22. The aggregate deficit up to that time was $5,138,913.64, including $21,846.54 in maintenance charges for public reservoir. A costly error had been made. The distributing system within the City was not adequate, and only about one-half the water conducted by the aqueduct could be delivered to consumers.

To remedy this a large further outlay was required. One item of nearly $5,000,000 in the later construction account shows part of the cost of removing and replacing the useless conduits. It was necessary to enlarge the mains, build storage reservoirs, change the aqueduct from a masonry to a pipe conduit within the City limits, construct receiving reservoirs within the City, erect pumping stations and high service towers, and reconstruct the upper portion of High Bridge so as to permit the introduction of much larger mains. These and many other changes were made during the period from 1850 to 1880, and involved the expenditure of $21,000,000, making the cost of the aqueduct, with its distributing system, up to the time when the limit of 95,000,000 gallons a day was reached, in round numbers, $33,000,000. Although this sum of $33,000,000 is set down as the cost of the old aqueduct plant, a considerable portion, perhaps $5,000,000, was expended for storage reservoirs and other improvements in connection with and anticipated by the further supply which became available in 1891, after the construction of the new aqueduct.

Between 1880 and 1884 about $4,000,000 additional was expended in securing about 20,000,000 gallons daily from the Bronx and Byram River water-sheds. This, added to the $33,382,521.25 above mentioned, makes the aggregate capital investment $37,382,521.25.

During this period the aggregate receipts were $41,625,530.95; the aggregate expenses were $38,564,592.61; and the net surplus was $3,060,938.34.

Second Period (1885–1889).

The second period may be called the period of the construction of the New Aqueduct. The temporary relief afforded by the 20,000,000 gallons additional daily supply from the Bronx and Byram rivers, tided the City over until the end of 1889; but it had long been evident that the old systems, even with the additional supplies, would not suffice for any extended period. Plans were accordingly made for the building of a New Aqueduct and additional storage reservoirs; work thereon was begun on December 30, 1884, and water was supplied to the City therefrom in 1890. During this period the City built the New Aqueduct, and expended for the purposes mentioned the sum of $24,571,264.63. The net profit on operation of the old plant was $4,510,543.64. The maximum capacity of the New Aqueduct built during this period was 290,000,000 gallons per day.

Third Period (1890–1898).

This period is marked by the building of the Cornell and Jerome Park reservoirs, under the reorganized Aqueduct Commission, whose official existence will terminate when the reservoirs are completed, probably in 1903. The total expenditure between 1890 and 1898 was $24,405,776.21. The net profit during the same period on the operation of the plant as it existed in 1890 was $10,504,173.85.

TABLES EXHIBITING COST AND REVENUE OF CROTON SYSTEM 1832–1898, INCLUSIVE.

Cost, Earnings and Net Profits of Croton Water Per Million Gallons Each Year, 1866–1898.

	Cost.	Revenue.	Net Profit.
1866	$30.54	$46,30	$15.76
1867	29.04	47.14	18.10
1868	27.83	44.78	16.95
1869	29.45	46.23	16.78
1870	31.28	42.29	11.01
1871	31.38	43.60	12.22
1872	34.39	47.93	13.54
1873	36.76	45.76	9.00
1874	37.85	42.32	4.47
1875	43.00	40.69	Loss 2.31
1876	36.30	44.97	8.67
1877	38.35	46.61	8.26
1878	37.76	48.77	11.01
1879	39.22	49.83	10.61
1880	43.39	47.59	4.20
1881	42.15	46.34	4.19
1882	43.11	50.21	7.10
1883	32.55	57.35	24.80
1884	35.81	58.97	23.16
1885	33.89	58.41	24.52
1886	34.20	62.82	28.62
1887	41.95	66.15	24.20
1888	46.03	62.49	16.46
1889	46.71	65.58	18.87
1890	38.37	53.80	15.43
1891	34.33	54.23	19.90
1892	34.08	55.91	21.83
1893	32.75	60.74	27.99
1894	32.30	54.76	22.46
1895	31.28	55.78	24.50
1896	28.34	50.63	22.29
1897	29.61	52.44	22.83
1898	29.07	50.29	21.22

TABLE I.

EARNINGS, ANNUAL CHARGES, NET PROFITS, COST OF CONSTRUCTION AND NET INVESTMENT OF CROTON WATER SYSTEM.

Exhibits in Aggregate and Three Periods of Construction.

FIRST PERIOD, 1832-1884, INCLUSIVE.			
Total Expenses for Construction		$37,382,521.25	
Total Expenses for Maintenance	*$6,991,631.59		
Net Interest Cost	31,572,961.02		
	38,564,592.61		
Total Receipts	41,625,530.95		
Profit on Operation		3,060,938.34	
Cost at End of First Period			$34,321,582.91
SECOND PERIOD, 1885-1889, INCLUSIVE.			
Total Expenses for Construction		$24,571,264.63	
Total Expenses for Maintenance	$2,854,166.62		
Net Interest Cost	5,317,233.69		
	8,171,400.31		
Total Receipts	12,681,943.95		
Profit on Operation		4,510,543.64	
Cost During Second Period			$20,060,720.99
Cost During First and Second Periods			$54,382,303.90

TABLE I—(Continued).

THIRD PERIOD, 1890-1898, INCLUSIVE.

Total Expenses for Construction		$24,405,776.21	
Total Expenses for Maintenance	$5,739,575.71		
Net Interest Cost	14,068,676.75		
	19,808,252.46		
Total Receipts	33,709,854.82		
Profit on Operation		13,901,602.36	
Cost During Third Period			$10,504,173.85
Cost at December 31, 1898			$64,886,477.75

*Includes $3,670.57 expenses charged against Croton Water Rents as shown at end of statement of Water Rent Receipts.

RECAPITULATION: EARNINGS, ANNUAL CHARGES, NET PROFITS, COST, NET INVESTMENT.

Earnings, Annual Charges and Profits.			Cost of Construction and Net Investment.	
Earnings:			Cost of Construction	$86,359,562.09
Water Rents	$87,893,325.84		Less Net Profits	21,473,084.34
Miscellaneous	124,003.88			
Total Earnings		$88,017,329.72		
Annual Charges:				
Maintenance	$15,585,373.92			
Interest	50,958,871.46			
Total An. Charges		$66,544,245.38		
Net Profits		$21,473,084.34	Net Present Investment	$64,886,477.75

TABLE II.

FINANCIAL SUMMARY OF CROTON WATER SYSTEM, 1832–1898.

Showing Disbursements, Receipts, Surplus or Deficit, and Annual Capacity and Delivery in Million Gallons.

1	2	3	4	5	6	7	8	9	10	11
First Period. Years.	Construction.	Maintenance.	Interest Cost.	Receipts of Interest.	Miscellaneous Receipts.	Receipts from Croton Water Rents.	Excess of Interest Costs and Maintenance over Receipts.	Excess of Receipts over Interest Costs and Maintenance.	Max. Delivery Capacity in Million Gals.	Annual Delivery in Million Gallons.
1832	$81,078.28	—	—	—	—	—	—	—	—	—
1833	47,632.46	—	—	—	$610.75	—	—	$610.75	—	—
1834	39,235.33	—	—	—	—	—	—	—	—	—
1835	91,222.48	—	$13,472.21	—	—	—	$13,472.21	—	—	—
1836	67,970.10	—	50,000.00	$66,178.57	—	—	—	16,178.57	—	—
1837	342,971.38	—	55,129.37	5,250.00	784.27	—	49,095.10	—	—	—
1838	1,614,705.08	—	111,852.99	5,397.04	—	—	106,455.95	—	—	—
1839	2,029,739.40	—	206,637.27	224.74	988.60	—	205,423.93	—	—	—
1840	2,121,285.98	$5,960.56	306,644.00	—	1,833.12	—	310,771.44	—	—	—
1841	2,002,975.47	5,333.84	409,474.73	—	2,219.10	—	412,589.47	—	—	—
1842	1,276,545.93	10,552.14	579,974.25	—	387.66	$17,862.17‡	572,276.56	—	13,140	4,380
1843	556,765.16	—	633,763.78	—	2,827.50	86,887.31	544,048.97	—	13,140	4,380
1844	173,714.84	11,988.43	650,123.00*	—	336.01	118,124.35	543,651.07	—	13,140	4,380
1845	212,075.25	16,056.55	686,084.85	—	253.00	157,791.66	544,096.74	—	13,140	4,380
1846	243,838.05	4,675.79	689,859.14	—	—	193,914.70	500,620.23	—	13,140	4,380
1847	128,062.38	4,212.87	693,304.72	—	1,512.34	221,635.10	474,370.15	—	13,140	4,380
1848	206,219.81	3,194.41	697,247.60	—	—	255,053.09	445,388.92	—	13,140	4,380
1849	440,699.32	12,364.00	700,000.26	—	110.32	278,811.72	433,442.22	—	13,140	13,140
1850	185,490.00	20,000.00	700,931.04	—	1,709.37	458,951.87	260,269.80	—	13,140	14,600
1851	179,850.81	13,729.32	702,535.93	—	1,243.26	458,789.78	256,232.21	—	—	—
1852	150,651.25	23,451.41	701,752.73	—	1,563.53	562,189.89	161,450.72	—	—	—
1853	252,200.97	17,254.85	665,464.16	—	847.97	601,294.79	80,576.25	—	—	—
1854	133,059.08	44,513.81	665,464.16	—	1,615.49	641,853.18	66,509.30	—	—	—
1855	290,044.51	20,110.60	665,464.16	—	1,631.84	708,806.43	—	24,863.51	—	—
1856	206,218.29	27,817.49	665,464.16	—	1,177.13	703,170.78	—	11,066.26	—	—
1857	596,674.53	45,252.02	613,668.44	—	839.40	735,364.11	—	77,283.05	—	—
1858	339,432.53	19,704,37	483,270.14	—	149.20	783,623.88	—	280,798.57	—	—

Continued next page.

TABLE II.—(Continued).

1	2	3	4	5	6	7	8	9	10	11
1859	685,085.85	18,046,82	512,193.35	—	255.51	821,505.99	—	291,521.33	—	—
1860	754,645.24	48,884.87	451,901.39	—	—	822,920.81	—	322,134.55	—	—
1861	1,139,692.11	70,943.95	476,407.29	—	456.28	809,648.50	—	262,753.54	21,900	—
1862	489,804.72	85,173.76	526,950.71	—	—	848,549.99	—	236,425.52	—	—
1863	347,889.01	163,123.58	543,329.00	—	—	943,887.57	—	237,434.99	—	—
1864	262,511.22	140,327.24	552,953.46	—	—	967,342.25	—	274,061.55	—	—
1865	167,359.57	157,713.42	554,829.00	—	—	1,049,556.20	—	337,013.78	—	—
1866	646,166.67	169,845.79	565,901.05	—	—	1,115,563.16	—	379,816.32	—	24,090
1867	550,584.41	179,832.43	583,539.80	—	—	1,238,865.23	—	475,493.00	—	26,280
1868	622,322.14	193,542.99	598,727.95	—	—	1,274,989.18	—	482,718.24	—	28,470
1869	744,483.15	198,084.73	618,714.46	—	—	1,265,695.73	—	448,896.54	—	27,375
1870	1,084,988.11	209,192.84	669,947.59	—	—	1,188,660.98	—	309,520.55	—	28,105
1871	2,275,824.80	301,446.04	603,649.78	—	—	1,257,297.87	—	352,202.05	—	28,835
1872	2,026,090.76	264,205.64	752,519.57	—	—	1,417,158.53	—	400,433.32	29,200	29,565
1873	1,836,503.52	301,552.63	879,362.92	—	—	1,470,061.77	—	289,146.22	29,200	32,120
1874	1,311,504.79	289,507.04	981,503.12	—	—	1,422,148.55	—	151,138.39	29,200	33,580
1875	645,459.47	307,744.00	1,181,198.59†	—	—	1,411,049.64	77,892.95	—	29,200	34,675
1876	707,504.57	243,869.88	948,892.61	—	—	1,447,255.79	—	254,493.30	29,200	32,850
1877	899,206.06	255,411.03	990,426.87	—	—	1,514,217.38	—	268,379.48	29,200	32,485
1878	548,402.28	253,951.20	1,027,961.01	—	—	1,655,671.84	—	373,759.63	29,200	33,945
1879	404,547.58	282,505.75	1,048,805.41	—	—	1,691,843.59	—	360,532.43	29,200	33,945
1880	787,404.72	441,159.39	1,031,834.88	—	—	1,615,513.49	—	142,519.22	34,675	33,945
1881	654,422.96	508,286.95	937,940.19	—	—	1,589,931.61	—	143,704.47	34,675	34,310
1882	1,325,317.80	536,811.36	942,334.31	—	—	1,722,861.38	—	243,715.71	34,675	34,310
1883	1,204,565.31	464,912.46	652,105.62	—	—	1,967,699.53	—	850,681.45	34,675	34,310
1884	1,250,875.76	599,383.34	668,498.35	—	—	2,088,157.93	—	820,276.24	38,325	35,405
	$37,382,521.25	$6,991,631.59	$31,650,011.37	$77,050.35	$23,351.65	$41,602,179.30	$6,058,634.19	$9,119,572.53	—	—

(Continued, Next Page.)

TABLE II.—(Continued).

1	2	3	4	5	6	7	8	9	10	11
Second Period.										
1885	$2,921,977.34	$547,409.47	$751,490.93	——	$962.00	$2,238,602.51	——	$940,664.11	38,325	38,325
1886	5,482,212.43	481,268.81	879,588.17	——	295.00	2,499,501.84	——	1,138,939.86	38,325	39,785
1887	7,907,080.88	604,307.46	1,064,813.58	——	562.50	2,631,929.14	——	963,370.60	38,325	39,785
1888	5,516,486.50	623,490.86	1,275,189.00	——	1,749.50	2,577,650.24	——	680,719.88	38,325	41,245
1889	2,743,507.48	597,690.02	1,346,152.01	——	1,816.25	2,728.874.97	——	786.849.19	38,325	41,610
	$24,571,264.63	$2,854,166.62	$5,317,233.69	——	$5,385.25	$12,676,558.70	——	$4,510,543.64	——	——
Third Period.										
1890	$2,764,668.10	$639,968.20	$1,391,150.76	——	$1,530.00	$2,847,582.61	——	$817,993.65	——	52,925
1891	1,630,934.20	634,653.63	1,433,092.66	——	1,666.81	3,266,100.84	——	1,200,021.36	151,475	60,225
1892	1,834,197.88	622,132.75	1,393,460.47	——	390.21	3,306,225.52	——	1,291,022.51	151,475	59,130
1893	2,007,981.35	632,046.97	1,448,482.91	——	7,922.25	3,857,726.53	——	1,785,118.91	151,475	63,510
1894	1,988,880.12	659,868.69	1,497,745.55	——	2,130.08	3,653,974.99	——	1,498,490.82	151,475	66,795
1895	2,040,178.57	603,656.93	1,554,177.29	——	18,136.52	3,848,584.76	——	1,708,887.07	151,475	68,985
1896	4,665,047.52	636,170.78	1,639,902.37	——	10,965.66	4,065,907.89	——	1,800,800.39	151,475	80,300
1897	4,464,333.95	643,402.23	1,799,565.17	——	34,134.76	4,326,256.62	——	1,917,423.98	151,475	82,490
1898	3,009,554.52	667,675.53	1,911.099.57	——	18,390.69	4,442,228.08	——	1,881,843.67	151,475	88,695
	$24,405,776.21	$5,739,575.71	$14,068,676.75	——	$95,266.98	$33,614,587.84	——	$13,901,602.36	——	——
Totals	$86,359,562.09	$15,585,373.92	$50,958,871.46	——	$124,003.88	$87,893,325.84	——	$21,473,034.34	——	——

* Partly estimated.

‡ Begins August 6, 1842.

† Interest cost equaled to fiscal year as January 1, it having been formerly November 1, resulting in an apparent deficit in that year.

TABLE III.

THE OPERATION OF THE CROTON AQUEDUCT FROM 1832 TO 1849, INCLUSIVE.

Years.	Construction.	Mainten-ance.	Interest Cost.	Miscella-neous Receipts.	Receipts from Water Rents.	Deficit.	Maximum Delivery Capacity Annually in Million Gallons.	Annual De-livery in Million Gallons.
1832—1849, inclusive	$11,676,736.70	*$52,492.05	$6,406,517.82	$11,862.67	$1,330,080.10	$5,117,067.10	——	——
1849	400,699.32	12,364.00	700,000.26	110.32	278,811.72	433,442.22	13.140	13.140
EXHIBIT: INTEREST CHARGE TO COMPLETION OF AQUEDUCT IN JANUARY, 1844 ($2,289,898.25), TRANSFERRED FROM INTEREST ACCOUNT TO CONSTRUCTION ACCOUNT.								
1832—1849, inclusive	$13,966,634.95	*$52,492.05	$4,116,619.57	$11,862.67	$1,330,080.10	$2,827,168.85	——	——
1849	400,699.32	12,364.00	700,000.26	110.32	278,811.72	433,442.22	——	——

TABLE IV.

AGGREGATE DISBURSEMENTS FROM THE PROCEEDS OF SALES OF BONDS AND RECEIPTS FROM MISCELLANEOUS SOURCES FOR THE CONSTRUCTION OF THE CROTON AQUEDUCT AND ITS EXTENSIONS, ETC.

Divided into Three Periods: First Period, 1832-1884; Second Period, 1885-1897; Third Period, 1898.

Title of Fund.	Years.	First Period. 1832-1884.	Second Period. 1885-1897.	Third Period. 1898.	Total Disb'mts by Funds.
	Prior to Dec. 31, 1882	81,078.28	——	——	81,078.28
1. Water Pipes	1833-1848	2,016,784.34	——	——	2,016,784.34
6. Water Commissioners (Disbursements)	1833-1849	8,911,448.08	——	——	8,911,448.08
8. City Aqueduct (Miscellaneous Disbursements)	1835-1843	11,436.69	——	——	11,436.69
9 and 13. City Aqueduct and Temporary Water Loan (Interest payments, $2,366,948.60, less amount charged payable from taxation, $747,968.86)	1835-1843	1,618,979.74	——	——	1,618,979.74
15. Croton Waterworks Extension	1849-1858	851,691.83	——	——	851,691.83
16. Aqueduct Construction	1850	19,890.00	——	——	19,890.00
*17. New Reservoir Awards	1856-1858	549,512.12	——	——	549,512.12
18. Croton Waterworks Extension Storage Reservoir	1865-1872	589,580.40	——	——	589,580.40
19. Alterations of Aqueduct, 86th to 92d Streets	1865-1866	250,000.00	——	——	250,000.00
20. Croton Waterworks Extension High Service, Carmansville	1865-1877	969,930.14	——	——	969,930.14
21. Croton Water Main Fund	1871-1881	5,259,296.32	——	——	5,259,296.32
†22. Croton Water Pipe Fund	1869-1872	458,549.70	——	——	458,549.70
23. Croton Water Fund	1871-1898	4,924,482.88	3,823,273.10	223,064.60	8,970,820.58
24. Water Stock of 1870, Improv't Lower Reservoir	1872-1875	504,323.75	——	——	504,323.75
25. Croton Waterworks Extension and New Reserv.	1859-1867	3,020,991.69	——	——	3,020,991.69
27. Additional Alterations of Aqueduct, 93d St. to 113th St.	1870-1880	3,655,949.52	——	——	3,655,949.52
28. Additional Water Fund (1913-1933)	1883-1898	204,499.73	36,275,040.94	1,712,160.46	38,191,701.13
30. Additional Water Fund, City of New York	1893-1898	——	1,853,661.16	574,656.93	2,428,318.09
31. Water Main Fund	1893-1897	——	500,794.25	——	500,794.25
32. Water Main Fund, No. 2	1896-1898	——	536,368.62	420,457.62	956,826.24
		33,898,425.21	42,989,138.07	2,930,339.61	79,817,902.89

* Includes $1,263.05 on Old Books Open Account.

† Credit Balance of this account, $208.30, transferred to General Fund, December 31, 1881.

TABLE V.

AGGREGATE DISBURSEMENTS FROM ANNUAL APPROPRIATIONS FROM 1840 TO 1898, INCLUSIVE, FOR THE CONSTRUCTION OF THE CROTON AQUEDUCT, ITS EXTENSIONS, ETC.

In Addition to the Disbursements from the Proceeds of Sales of Bonds and Receipts from Miscellaneous Sources as Shown in Table 4.

1	2	3	4	5	6	7	8	9
Title of Accounts.	Years.	First Period. 1840-1884.		Second Period. 1885-1897.		Third Period. 1898.		Totals.
		Construction.	Maintenance.	Construction.	Maintenance.	Construction.	Maintenance.	
3 Water Pipes	1844—1858	$1,567,517.33	——	——	——	——	——	$1,567,517.33
3 Water Pipes, Freightage and Laying	1859—1871	2,209,914.88	——	——	——	——	——	2,209,914.88
11 Aqueduct Repairs by Commissioners	1844—1858	——	$280,655.35	——	——	——	——	280,655.35
11 Aqueduct Repairs and Improvements	1859—1872	——	976,965.57	——	——	——	——	976,965.57
11 Aqueduct Repairs and Maintenance	1873—1882	——	843,592.89	——	——	——	——	843,592.89
12 Public Reservoir	1840—1842	——	21,846.54	——	——	——	——	21,846.54
19 Alterations of Aqueduct, 86th to 92d Street	1866—1868	70,081.00	——	——	——	——	——	70,081.00
*26 Forty-second Street Reservoir, Removal of Pipes (Chapter 456, Laws of 1881)	1881—1883	——	9,053.51	——	——	——	——	9,053.51
†33 Salaries Croton Aqueduct Department	1860—1870	——	779,656.01	——	——	——	——	779,656.01
33 Salaries Department of Public Works	1870—1897	——	1,514,137.85	——	$2,091,795.42	——	——	3,605,933.27
‡34 Contingencies Croton Aqueduct Board	1860—1870	——	54,054.85	——	——	——	——	54,054.85
35 Deficiencies Croton Aqueduct Department	1866—1870	——	6,500.00	——	——	——	——	6,500.00
36 Aqueduct New Work	1872—1873	3,170.78	——	——	——	——	——	3,170.78
38 Aqueduct Repairs and Maintenance Pay-rolls Department of Public Works on the Construction of Gate House Waste Weir	1875	6,377.14	——	——	——	——	——	6,377.14
39 Additional Alterations of the Aqueduct	1876	364.06	——	——	——	——	——	364.06
40 Croton Water Main Fund from Taxation	1879—1881	76,959.50	——	——	——	——	——	76,959.50
41 Expenses of Providing a Supply of Water for the Twenty-fourth Ward	1880	——	12,500.00	——	——	——	——	12,500.00
41 Water Supply of the Twenty-fourth Ward	1880—1897	——	47,880.89	——	78,283.25	——	——	126,164.14
42 Repairing and Renewal of Pipes, Stop-cocks, etc.	1872—1897	——	1,328,994.80	——	2,425,753.52	——	——	3,754,748.32
42 Repairing and Renewal of Pipes, Stop-cocks, etc., "for Ordinary Repairs"	1888—1889	——	——	——	149,961.86	——	——	149,961.86
42 Repairing and Renewal of Pipes, Stop-cocks, etc., "for Replacing Water Mains, etc., etc."	1888—1889	——	——	——	49,909.16	——	——	49,909.16
43 Supplying Water to Shipping and for Building Purposes	1878	7,990.00	——	——	——	——	——	7,990.00

TABLE V—(Continued).

1	2	3	4	5	6	7	8	9
46 Aqueduct Repairs, Maintenance and Strengthening...	1880—1897	——	1,110,256.20	——	2,428,119.98	——	——	3,538,376.18
47 Expenses of Laying Four-foot Croton Mains, etc....	1880—1882	78,199.52	——	——	——	——	——	78,199.52
48 Laying Croton Pipes (Chapter 381, Laws of 1879)......	1880—1897	1,055,434.32	——	$2,737,258.50	——	——	——	3,792,692.82
49 Aqueduct Repairs, Maintenance and Strengthening, Care, Maintenance and Repairs......................	1890—1892	——	——	——	378,786.66	——	——	378,786.66
50 Aqueduct Repairs, Maintenance and Strengthening, Completing the Excavation in the Old Central Park Reservoir	1890—1895	——	——	128,500.00	——	——	——	128,500.00
51 Aqueduct Repairs, Maintenance and Strengthening, Building New Gate House and Removing Old Gate House..................................	1891—1892	——	——	——	9,977.05	——	——	9,977.05
52 Bronx River Works, Maintenance and Repairs.......	1885—1897	——	——	——	259,667.31	——	——	259,667.31
53 For Furnishing and Laying Pipes and Appurtenances for Supplying Water to North Brother Island for the use of the Health Department..................	1883—1885	27,067.25	——	3,135.25	——	——	——	30,202.50
54 Forty-second Street Reservoir Reconnections.........	1884—1885	——	1,866.56	——	3,133.44	——	——	5,000.00
55 For Repairing Water Mains Leading to North Brother Island	1887	——	——	——	2,045.75	——	——	2,045.75
56 For New Water Mains and Testing for Water Supply by Boring on North Brother Island.................	1888—1890	——	——	20,471.50	——	——	——	20,471.50
57 Aqueduct Repairs, Maintenance and Strengthening Connections, etc., Central Park Reservoir...........	1893—1896	——	——	88,983.00	——	——	——	88,983.00
58 Removal of Old Gate House at 119th Street and 10th Avenue and Construction of New Gate House and Connections	1894—1896	——	——	——	48.633.40	——	——	48,633.40
Aqueduct Repairs and Maintenance..................	——	——	——	——	——	——	$255,567.40	255,567.40
Bronx River Works, Maintenance and Repairs........	——	——	——	——	——	——	25,564.39	25,564.39
Laying Croton Pipes..................................	——	——	——	——	——	$79,214.91	——	79,214.91
Repairing and Renewal of Pipes, Stop-cocks, etc.....	——	——	——	——	——	——	213,358.90	213,358.90
Water for the Twenty-fourth Ward....................	——	——	——	——	——	——	5,539.88	5,539.88
Salaries Department of Water Supply and Balance of Salaries Department of Public Works...............	——	——	——	——	——	——	167,644.96	167,644.96
	——	$5,103,075.78	$6,987,961.02	$2,978,348.25	$7,926,066.80	$79,214.91	$667,675.53	$23,742,342.29

* $9,000 paid from Tax. $53.51 paid from Appropriation.

† Salaries Croton Acqueduct Department, 1860 to April 30, 1870, inclusive, treated as a direct charge to Maintenance Account, from April 30, 1870, to January, 1898; one-half of the expenditure for salaries of the Department of Public Works is charged to maintenance in the disbursements from gross appropriations for that purpose, as per the opinion of George W. Birdsall, Chief Engineer, Department of Water Supply, that portion being his estimated approximated amount properly chargeable to the Croton Aqueduct to cover salaries and miscellaneous expenses.

‡ After April 30, 1870, this expense is regarded as provided for in the treatment of salaries, Department of Public Works.

TABLE VII.

DISTRIBUTION OF DISBURSEMENTS FOR CONSTRUCTION AND MAINTENANCE OF THE CROTON AQUEDUCT SYSTEM FROM 1832 TO 1884, INCLUSIVE.

Separated Into Two Constructive Periods of Old Aqueduct and Works for Extension.

	1	1	3	4
Expenditures, 1832-1849—(Old Aqueduct).		Construction, 1832-1849.	Maintenance, 1832-1849.	Total Disbursements.
1 Water Pipes	1832—1845	$2,097,862.62	——	——
6 Water Commissioners (Disbursements)	1833—1849	8,911,448.08	——	——
8 City Aqueduct (Miscellaneous Disbursements)	1835—1843	11,436.69	——	——
15 Croton Water Works Extension	1849	230,000.00	——	——
3 Water Pipes	1844—1849	425,989.31	——	——
11 Aqueduct Repairs by Commissioners	1844—1849	——	52,492.05	——
Disbursements for Construction to December 31, 1849	——	$11,676,736.70	——	——
Disbursements for Maintenance to December 31, 1849	——	——	$52,492.05	$11,729,228.75
† Additional Expenditures, 1850-1884.				
15 Croton Water Works Extension	1850—1858	621,691.83	——	——
16 Aqueduct Construction	1850	19,890.00	——	——
17 New Reservoir Awards	1856—1858	549,512.12	——	——
18 Croton Water Works Extension Storage Reservoir	1865—1872	589,580.40	——	——
19 Alterations of Aqueduct, 86th to 92d Street	1865—1866	250,000.00	——	——
20 Croton Water Works Extension High Service Carmansville	1865—1877	969,930.14	——	——
21 Croton Water Main Fund	1871—1881	*5,259,296.32	——	——
22 Croton Water Pipe Fund	1869—1872	458,549.70	——	——
23 Croton Water Fund	1871—1884	*4,924,482.88	——	——
24 Water Stock 1870 Improvement Lower Reservoir	1872—1875	504,323.75	——	——
25 Croton Water Works Extension and New Reservoir	1859—1867	*3,020,991.69	——	——
27 Additional Alterations of Aqueduct 93d to 113th Street	1870—1880	3,655,949.52	——	——
28 Additional Water Fund (1913—1933)	1883—1884	204,499.73	——	——
3 Water Pipes	1850—1858	1,141,528.02	——	——
3 Water Pipes, Freightage and Laying	1859—1871	2,209,914.88	——	——
19 Alterations to Aqueduct, 86th to 92d Street	1866—1868	70,081.00	——	——
36 Aqueduct New Work	1872—1873	3,170.78	——	——
38 Aqueduct Repairs and Maintenance Pay Rolls, Department of Public Works, on the Construction of Gate House Waste Weir	1875	6,377.14	——	——
39 Additional Alterations of the Aqueduct	1876	364.06	——	——

TABLE VII.—(Continued).

	1	2	3	4
40 Croton Water Main Fund from Taxation	1879—1881	76,959.50	——	——
43 Supplying Water to Shipping and for Building Purposes	1878	7,990.00	——	——
47 Expenses for Laying Four-Feet Croton Mains, etc	1880—1882	78,199.52	——	——
48 Laying Croton Pipes (Chapter 381, Laws of 1879)	1880—1897	*1,055,434.32	——	——
53 For Furnishing and Laying Pipes, etc., for Supplying Water to North Brother Island for the use of the Health Department	1883—1884	27,067.25	——	——
General Maintenance Disbursements	1850—1884	——	6,939,139.54	——
Disbursements for Maintenance, 1850—1884, Inclusive	——	$25,705,784.55	$6,939,139.54	$32,644,924.09
Totals: Second Period, 1850—1884, Inclusive	——	$37,382,521.25	$6,991,631.59	$44,374,152.84

† Includes the Bronx and Byram River System, the estimated cost of which was $4,000,000 to January 1, 1885.

* Although the sum of $33,000.000 has been mentioned as the estimated cost of construction of the Old Aqueduct plant, at the end of 1884, a considerable portion of this amount, perhaps $5,000,000, was expended for improvements in connection with an anticipated further supply of water, which became effective in the new Croton Aqueduct—available in 1891—say a portion of Croton Water-Main Fund, Croton Water Fund, Croton Water Works Extension and New Reservoir, and laying Croton Pipes.

TABLE VI.

RECEIPTS OF MONEYS FROM MISCELLANEOUS SOURCES AND INTEREST INCLUDED IN THE DISBURSEMENTS ON ACCOUNT OF THE CONSTRUCTION AND MAINTENANCE OF THE CROTON AQUEDUCT.

Miscellaneous Receipts Credited to Disbursements from Sale of Bonds, Construction Account.		1st Period. 1832-1882.	2d Period. 1883-1897.	3d Period. 1898.	Totals.
2. Receipts from sale of old material, etc	1833-1843	$5,547.24	——	——	$5,547.24
7. Water Commissioners, rents received from land, etc	1837-1861	6,372.38	——	——	6,372.38
24. Croton Water Fund, sundry receipts	1893	——	$1,139.05	——	1,139.05
29. Additional Water Fund, 1913-1933, sundry receipts	1885-1897	——	81,122.49	$18,390.69	99,513.18
		$11,919.62	$82,261.54	$18,390.69	$112,571.85
10. City Aqueduct interest receipts	1836-1839	$77,050.35	——	——	$77,050.35
		$77,050.35	——	——	$77,050.35
4. Water pipes, sale of old material, etc	1844-1858	$11,176.52	——	——	$11,176.52
4. Water pipes, freightage and laying, etc	1859	255.51	——	——	255.51
		$11,432.03	——	——	$11,432.03

TABLE VIII.

STATEMENT SHOWING ANNUAL AND TOTAL RECEIPTS FROM CROTON WATER RENTS.

For the Period August 6, 1842, to December 31, 1898.

	Water Rents.	Interest.	Refunds.	Net Water Revenue.
1842				$17,862.17
1843				86,887.31
1844				118,124.35
1845				157,791.66
1846				193,914.70
1847				221,635.10
1848				255,053.09
1849				278,811.72
1850				458,951.87
1851				458,789.78
1852				562,189.89
1853				601,294.79
1854				641,853.18
1855				708,806.43
1856				703,170.78
1857				735,364.11
1858				783,623.88
1859	$781,945.62	$8,053.46 *31,506,91	——	$821,505.99
1860	814,711.96	8,208.85	——	822,920.81
1861	804,938.08	4,710.42	——	809,648.50
1862	840,549.62	8,000.37	——	848,549.99
1863	936,513.15	7,374.42	——	943,887.57
1864	958,974.41	8,367.84	——	967,342.25
1865	1,033,991.48	15,564.72	——	1,049,556.20
1866	1,100,433.54	15,129.62	——	1,115,563.16
1867	1,229,632.96	9,232.27	——	1,238,865.23
1868	1,271,222.44	3,766.74	——	1,274,989.18
1869	1,258,939.36	6,756.37	——	1,265,695.73
1870	1,185,966.18	2,694.80	——	1,188,660.98
1871	1,250,295.69	7,002.18	——	1,257,297.87
1872	1,411,091.16	6,067.37	——	1,417,158.53
1873	1,465,565.02	4,496.75	——	1,470,061.77
1874	1,412,495.90	9,652.65	——	1,422,148.55
1875	1,406,274.83	4,774.81	——	1,411,049.64
1876	1,454,162.78	3,593.01	$10,500.00	1,447,255.79
1877	1,520,344.60	4,872.78	11,000.00	1,514,217.38
1878	1,655,074.10	5,597.74	5,000.00	1,655,671.84
1879	1,688,050.29	6,293.30	2,500.00	1,691,843.59
1880	1,616,009.47	9,504.02	10,000.00	1,615,513.49
1881	1,581,915.43	13,016.18	5,000.00	1,589,931.61
1882	1,714,409.06	8,452.32	——	1,722,861.38
1883	1,960,610.29	12,890.94	5,801.70	1,967,699.53
1884	2,085,320.24	7,146.14	4,308.45	2,088,157.93
1885	2,235,272.30	7,851.23	4,521.02	2,238,602.51
1886	2,485,657.61	16,317.30	2,473.07	2,499,501.84
1887	2,628,623.79	8,831.96	5,526.61	2,631,929.14

* Revenue accrued prior to 1859.

TABLE VIII—(Continued).

	Water Rents.	Interest.	Refunds.	
1888	2,568,718.38	13,006.04	4,074.18	2,577,650.24
1889	2,712,259.54	21,146.44	4,531.01	2,728,874.97
1890	2,840,257.02	12,134.89	4,809.29	2,847,582.61
1891	3,261,723.73	10,356.10	5,978.99	3,266,100.84
1892	3,301,248.75	14,249.50	9,272.73	3,306,225.52
1893	3,846,967.64	16,792.23	6,033.34	3,857,726.53
1894	3,638,463.42	22,012.54	6,500.97	3,653,974.99
1895	3,830,340.71	22,055.71	3,811.66	3,848,584.76
1896	4,051,555.15	22,301.17	7,948.43	4,065,907.89
1897	4,301,631.11	31,690.09	7,064.58	4,326,256.62
1898	4,416,759.00	31,123.17	5,654.11	4,442,228.08
Total	——	——	——	$87,893,325.84

EXPENSES CHARGED AGAINST CROTON WATER RENTS.

1853	Advertising	$1,255.13		
1854	"	345.00		
	Compiling Returns, etc., Pay Rolls		$394.91	
1855	" " " "		116.05	
1856	" " " "		928.18	
1857	" " " "		631.30	
		$1,600.13	$2,070.44	$3,670.57

TABLE IX.

AGGREGATE AMOUNT OF BONDS AND STOCKS ISSUED FROM 1835 TO 1898, INCLUSIVE, BY THE CITY OF NEW YORK FOR THE CONSTRUCTION OF THE CROTON AQUEDUCT AND THE ADDITIONS AND EXTENSIONS THEREOF.

Divided into Three Periods, Each Period Displaying the Annual Issue, Redemption, Net Proceeds from Sales, and the Amount of Bonds and Stocks Outstanding at the End of Each Period.

First Period, 1835-1883.

1	2	3	4	5	6	7	8	9	10
Title of Fund.	Issue.		Redemptions.		Proceeds of Sales.		Premium Realized	Inter't Reali'd	Discount Paid.
	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.			
1 The Water Stock of the City of New York..........	1835—1849	10,647,000.00	1858—1880	10,647,000.00	1835—1849	9,999,842.68	119,300.00	3,204.17	769,661.49
2 The 7% Water Loan of the City of New York.......	1842	2,000,000.00	1847—1857	2,000,000.00	1842	2,000,000.00	——	——	——
3 The Croton Water Stock of the City of New York..	1845—1852	1,000,000.00	1882	678,600.00	1845—1852	1,005,479.00	5,479.00	——	——
4 The Water Stock of the City of New York (1849)...	1849—1866	522,600.00	1875—1879	522,600.00	1849—1866	525,238.00	2,638.00	——	——
5 The Water Stock of the City of New York (1854)..	1856—1860	1,908,000.00	1875—1877	1,908,000.00	1856—1860	1,919,975.92	10,060.05	115.87	——
6 The Croton Water Stock of the City of New York (1883)	1860—1869	1,900,000.00	1882	1,449,400.00	1860—1869	1,923,676.43	23,676.43	——	——
7 The Croton Aqueduct Bonds of the City of New York	1865—1870	490,000.00	1882	490,000.00	1865—1870	490,000.00	——	——	——
8 The Croton Reservoir Bonds of the City of New York	1865—1877	970,637.36	1882	950,637.36	1865—1877	970,637.36	——	——	——
9 The New Aqueduct Stock of the City of New York..	1865—1866	250,000.00	1882	150,000.00	1865—1866	250,000.00	——	——	——
10 The Croton Water Pipe Bonds of the City of New York..........	1869	450,000.00	1880	450,000.00	1869	458,758.00	8,758.00	——	——
11 The Additional New Croton Aqueduct Stock of the City of New York..........	1870—1879	3,618,635.11	1882	2,287,335.11	1870—1879	3,657,241.16	38,606.05	——	——
12 The Croton Water Main Stock of the City of New York..........	1871—1881	5,196,000.00	——	——	1871—1881	5,265,124.60	69,124.60	——	——
13 The Additional Croton Water Stock (1891) of the City of New York..........	1871—1882	3,080,000.00	——	——	1871—1882	3,090,598.60	10,598.60	——	——
14 The Water Stock of 1870—1902 of the City of New York	1872	500,000.00	1882	25,000.00	1872	513,797.15	13,797.15	——	——
	——	32,532,872.47	——	21,558,572.47	——	32,069,468.90	302,937.88	3,320.04	769,661.49

Stock outstanding at Dec. 31, 1882............ 10,974,300.00

TABLE IX—(Continued).

Second Period, 1884–1897.

1	2	3	4	5	9	7	8	8	10
3 The Croton Water Stock of the City of New York..	——	——	1890	321,400.00	——	——	——	——	——
6 The Croton Water Stock of the City of New York (1883)	——	——	1883	450,600.00	——	——	——	——	——
9 The New Aqueduct Stock of the City of New York..	——	——	1884	100,000.00	——	——	——	——	——
13 The Additional Croton Water Stock (1891) of the City of New York..................................	1883—1897	5,856,000.00	1891—1895	2,020,000.00	1883—1897	5,880,071.00	24,071.00	——	——
15 The Additional Water Stock (1913—1933) of the City of New York..................................	1883—1897	36,045,000.00	——	——	1883—1897	36,885,766.45	840,766.45	——	——
16 The Water Main Stock (No. 1) of the City of New York..................................	1893—1895	500,000.00	——	——	1893—1895	500,794.25	794.25	——	——
17 The Additional Water Stock of the City of New York	1893—1897	1,950,000.00	——	——	1893—1897	1,961,070.75	11,070.75	——	——
18 The Water Main Stock (No. 2) of the City of New York..................................	1896—1897	650,000.00	——	——	1896—1897	673,648.00	23,648.00	——	——
	——	45,001,000.00	——	2,992,000.00	——	45,901,350.45	900,350.45	——	——

Stock outstanding at Dec. 31, 1897............ 53,083,300.00

Third Period, 1898.

1	2	3	4	5	9	7	8	8	10
15 The Additional Water Stock (1913—1933) of the City of New York..................................	1898	2,300,000.00	——	——	1898	2,398,800.00	98,800.00	——	——
17 The Additional Water Stock of the City of New York	1898	500,000.00	——	——	1898	517,290.00	17,290.00	——	——
18 The Water Main Stock (No. 2) of the City of New York..................................	1898	350,000.00	——	——	1898	364,820.00	14,820.00	——	——
	——	3,150,000.00	——	——	——	3,280,910.00	130,910.00	——	——
Stock outstanding at Dec. 31, 1987		53,083,300.00							
Stock outstanding at Dec. 31, 1898				56,233,300.00					
	1835—1898	80,683,872.47	——	24,450,572.47	——	81,251,729.35	1,334,198.33	3,320.04	769,661.49

Stock outstanding at Dec. 31, 1898............ 56,233,300.00

TABLE X.

OUTSTANDING WATER STOCKS AND BONDS AT DECEMBER 31, 1898.

Issued by the City of New York for the Construction of the Croton Aqueduct and Appurtenances Thereto, the Amounts Issued at Their Respective Rates of Interest, How Payable and the Amount Held by the Sinking Fund, Etc., Etc.

Title of Fund.	When Issued.	Amounts Issued at Respective Rates of Interest.						
		2½%.	3%.	3½%.	4%.	5%.	6%.	7%.
8 The Croton Reservoir Bonds of the City of New York	1866	—	—	—	—	—	$20,000.00	—
11 The Additional New Croton Aqueduct Stock of the City of New York	1872—1877	—	—	—	$15,000.00	1,697,000.00	1,256,000.00	2,228,000.00
12 The Croton Water Main Stock of the City of New York	1871—1881	—	—	—	—	$57,000.00	269,800.00	$1,004,500.00
13 The Additional Croton Water Stock (1891) of the City of New York	1871—1897	$300,000.00	$3,986,000.00	$400,000.00	2,230,000.00	—	—	—
14 The Water Stock (1870-1902) of the City of New York	1872	—	—	—	—	—	63,000.00	412,000.00
15 The Additional Stock (1913-1933) of the City of New York	1883—1898	950,000.00	28,814,500.00	8,580,500.00	—	—	—	—
16 The Water Main Stock (No. 1) of the City of New York	1893—1895	—	500,000.00	—	—	—	—	—
17 The Additional Water Stock of the City of New York	1893—1898	—	1,925,000.00	525,000.00	—	—	—	—
18 The Water Main Stock (No. 2) of the City of New York	1896—1898	—	300,000.00	700,000.00	—	—	—	—
	—	$1,250,000.00	$35,525,500.00	$10,205,500.00	$2,245,000.00	$1,754,000.00	$1,608,800.00	$3,644,500.00

TABLE X—(Continued).

Title of Fund.	Total amount outstanding at Dec. 31, 1898.	When Payable.	How Payable.				
			From sinking fund under ordinance, etc., authorizing their issue.	From special fund derived from the sinking fund and from taxation.	From taxation under laws authorizing their issue.	Water sinking fund of the City of New York, § 208, chap. 378, L. 1897.	Amount held by the sinking fund.
8 The Croton Reservoir Bonds of the City of New York	$20,000.00	1907	$20,000.00	——	——	——	——
11 The Additional New Croton Aqueduct Stock of the City of New York	1,331,300.00	1900	1,331,300.00	——	——	——	——
12 The Croton Water Main Stock of the City of New York	5,196,000.00	1900—1906	——	$710,000.00	$4,486,000.00	——	$2,555,000.00
13 The Additional Croton Water Stock (1891), of the City of New York	$6,916,000.00	1899—1914	——	6,916,000.00	——	——	5,816,000.00
14 The Water Stock (1870-1902) of the City of New York	475,000.00	1902	475,000.00	——	——	——	——
15 The Additional Stock (1913-1933) of the City of New York	38,345,000.00	1904—1905 1907—1912 1913—1915 1916—1917	——	35,600,000.00	445,000.00	$2,300,000.00	11,214,500.00
16 The Water Main Stock (No. 1) of the City of New York	500,000.00	1912	——	500,000.00	——	——	250,000.00
17 The Additional Water Stock of the City of New York	2,450,000.00	1912—1917	——	1,950,000.00	——	500,000.00	1,533,500.00
18 The Water Main Stock (No. 2) of the City of New York	1,000,000.00	1918	——	650,000.00	——	350,000.00	300,000.00
	$56,233,300.00	——	$1,826,300.00	$46,326,000.00	$4,931,000.00	$3,150,000.00	$21,669,000.00

TABLE XI.

SCHEDULE A.—THE WATER STOCK OF THE CITY OF NEW YORK.

Showing the Annual Issue, Redemptions, Proceeds of Sales, Premium and Interest Received and Discount Paid.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.				
	Amount Authoriz'd.	Interest Rates.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premi'm Realiz'd.	Interest Realized.	Discount Paid.
			—	—	1858	2,831,670.00	—	—	—	—	—
The Water Stock of the City of New York, Act May 2, 1834, Ordinance			—	—	1859	122,209.00	—	—	—	—	—
			1835	1,000,000.00	1860	2,480,716.00	1835	1,119,300.00	119,300.00	—	—
of the Common Council, May 7,			1837	350,000.00	1861	8,400.00	1837	350,000.00	—	—	—
1835, Chap. 256, Laws of 1834......	2,500,000.00	5% Quarterly	1838	1,935,030.00	1862	31,572.00	1838	1,456,553.04	—	—	500.00
			1839	2,148,700.00	1864	1,885.00	1839	1,910,399.15	—	3.50	253,679.35
			1840	2,369,539.00	1866	20,348.00	1840	2,408,449.02	—	3,025.44	426,717.38
Act March 29, 1838, Ordinance of			1841	817,231.00	1870	2,675,704.00	1841	728,641.47	—	175.23	88,764.76
the Common Council, May 3,			1842	191,000.00	1871	163,488.00	1842	191,000.00	—	—	—
1838, Chap. 127, Laws of 1838......	3,000,000.00	5% Quarterly	1843	234,000.00	1872	145,053.00	1843	234,000.00	—	—	—
			1844	432,854.00	1873	13,250.00	1844	432,854.00	—	—	—
Act April 27, 1840, Ordinance of the			1845	397,223.00	1874	3,550.00	1845	397,223.00	—	—	—
Common Council, April 28, 1840,			1847	70,000.00	1875	1,600.00	1847	70,000.00	—	—	—
			1848	301,434.00	1877	555.00	1848	301,434.00	—	—	—
Chap. 175, Laws of 1840...........	3,000,000.00	5% Quarterly	1849	399,989.00	1880	2,147,000.00	1849	399,989.00	—	—	—
Act May 26, 1841, Ordinance of the Common Council, June 25, 1841, Chap. 306, Laws of 1841...........	3,500,000.00	5% Quarterly	—	—	—	—	—	—	—	—	—
	12,000,000.00	—	—	—	—	—	—	—	—	—	—
Deduct stock not issued under Chap. 306, Laws of 1841...........	1,353,000.00	—	—	—	—	—	—	—	—	—	—
	10,647,000.00	—	—	10,647,000.00	—	10,647,000.00	—	9,999,842.68	119,300.00	3,204.17	769,661.49

All of the above stock issued for supplying the City of New York with pure and wholesome water.

TABLE XI—(Continued).

SCHEDULE B.—THE 7 PER CENT. WATER LOAN OF THE CITY OF NEW YORK.

Showing Annual Issue, Redemptions and Proceeds of Sales.

	Issue.				Redemptions.		Proceeds of Sales.				
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Am'ts.	Prem. Real'd.	Inter't Real'd.	Disc't Paid.
The 7% water loan of the City of New York for supplying the City of New York with pure and wholesome water. Chapter 306, Laws of 1841, Section No. 3.	——	7%	1842	2,000,000.00	1847	120,305.00	1842	2,000,000.00	——	——	——
	——	——	——	——	1852	889,207.00	——	——	——	——	——
	——	——	——	——	1857	990,488.00	——	——	——	——	——
	——	——	——	2,000,000.00	——	2,000,000.00	——	2,000,000.00	——	——	——

SCHEDULE C.—THE CROTON WATER STOCK OF THE CITY OF NEW YORK.

Showing the Annual Issue, Redemptions, Proceeds of Sales, Premium Received, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.				
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Am'ts.	Prem. Real'd.	Inter't Real'd.	Disc't Paid.
The Croton water stock of the City of New York, Chapter 225, Laws of 1845; for the purpose of liquidating the damages and expenses of introducing the Croton water into the City of New York.	500,000.00	5% Quarterly	1845	70,000.00	1882	678,600.00	1845	70,000.00	——	——	——
	——	——	1846	215,000.00	1890	321,400.00	1846	215,000.00	——	——	——
	——	——	1847	100,000.00	——	——	1847	100,000.00	——	——	——
	——	——	1848	95,000.00	——	——	1848	95,000.00	——	——	——
	——	——	1850	20,000.00	——	——	1850	20,000.00	——	——	——
Chapter 235, Laws of 1851. For the purpose of reimbursing the treasury of said city, the amount advanced for extending water pipes (mains), in said city for the distribution of the Croton water, and for further extension of the same.	500,000.00	400,000@5%	1851	350,000.00	——	——	1851	350,854.00	854.00	——	——
	——	100,000@6%	1852	150,000.00	——	——	1852	154,625.00	4,625.00	——	——
	1,000,000.00	——	——	1,000,000.00	——	1,000,000.00	——	1,005,479.00	5,479.00	——	——

TABLE XI—(Continued).

SCHEDULE D.—THE WATER STOCK OF THE CITY OF NEW YORK (1849).

Showing the Annual Issue, Redemptions, Proceeds of Sales, Premium Realized, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.				
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premi'm Realiz'd.	Int'st Re'l'd.	Discount Paid.
The water stock of the City of New York of 1849, Chapter 90, Laws of 1849.	600,000.00	5% Quarterly	1849	230,000.00	1875	229,900.00	1849	232,600.00	2,600.00	—	—
	—	485,600@5%	1850	25,600.00	1876	23,700.00	1850	25,600.00	—	—	—
Amended by Chapter 109 of 1866, changing rate of interest not to exceed 7%.	—	37,000@6%	1863	228,000.00	1877	2,000.00	1863	228,038.00	38.00	—	—
	—	—	1864	2,000.00	1879	267,000.00	1864	2,000.00	—	—	—
	77,400.00	—	1866	37,000.00	—	—	1866	37,000.00	—	—	—
Stock not issued....................	522,600.00	—	—	522,600.00	—	522,600.00	—	525,238.00	2,638.00	—	—
For the purpose of purchasing ground, if necessary or expedient, of building an additional reservoir, of laying new mains and increasing the supply of water in the city.											

SCHEDULE E.—THE WATER STOCK OF THE CITY OF NEW YORK (1854).

Showing the Annual Issue, Redemptions, Proceeds of Sales, Premium and Interest Realized, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.				
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Prem. Real'd.	Int'st R'l'd.	Disco'nt Paid.
The water stock of the City of New York (of 1854), Chapter 342, Laws of 1854, for the purpose of building a new reservoir, purchasing lands, and extending the Croton water works in said city.	500,000.00	5% Quarterly	1856	29,100.00	1875	1,902,400.00	1856	29,100.00	—	—	—
	—	29,100@5%	1857	988,300.00	1876	4,600.00	1857	988,441.92	62.63	79.29	—
	—	1,878,900@5%	1858	11,700.00	1877	1,000.00	1858	11,736.58	—	36.58	—
	—	1,908,000	1859	650,000.00	—	—	1859	654,325.10	4,325.10	—	—
	1,408,000.00	—	1860	228,900.00	—	—	1860	235,472.32	6,572,32	—	—
Chapter 24, Laws of 1857. An act to amend Chapter 342, Laws of 1854, for same purpose, changing interest rate and authorizing issue to the sum of $1,908,000.00.	1,908,000.00	—	—	1,908,000.00	—	1,908,000.00	—	1,919,075.92	10,960.05	115.87	—

TABLE XI—(Continued).

SCHEDULE F.—THE CROTON WATER STOCK OF THE CITY OF NEW YORK (1883).

Showing the Annual Issue, Redemptions, Proceeds of Sales, Premium Realized, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amounts Authoriz'd.	Interest Rates.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realiz'd.
The Croton water stock of the City of New York (1883), Chapter 372, Laws of 1860. To increase the supply of Croton water and to the extension of the necessary works for accumulating and distributing the same in said city, and to no other purpose whatsoever.	1,000,000.00	6% Quarterly	1860	525,000.00	1882	1,449,400.00	1860	531,691.80	6,691.80
	——	——	1861	1,025,000.00	1883	450,600.00	1861	1,025,076.20	76.20
	——	——	1862	250,000.00	——	——	1862	266,908.43	16,908.43
	——	——	1869	100,000.00	——	——	1869	100,000.00	——
Chapter 181, Laws of 1861. Increasing issue to $1,900,000.00.	900,000.00	6% Quarterly	——	——	——	——	——	——	——
	1,900,000.00	——	——	1,900,000.00	——	1,900,000.00	——	1,923,676.43	23,676.43

SCHEDULE G.—THE CROTON AQUEDUCT BONDS OF THE CITY OF NEW YORK.

Showing the Annual Issue, Redemptions, Proceeds of Sales, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.	
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.
The Croton aqueduct bonds of the City of New York. Chapter 285, Laws of 1865. For the construction of impounding or storage reservoirs in the Counties of Putnam and Westchester.	300,000.00	Not to exceed	1865	25,000.00	1882	490,000.00		
		7%-40-yr bonds	1866	15,000.00	——	——	1865	25,000.00
		Issued at 6%,	1867	160,000.00	——	——	1866	15,000.00
		pay'ble quar'ly	1868	80,000.00	——	——	1867	160,000.00
Chapter 784, Laws of 1869. Authority to increase issue.	190,000.00	Not to exceed	——	——	——	——		
		7%-40-yr bonds	1869	50,000.00	——	——	1868	80,000.00
		Issued at 6%,	1870	160,000.00	——	——	1869	50,000.00
		pay'ble quar'ly	——	——	——	——	1870	160,000.00
	490,000.00	——	——	490,000.00	——	490,000.00	——	490,000.00

TABLE XI—(Continued.)

SCHEDULE H.—CROTON RESERVOIR BONDS OF THE CITY OF NEW YORK.

Showing Annual Issue, Redemptions, Proceeds of Sales, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.	
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.
Croton reservoir bonds, Chapter 95, Laws of 1863. For acquiring	$200,000.00	Not exceed-	1865	$20,000.00	1882	$950,637.36	1865	$20,000.00
lands north of One Hundred and Seventeenth street, etc., for	——	ing 6% quar-	1866	95,000.00	—	——	1866	95,000.00
the building of a reservoir or reservoirs, etc.	——	terly. All is-	1867	85,000.00	—	——	1867	85,000.00
Chapter 267, Laws of 1864. To establish a scale of annual rents.	——	sued at 6%	1868	170,000.00	—	——	1868	170,000.00
Chapter 251, Laws of 1867. Authority to expend in completion	——	excepting $5,-	1869	255,000.00	—	——	1869	255,000.00
of the High Service Water Works at Carmansville, and further	300,000.00	000 issued on	1870	275,000.00	—	——	1870	275,000.00
to expend the sum of	200,000.00	April 3, 1877,	1871	20,000.00	—	——	1871	20,000.00
in laying water pipes, etc.	——	which was is-	1872	34,500.00	—	——	1872	34,500.00
	——	sued at 5%,	1874	6,137.36	—	——	1874	6,137.36
Chapter 784, Laws of 1869. Authority to expend in the completion	——	interest due	1875	5,000.00	—	——	1875	5,000.00
of the High Service Water Works at Carmansville, an addi-	——	in 1917.	1877	5,000.00	—	——	1877	5,000.00
tional amount.	290,000.00	——	—	——	—	20,000.00		
	$990,000.00	——	—	——	—	——	—	——
Stock not issued..	19,362.64	——	—	——	—	——	—	——
Stock outstanding at close of business Dec. 31, 1898, payable Aug. 1, 1907, interest at 6%....................................	——	——	—	——	—	——	—	——
	$970,637.36	——	—	$970,637.36	—	$970,637.36	—	$970,637.36

SCHEDULE I.—NEW AQUEDUCT STOCK OF THE CITY OF NEW YORK.

Showing Annual Issue, Redemptions and Proceeds of Sales.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.	
	Amount Author'd	Interest Rate.	Years.	Am'ts.	Years.	Am'ts.	Years.	Amounts.
New Aqueduct Stock, Chapter 581, Laws of 1865. To make the necessary excavations and construct a branch aqueduct, etc., at some point between the westerly line of the Eighth Avenue and the new reservoir in Central Park to the old reservoir in said park, etc.	$250,000.00	6% quarterly	1865 1866	$50,000.00 200,000.00	1882 1884	$150,000.00 100,000.00	1865 1866	$50,000.00 200,000.00
	$250,000.00	——	—	$250,000.00	—	$250,000.00	—	$250,000.00

TABLE XI—(Continued).

SCHEDULE J.—CROTON WATER PIPE BONDS OF THE CORPORATION OF THE CITY OF NEW YORK.
Showing Annual Issue, Redemptions, Proceeds of Sales and Premium Realized.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Author'd	Interest Rate.	Years.	Am't.	Years.	Am'ts.	Years.	Am'ts.	Prem. Real'd.
Croton water pipe bonds, Chapter 876, Laws of 1869. For the purpose of providing means for purchase of water pipes and laying the same.	$450,000.00	Not to exceed 7%, May & November	1869	$450,000.00	1880	$450,000.00	1869	$458,758.00	$8,758.00
	$450,000.00	——	——	$450,000.00	——	$450,000.00	——	$450,000.00	$8,758.00

SCHEDULE K.—ADDITIONAL NEW CROTON AQUEDUCT STOCK OF THE CITY OF NEW YORK.
Showing Annual Issue, Redemptions, Proceeds of Sales, Premium Received, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Authorized.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realized.
Additional new Croton aqueduct stock, Chapter 230, Laws of 1870. To lay iron pipes or build a brick or stone conduit for the Croton water (as in the judgment of said Commissioner may seem best), etc., to connect with the aqueduct at Ninety-third street, as was laid down by the late Croton Aqueduct Board, Chapter 872, Laws of 1872; Chapter 461, Laws of 1874; Chapter 252, Laws of 1875; Chapter 269, Laws of 1875; Chapter 278, Laws of 1877.		Not to exceed 7%	1870	$246,000.00	1882	$2,287,335.11	1870	$246,000.00	——
	$57,000.00	@ 5%	1871	933,000.00	——	——	1871	933,000.00	——
	269,800.00	@ 6%	1872	952,000.00	——	——	1872	967,414.50	15,414.50
	*1,004,500.00	@ 7%	1873	710,000.00	——	——	1873	725,091.30	15,091.30
			1874	320,000.00	——	——	1874	324,225.00	4,225.00
			1875	240,000.00	——	——	1875	242,706.75	2,706.75
	192,635.11	@ 5%	1876	67,000.00	——	——	1876	67,000.00	——
	2,421,500.00	@ 6%	1877	146,635.11	——	——	1877	147,803.61	1,168.50
	1,004,500.00	@ 7%	1879	4,000.00	——	——	1879	4,000.00	——
*Stock outstanding at December 31, 1898	——	——	——	——	——	$1,331,300.00	——	$3,657,241.16	$38,606.05
	——	——	——	$3,618,635.11	——	$3,618,635.11	——	——	——

TABLE XI—(Continued).

SCHEDULE L.—CROTON WATER MAIN STOCK OF THE CITY OF NEW YORK.

Showing the Annual Issue, Proceeds of Sales and Premium Realized.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realized.
		Not to exceed 7%.	1871	$1,075,000.00	—	—	1871	$1,102,600.00	$27,600.00
			1872	425,000.00	—	—	1872	432,760.00	7,760.00
	$15,000.00	@ 4%	1873	800,000.00	—	—	1873	817,821.55	17,821.55
Croton water main stock, 1900-1906, Chapter 477,	1,697,000.00	@ 5%	1874	949,000.00	—	—	1874	962,000.00	13,000.00
Laws of 1875. An act to amend an act entitled,	1,256,000.00	@ 6%	1875	176,000.00	—	—	1875	177,578.05	1,578.05
etc., etc. Passed February 27, 1871, and also	2,228,000.00	@ 7%	1876	490,000.00	—	—	1876	490,000.00	—
April 6, 1871. Chapter 593, Laws of 1872 as	—	—	1877	412,000.00	—	—	1877	413,025.00	1,025.00
amended by Laws of 1878, Chapter 386.	—	—	1878	443,000.00	—	—	1878	443,340.00	340.00
	—	—	1879	256,000.00	—	—	—	256,000.00	—
	—	—	1880	145,000.00	—	—	—	145,000.00	—
	—	—	1881	25,000.00	—	—	1881	25,000.00	—
Stock outstanding December 31, 1898................	—	—	—	—	—	5,196,000.00	—	—	—
	—	—	—	$5,196,000.00	—	$5,196,000.00	—	$5,265,124.60	$69,124.60

TABLE XI—(Continued).

SCHEDULE M.—ADDITIONAL CROTON WATER STOCK OF THE CITY OF NEW YORK (1891).

Showing Annual Issue, Redemptions, Proceeds of Sales, Premium, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Prem. Real'd.
			1871	$126,000.00	1891	$1,780,000.00	1871	$126,000.00	——
			1872	324,000.00	1895	240,000.00	1872	332,705.60	$8,705.60
			1874	18,000.00	——	——	1874	18,000.00	——
	$300,000.00	@ 2½%	1875	132,000.00	——	——	1875	133,768.00	1,768.00
Additional Croton water stock (1891.) Chapter 56,	3,986,000.00	@ 3%	1876	130,000.00	——	——	1876	130,000.00	——
Laws of 1871; Chapter 328, Laws of 1871. An act	640,000.00	@ 3½%	1877	365,000.00	——	——	1877	365,000.00	——
to provide a further supply of pure and wholesome	2,395,000.00	@ 4%	1878	75,000.00	——	——	1878	75,125.00	125.00
water for the City of New York, etc.	1,005,000.00	@ 5%	1879	109,000.00	——	——	1879	109,000.00	——
	373,000.00	@ 6%	1880	325,000.00	——	——	1880	325,000.00	——
	237,000.00	@ 7%	1881	466,000.00	——	——	1881	466,000.00	——
			1882	1,010,000.00	——	——	1882	1,010,000.00	——
			1883	930,000.00	——	——	1883	930,000.00	——
			1884	999,000.00	——	——	1884	1,006,161.00	7,161.00
			1885	450,000.00	——	——	1885	450,000.00	——
			1886	250,000.00	——	——	1886	250,000.00	——
			1887	550,000.00	——	——	1877	550,000.00	——
			1888	150,000.00	——	——	1888	150,000.00	——
			1889	200,000.00	——	——	1889	200,000.00	——
Chapter 445, Laws of 1877. An act to provide a further	300,000.00	@ 2½%	1890	275,000.00	——	——	1890	275,000.00	——
supply of pure and wholesome water for the City of	3,986,000.00	@ 3%	1891	225,000.00	——	——	1891	225,000.00	——
New York, etc. As amended by Laws of 1879,	400,000.00	@ 3½%	1892	350,000.00	——	——	1892	350,000.00	——
Chapter 516, Sec. 1.	2,230,000.00	@ 4%	1893	245,000.00	——	——	1893	245,000.00	——
			1894	237,000.00	——	——	1894	237,000.00	——
			1895	245,000.00	——	——	1895	245,554.00	554.00
			1896	500,000.00	——	——	1896	516,356.00	16,356.00
			1897	250,000.00	——	——	1897	250,000.00	——
	——	——	——	$8,936,000.00	——	$2,020,000.00	——	$8,970,669.60	$34,669.60
Stock outstanding at December 31, 1898............	——	——	——	——	——	6,916,000.00	——	——	——
	——	——	——	——	——	$8,936,000.00	——	——	——

TABLE XI—(Continued).

SCHEDULE N.—WATER STOCK OF THE YEAR 1870.

Showing Annual Issue, Redemptions, Proceeds of Sales, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amounts Author'd	Interest Rates.	Years.	Amounts	Years.	Amounts.	Years.	Amounts.	Premium Realiz'd.
Water stock of 1870-1902, Chapter 383, Laws of 1870. To provide for the improvement of the lower reservoir, and for increasing the supply of water in the lower part of the City of New York, etc.	$500,000.00	Not to exceed 7%	1872	$500,000.00	1882	$25,000.00	1872	$513,797.15	$13,797.15
	88,000.00	@ 6%							
	412,000.00	@ 7%							
	63,000.00	@ 6%							
	412,000.00	@ 7%							
Stock outstanding at December 31, 1898.............	——	——	——	——	——	$475,000.00	——	——	——
	——	——	——	$500,000.00	——	$500,000.00	——	$513,797.15	$13,797.15

TABLE XI—(Continued).

SCHEDULE O.—ADDITIONAL WATER STOCK OF THE CITY OF NEW YORK.

Showing Annual Issue, Proceeds of Sales, Premium, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Authoriz'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realized.
Additional water stock 1913-1933, Chapter 490, Laws of 1883. An act to provide new reservoirs, dams and a new aqueduct with appurtenances thereto, for the purpose of supplying the City of New York with an increased supply of pure and wholesome water.			1883	$50,000.00	——	——	1883	$50,750.00	$750.00
	——	Not to exceed 5% or may be issued free of tax. In that case they shall bear interest not to exceed 4½%.	1884	395,000.00	——	——	1884	400,085.00	5,085.00
	——		1885	4,500,000.00	——	——	1885	4,664,483.00	164,483.00
	——		1886	2,500,000.00	——	——	1886	2,600,920.00	100,920.00
	——		1887	8,500,000.00	——	——	1887	8,665,551.95	165,551.95
	——		1888	4,000,000.00	——	——	1888	4,143,698.75	143,698.75
	——		1889	1,600,000.00	——	——	1889	1,614,150.00	14,150.00
	——		1890	2,400,000.00	——	——	1890	2,412,530.00	12,530.00
	——		1891	1,000,000.00	——	——	1891	1,000,000.00	——
	$950,000.00	@ 2½%	1892	1,300,000.00	——	——	1892	1,300,000.00	——
	28,814,500.00	@ 3%	1893	1,450,000.00	——	——	1893	1,450,000.00	——
	8,580,500.00	@ 3½%*	1894	1,000,000.00	——	——	1894	1,000,000.00	——
	——	——	1895	900,000.00	——	——	1895	900,000.00	——
	——	——	1896	4,100,000.00	——	——	1896	4,230,137.75	130,137.75
	——	——	1897	2,350,000.00	——	——	1897	2,453,460.00	103,460.00
			1898	2,300,000.00	——	——	1898	2,398,800.00	98,800.00
*Stock outstanding at December 31, 1898.	——	——	——	$38,345,000.00	——	$38,345,000.00	——	$39,284,566.45	$939,566.45

TABLE XI—(Continued).

SCHEDULE P.—WATER MAIN STOCK OF THE CITY OF NEW YORK.

Showing Annual Issue, Proceeds of Sales, Premium, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realiz'd.
Water main stock (No. 1) of the City of New York. Chapter 38, Laws of 1892. For labor and service in erecting the necessary pumping machinery, etc., and in laying the necessary mains to deliver water at high elevations in the City of New York from the new aqueduct.	$500,000.00	Not to exceed 4%	1893	$35,000.00	—	—	1893	$35,000.00	—
			1894	77,500.00	—	—	1894	77,500.00	—
		Redeemable in not less than 10 to 50 years. Issued at 3%. Payable, 1912.	1895	387,500.00	—	—	1895	388,294.25	$794.25
Stock outstanding at December 31, 1898..........	—	—	—	—	—	$500,000.00	—	—	—
	—	—	—	$500,000.00	—	—	—	$500,794.25	$794.25

SCHEDULE Q.—ADDITIONAL WATER STOCK OF THE CITY OF NEW YORK.

Showing Annual Issue, Proceeds of Sales, Premium, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Authoriz'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realized.
Additional water stock of the City of New York. Chapter 189, Laws of 1893. An act to provide for the sanitary protection of the sources of the water supply of the City of New York.	—	Not to exceed 4%. Redeemable in not less than 10 or more than 50 years.	1893	$95,000.00	—	—	1893	$95,000.00	—
	—		1894	248,000.00	—	—	1894	248,000.00	—
	—		1895	500,000.00	—	—	1895	503,915.00	$3,915.00
Chapter 515, Laws of 1893. An act to amend Section 13, of Chapter 189, Laws of 1893. Corporate stock for the sanitary protection of the sources of water supply.	$1,925,000.00	@ 3%	1896	500,000.00	—	—	1896	507,155.75	7,155.75
	525,000.00	@ 3½%	1897	607,000.00	—	—	1897	607,000.00	—
			1898	500,000.00	—	—	1898	517,290.00	17,290.00
Stock outstanding at December 31, 1898......	—	—	—	—	—	2,450,000.00	—	—	—
	—	—	—	$2,450,000,00	—	$2,450,000.00	—	$2,478,360.75	$28,360.75

TABLE XI—(Concluded).

SCHEDULE R.—WATER MAIN STOCK (No. 2) OF THE CITY OF NEW YORK.

Showing Annual Issue, Proceeds of Sales, Premiums, Etc.

Title of Fund.	Issue.				Redemptions.		Proceeds of Sales.		
	Amount Author'd.	Interest Rate.	Years.	Amounts.	Years.	Amounts.	Years.	Amounts.	Premium Realized.
Water main stock (No. 2) Chapter 669, Laws of 1896. An act to provide for laying additional water mains in the City of New York.	$300,000.00 700,000.00 Not to exceed $1,000,000.00 in addition to the amounts heretofore authorized, etc. See Water Main Stock (No. 1), Chap. 38, Laws 1892.	@ 3% @ 3½%	1896 1897 1898	$100,000.00 550,000.00 350,000.00	— — —	— — —	1896 1897 1898	$100,000.00 573,648.00 364,820.00	— $23,648.00 14,820.00
Stock outstanding at December 31, 1898..................	—	—	—	—	—	$1,000,000.00	—	—	—
			—	$1,000,000.00	—	—	—	$1,038,468.00	$38,468.00

II.

Tables Exhibiting the Comparative Cost of a New Water Supply During Forty Years, by Contract and by Municipal Ownership.

The direct cause of the inquiry undertaken by the Committee on Water Supply was a proposal that the City depart from the policy of municipal ownership of its water-supply system, and obtain an increased supply by contract with a private company. To ascertain the relative financial advantages or disadvantages of the two systems, it is necessary to contrast the probable receipts and expenditures for the term of the Ramapo contract—forty years—which has been done in Tables XII. to XIV. In this comparison, the cost to the City under the Ramapo contract—$70 per million gallons—is contrasted with the cost of a supply taken from the Hudson River near Poughkeepsie, recommended as the best available supply by the Engineering Committee (pages 63, 64 and 263).

A system capable of delivering 250,000,000 gallons daily will cost $36,880,000. But as the total supply will probably not be needed in 1906—the date of completion of the system—the pumping plant and filter beds are assumed to be constructed in four sections, as needed. The aqueduct, the Adirondack storage reservoirs and the covered reservoir at New York are completed by 1906, capable of supplying 250,000,000 gallons daily at that date. Thus the system will be capable of supplying 100,000,000 gallons daily by 1906; 150,000,000 gallons by 1911; 200,000,000 gallons by 1914, and 250,000,000 gallons by 1917 and in every subsequent year.

The cost of a system so constructed, shown in Table XII., column 1, is estimated by Mr. Fuertes for this Committee upon the basis of the estimates given in his report (page 263). In computing the annual charges of the Poughkeepsie system, Table XII., the rate of interest is three per cent.—the present market rate on New York City water bonds. Four per cent. of the amount of bonds outstanding is annually set aside as a sinking fund, which, with accrued interest at three per cent., will easily wipe out the bonds when they become due—twenty years after date of issue. This rate of four per cent. is unusually and unnecessarily high, but the present charter requires

(Section 169) that all water bonds be paid in twenty years, and to accomplish this a sinking fund of somewhat less than four per cent. must be provided. Four per cent. is, therefore, ample. If an act were passed extending the period of repayment, the annual charges would be less than estimated, and the earnings of the City system correspondingly increased. The annual charge for depreciation is the estimate made by Mr. Fuertes (page 263) for the system at its full capacity, but as the plant entire is not built until 1917, this charge actually would be much less than the estimate in the years prior to 1917. Here again, the committee has been very conservative, somewhat unfair to the City system and quite generous to the Ramapo Company. The annual "Cost of Operation" (Table XII., column 5), is estimated by Mr. Fuertes for this Committee upon the basis of his report to the Engineering Committee and of a yearly consumption as given in Table XIII., column 2. In every instance the estimates are liberal and probably higher than necessary.

Table XIII. gives the probable annual cost and revenue of the Poughkeepsie system, and the cost and deficits under the Ramapo contract. As a basis for this comparison, it was necessary to assume some annual rate of increase of population. The census returns for 1880 and 1890 show that for Greater New York the annual increase during that decade was 2.7 + per cent. The City Board of Health, in estimating the population for 1899 and 1900, have adopted a much higher rate, over 3.7 per cent. It seemed very conservative to assume, therefore, a three per cent. annual increase. If the actual rate of increase between 1890 and 1906 should prove to be more, as seems likely, the system would reach its maximum capacity sooner than 1920, and the profits of municipal ownership would be still greater than those given. At a three per cent. rate of increase, Greater New York would have a population in 1905 of over 4,000,000, and in 1906, of 4,120,000. Now, as 1906 is three years after the present system at present rate of consumption will have reached its maximum delivery capacity (Engineering Committee's report, page 47), it is very probable that as soon as the Poughkeepsie system is ready it will be called upon to deliver a considerable quantity of water. This amount the Committee conservatively estimates at 40,000,000 gallons daily. Beginning then in 1906 with a population of 4,120,000, there will be in 1907, at a three per cent. rate of increase, a population of 4,243,600. This increase of 123,600 people, at 103 gallons per capita—the present average per capita consumption—will call for a supply of 12,730,800 gallons daily, which, added to 40,000,000 gallons consumed daily during 1906, gives a total daily consumption for 1907 of 52,-730,800 gallons. The data for subsequent years are similarly obtained. In 1920 the entire supply is consumed and an additional supply is made necessary. Upon these figures as a basis, the total annual receipts of the City are secured (column 3) by using the present rate of revenue—$50.29 per million gallons. The annual deficit or profit to the City (columns 5 and 6) can then easily be ascertained. Comparing the City receipts with the amounts paid the Ramapo Company at $70 per million gallons, the annual deficits under the Ramapo contract (column 8) are secured.

In studying Table XIII., as well as Tables XII. and XIV., it is to be noted that no attention has been paid to cost of distribution after water reaches the city limits. This is proper, because all estimates of cost relative to the Poughkeepsie system exclude distributing charges and because the Ramapo Company proposes to deliver water only at the city limits. The additional charge for distribution would decrease the City's profit, but would increase in like amount the deficit under the Ramapo contract, and therefore would not alter by one dollar the figures as to final cost in columns 4 and 5 of Table XIV.

Summary.

From a financial point of view, the acceptance of the Ramapo contract means, therefore, that the City of New York will lose over $108,000,000 upon a supply of from 40,000,000 to 250,000,000 gallons of water daily. It means, further, that at the end of the period the City will own nothing, instead of possessing a plant fully worth $37,000,000, owing to the liberal allowance for depreciation.

The continuance of the policy of municipal ownership, upon the other hand, means a saving to the City of $108,000,000, plus $37,000,000, or a total of $145,000,000, for the City will own the Poughkeepsie system free from all debt in 1936. Further, in 1920, an additional supply will be needed, and another system must be built which would increase the financial gains of municipal ownership by some $50,000,000 up to 1945. Thus the total cost to the City of accepting the Ramapo contract would be over $195,000,000 in forty years.

TABLE XII.

BOND ACCOUNT AND ANNUAL CHARGES FOR 40 YEARS OF A MUNICIPAL WATER SYSTEM. POUGHKEEPSIE SYSTEM.

Year.	(1) Total Bonds Outstanding	(2) Interest at 3 Per Cent.	(3) Sinking Fund. 4 Per Cent.	(4) Depreciation.	(5) Cost of Operation.	(6) Total Cost. (The sum of cols. 2, 3, 4 and 5)
1906	$29,691,000	$890,730	$1,187,640	$171,179	$282,403	$2,531,952
1907	29,691,000	890,730	1,187,640	171,179	345,867	2,595,416
1908	29,691,000	890,730	1,187,640	171,179	408,749	2,658,298
1909	29,691,000	890,730	1,187,640	171,179	472,796	2,722,345
1910	29,691,000	890,730	1,187,640	171,179	541,142	2,790,681
1911	32,088,000	962,640	1,283,520	171,179	614,370	3,031,709
1912	32,088,000	962,640	1,283,520	171,179	682,718	3,100,057
1913	32,088,000	962,640	1,283,520	171,179	757,648	3,174,987
1914	34,483,000	1,034,490	1,379,320	171,179	834,055	3,419,044
1915	34,483,000	1,034,490	1,379,320	171,179	912,168	3,497,157
1916	34,483,000	1,034,490	1,379,320	171,179	995,158	3,580,147
1917	36,880,000	1,106,400	1,475,200	171,179	1,078,049	3,830,828
1918	36,880,000	1,106,400	1,475,200	171,179	1,164,962	3,917,741
1919	36,880,000	1,106,400	1,475,200	171,179	1,253,896	4,006,675
1920	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1921	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1922	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1923	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1924	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1925	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1926	36,880,000	1,106,400	1,475,200	171,179	1,307,597	4,060,376
1927	7,189,000	215,670	287,560	171,179	1,307,597	1,982,006
1928	7,189,000	215,670	287,560	171,179	1,307,597	1,982,006
1929	7,189,000	215,670	287,560	171,179	1,307,597	1,982,006
1930	7,189,000	215,670	287,560	171,179	1,307,597	1,982,006
1931	7,189,000	215,670	287,560	171,179	1,307,597	1,982,006
1932	4,792,000	143,760	191,680	171,179	1,307,597	1,814,216
1933	4,792,000	143,760	191,680	171,179	1,307,597	1,814,216
1934	4,792,000	143,760	191,680	171,179	1,307,597	1,814,216
1935	2,397,000	71,910	95,880	171,179	1,307,597	1,646,566
1936	2,397,000	71,910	95,880	171,179	1,307,597	1,646,566
1937	Bonds paid	——	——	171,179	1,307,597	1,478,776
1938	——	——	——	171,179	1,307,597	1,478,776
1939	——	——	——	171,179	1,307,597	1,478,776
1940	——	——	——	171,179	1,307,597	1,478,776
1941	——	——	——	171,179	1,307,597	1,478,776
1942	——	——	——	171,179	1,307,597	1,478,776
1943	——	——	——	171,179	1,307,597	1,478,776
1944	——	——	——	171,179	1,307,597	1,478,776
1945	——	——	——	171,179	1,307,597	1,478,776

TABLE XIII.

COST AND REVENUE OF CITY SYSTEM AND RAMAPO CONTRACT.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year.	Estimated Population of Greater New York.	Daily Consumption.	Total Annual City Receipts @ $50.29 per Million Gals.	Total Annual Cost Under City System (from col. 6, Table XII).	Annual Deficit of City System.	Annual Profit of City System.	Annual Cost Under Ramapo Contract @ $70.00 per Million Gals.	Annual Deficit to the City Under Ramapo Contract.
1906	4,120,000	40,000,000	$734,234.00	$2,531,952	$1,797,718.00	——	$1,022,000.00	$287,766.00
1907	4,243,600	52,730,800	967,918.65	2,595,416	1,627,497.35	——	1,347,271.94	379,353.29
1908 (Leap Year)	4,370,908	65,843,524	1,211,925.12	2,658,298	1,446,372.88	——	1,686,910.47	474,985.35
1909	4,502,035	79,349,605	1,456,529.44	2,722,345	1,265,815.56	——	2,027,382.28	570,852.84
1910	4,637,096	93,260,888	1,711,882.87	2,790,681	1,078,798.13	——	2,382,813.44	670,930.57
1911	4,776,209	107,589,527	1,974,881.22	3,031,709	1,056,827.78	——	2,748,911.72	774,030.50
1912 (Leap Year)	4,919,495	122,347,985	2,251,954.14	3,100,057	848,102.86	——	3,134,553.19	882,599.05
1913	5,067,079	137,549,137	2,524,831.33	3,174,987	650,155.67	——	3,514,379.50	989,548.17
1914	5,219,091	153,206,373	2,812,231.56	3,419,044	606,812.44	——	3,914,420.96	1,102,189.40
1915	5,375,663	169,333,289	3,108,254.80	3,497,157	388,902.20	——	4,326,463.26	1,218,208.46
1916 (Leap Year)	5,536,933	185,944,099	3,422,511.27	3,580,147	157,635.73	——	4,750,869.20	1,328,357.93
1917	5,703,041	203,053,223	3,727,214.07	3,830,828	103,613.93	——	5,188,009.26	1,460,795.19
1918	5,874,132	220,675,596	4,050,686.34	3,917,741	——	$132,945.34	5,638,259.02	1,587,572.68
1919	6,050,356	238,826,668	4,383,865.24	4,006.675	——	377,190.24	6,102,019.63	1,718,154.39
1920 (Leap Year)	6,231,866	250,000,000	4,601,535.00	4,060,376	——	541,159.00	6,405,000.00	1,803,465.00
1921	Pough-	250,000,000	4,588,962.50	4,060,376	——	528,586.50	6,387,500.00	1,798,537.50
1922	keepsie	250,000,000	4,588,962.50	4,060,376	——	528,586.50	6,387,500.00	1,798,537.50
1923	system	250,000,000	4,588,962.50	4,060,376	——	528,586.50	6,387,500.00	1,798,537.50
1924 (Leap Year)	must be	250,000,000	4,601,535.00	4,060,376	——	541,159.00	6,405,000.00	1,803,465.00
1925	enlarged	250,000,000	4,588,962.50	4,060,376	——	528,586.50	6,387,500.00	1,798,537.50
1926	to supply	250,000,000	4,588,962.50	4,060,376	——	528,586.50	6,387,500.00	1,798,537.50
1927	incr'sed	250,000,000	4,588,962.50	1,982,006	——	2,606,956.50	6,387,500.00	1,798,537.50
1928 (Leap Year)	popul'n	250,000,000	4,601,535.00	1,982,006	——	2,619,529.00	6,405,000.00	1,803,465.00
1929	in 1920.	250,000,000	4,588,962.50	1,982,006	——	2,606,956.50	6,387,500.00	1,798,537.50
1930	——	250,000,000	4,588,962.50	1,982,006	——	2,606,956.50	6,387,500.00	1,798,537.50
1931	——	250,000,000	4,588,962.50	1,982,006	——	2,606,956.50	6,387,500.00	1,798,537.50
1932 (Leap Year)	——	250,000,000	4,601,535.00	1,814,216	——	2,787,319.00	6,405,000.00	1,803,465.00
1933	——	250,000,000	4,588,962.50	1,814,216	——	2,774,746.50	6,387,500.00	1,798,537.50
1934	——	250,000,000	4,588,962.50	1,814,216	——	2,774,746.50	6,387,500.00	1,798,537.50
1935	——	250,000,000	4,588,962.50	1,646,566	——	2,774,886.50	6,387,500.00	1,798,537.50
1936 (Leap Year)	——	250,000,000	4,601,535.00	1,646,566	——	2,955,249.00	6,405,000.00	1,803,465.00
1937	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50
1938	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50
1939	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50
1940 (Leap Year)	——	250,000,000	4,601,535.00	1,478,776	——	3,122,759.00	6,405,000.00	1,803,465.00
1941	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50
1942	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50
1943	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50
1944 (Leap Year)	——	250,000,000	4,601,535.00	1,478,776	——	3,122,759.00	6,405,000.00	1,803,465.00
1945	——	250,000,000	4,588,962.50	1,478,776	——	3,110,186.50	6,387,500.00	1,798,537.50

TABLE XIV.

COMPARATIVE DEFICIT AND PROFIT OF CITY SYSTEM AND RAMAPO CONTRACT.

Year.	(1) Ramapo Contract Deficit. (From Col. 8, Table XIII.)	(2) City System. Deficit. (From Col. 5, Table XIII.)	(3) City System. Profit. (From Col. 6, Table XIV.)	(4) Comparative Final Costs. Advantage Under Ramapo Contract. (Col. 2—Col. 1.)	(5) Comparative Final Costs. Advantage of City System. (Col. 1—Col. 2 or Col. 1+Col. 3)
1906	$287,766.00	$1,797,718.00	——	$1,299,952.00	——
1907	379,353.29	1,627,497.35	——	1,038,144.06	——
1908	474,985.35	1,446,372.88	——	761,387.53	——
1909	570,852.84	1,265,815.56	——	484,962.72	——
1910	670,930.57	1,078,798.13	——	197,867.56	——
1911	774,030.50	1,056,827.78	——	282,797.28	——
1912	882,599.05	848,102.86	——	——	$34,496.19
1913	989,548.17	650,155.67	——	——	339,392.50
1914	1,102,189.40	606,812.44	——	——	495,376.96
1915	1,218,208.46	388,902.20	——	——	829,306.26
1916	1,328,357.93	157,635.73	——	——	1,170,722.20
1917	1,460,795.19	103,613.93	——	——	1,357,181.26
1918	1,587,572.68	——	$132,945.34	——	1,720,518.02
1919	1,718,154.39	——	377,190.24	——	2,095,344.63
1920	1,803,465.00	——	541,159.00	——	2,344,624.00
1921	1,798,537.50	——	528,586.50	——	2,327,124.00
1922	1,798,537.50	——	528,586.50	——	2,327,124.00
1923	1,798,537.50	——	528,586.50	——	2,327,124.00
1924	1,803,465.00	——	541,159.00	——	2,344,624.00
1925	1,798,537.50	——	528,586.50	——	2,327,124.00
1926	1,798,537.50	——	528,586.50	——	2,327,124.00
1927	1,798,537.50	——	2,606,956.50	——	4,195,494.00
1928	1,803,465.00	——	2,619,529.00	——	4,212,994.00
1929	1,798,537.50	——	2,606,956.50	——	4,195,494.00
1930	1,798,537.50	——	2,606,956.50	——	4,195,494.00
1931	1,798,537.50	——	2,606,956.50	——	4,195,494.00
1932	1,803,465.00	——	2,787,319.00	——	4,590,784.00
1933	1,798,537.50	——	2,774,746.50	——	4,573,284.00
1934	1,798,537.50	——	2,774,746.50	——	4,573,284.00
1935	1,798,537.50	——	2,774,886.50	——	4,573,424.00
1936	1,803,465.00	——	2,955,249.00	——	4,758,714.00
1937	1,798,537.50	——	3,110,186.50	——	4,908,724.00
1938	1,798,537.50	——	3,110,186.50	——	4,908,724.00
1939	1,798,537.50	——	3,110,186.50	——	4,908,724.00
1940	1,803,465.00	——	3,122,759.00	——	4,926,224.00
1941	1,798,537.50	——	3,110,186.50	——	4,908,724.00
1942	1,798,537.50	——	3,110,186.50	——	4,908,724.00
1943	1,798,537.50	——	3,110,186.50	——	4,908,724.00
1944	1,803,465.00	——	3,122,759.00	——	4,926,224.00
1945	1,798,537.50	——	3,110,186.50	——	4,908,724.00
Total	$60,241,811.32	$10,188,252.53	$58,526,512.08	$4,065,111.15	$112,645,192.02
Less					$4,065,111.15
Total Cash Loss					$108,580,070.87

III.

THE FINANCIAL RESULTS OF PUBLIC, AS COMPARED WITH PRIVATE OWNERSHIP OF WATER-WORKS.

To the Committee on Municipal Finance and Public Policy, Horace E. Deming, Esq., Chairman:

GENTLEMEN:

Your Sub-Committee on Statistics of Water-Works begs to report as follows:

I.

UNITED STATES AND CANADA.

The American statistics upon which the Committee have relied are found:

1. In "The Manual of American Water Works," published by "The Engineering News," and edited by M. N. Baker, Associate Editor of that journal. For the most part, these statistics are found in the Manual for '89-'90.

2. Bemis's "Municipal Monopolies," article by M. N. Baker on Water Works. This article summarizes the statistics given in the Manual.

These statistics are obtained, in large part, from correspondence with the various water works in the country, and purport to give the details with regard to all water works in the United States and Canada.

Mr. Baker shows in his article on water works, in Bemis's "Municipal Monopolies," that in 1800 there were 16 plants in operation in the United States, all but one of which were under private ownership. This one was that in Winchester, Va. Since that time 14 of these 15 private water works have become public, the only water works existing at the beginning of the century which has remained under private control being that in Morristown, N. J.

At the close of 1896 there were in the United States 3,196 water works. Of these, 1,690 were under public control, 1,489 were under private control, 12 were under joint control, and of 5 the ownership was unknown.

The following table will give an idea of the tendency towards either municipal or private ownership, existing at periods of five years during the present century, up to the close of 1896:

TABLE I.

Ratio of Public to Private Water Companies.

At Five Year Intervals, 1800 to 1896.

(From Bemis's "Municipal Monopolies.")

				Per Cent. of Total.	
Year.	Public.	Private.	Total.	Public.	Private.
1800	1	15	16	6.3	93.7
1805	2	21	23	8.7	91.3
1810	5	21	26	19.2	80.8
1815	5	21	26	19.2	80.8
1820	5	25	30	16.6	83.4
1825	5	27	32	15.6	84.4
1830	9	35	44	20.5	79.5
1835	15	39	54	27.8	72.2
1840	23	41	64	35.9	64.1
1845	27	43	70	38.6	61.4
1850	33	50	83	39.7	60.3
1855	48	58	106	45.3	54.7
1860	57	79	136	41.9	58.1
1865	68	94	162	42.0	58.0
1870	116	127	243	47.7	52.3
1875	227	195	422	53.8	46.2
1880	293	305	598	49.0	51.0
1885	447	566	1,013	44.1	55.9
1890	806	1,072	1,878	42.9	57.1
1896	1,690	1,489	3,196*	53.2	46.8

* Include 12 of joint and 5 of unknown ownership.

This shows that, whereas at the beginning of this century 93.7 per cent. of the water works were under private control and only 6.3 per cent. were under public control, at the close of 1896 53.2 per cent. were under public control and 46.8 per cent. were under private control.

An examination of the table given will show that, while the tendency has been pretty steadily from private to public ownership, there have been at times instances of a reaction. For instance, in 1875, the percentage of publicly owned water works was 53.8. From that time to 1890 there appears to have been a strong tendency in the direction of private ownership; but from 1890-1896 the percentage of water works controlled by municipalities had increased from 42.9 to 53.2.

The following table gives an idea of the changes which have been made during the century from private to public ownership, and *vice versa*:

TABLE II.

Changes From Private to Public Ownership.

(From Bemis's "Municipal Monopolies.")

		No. and Ownership of Works.				Changes in Ownership.	
States and Groups.	Total.	Public.	Private.	Joint or Unknown.	Per Cent. Public.	Private to Public.	Public to Private
N. E.	381	194	185	2	50.9	53	1
Middle	814	305	508	1	37.5	51	2
South At.	156	77	78	1	49.3	9	1
South Cen.	120	40	80	0	33.3	3	5
North Cen.	709	525	182	2	74.0	25	2
North W.	515	387	125	3	75.1	26	3
South W.	252	95	153	4	37.7	16	5
Pacific	249	67	178	4	26.9	22	1
Total U. S.	3,196	1,690	1,489	17	53.2	205	20
Canada	145	109	35	1	75.2	19	0
Total	3,341	1,799	1,524	18	53.9	224	20

Of the 3,196 water works in the United States, 205 which were once private, have become public, while only 20 which were once public have become private. Over one-half of the changes from private to public ownership have been made since

1890, and one-third of the changes made since that time have been from public to private ownership.

In the State of New York alone 26 have changed from private to public ownership, and only one from public to private ownership.*

The above table shows further, that in Canada, of 145 water works 109 are public, 35 are private, and one is under joint ownership; 75.2 per cent. of all the water works in the Dominion thus being controlled by the municipalities; further, that 19 water works which once were under private control have become public, while none that was originally public has become private.

In the United States the population supplied by public works, in 1890, was 66.2 per cent. of the total population in municipalities having water works facilities, or 15,019,000 out of 22,678,000. In the last six years it is believed that this percentage has held its own, if it has not materially increased; the net gain in public works being 800, as against 400 private, while many of the works contributing to this greater gain in public ownership have been in cities of fair size.†

Of the 50 largest cities, in 1896, in the United States, 22 have always owned their works, 19 have changed from private to public ownership, and only 9 are now dependent upon private companies for their supply, these nine being San Francisco, New Orleans, Omaha, Denver, Indianapolis, New Haven, Paterson, Scranton and Memphis.§ Of these, two have changed from private to public ownership since 1896. In San Francisco and Memphis such a change is now being strongly urged.

"The Bulletin of the Department of Labor," Statistics of Cities, for September, 1899, shows that of 140 cities in the United States of 30,000 inhabitants and over, 96 own their own water works, 2 own their distributing systems, 41 are entirely dependent upon private ownership, and 1 makes no return.

If we are to judge from the statistics relative to municipal and private ownership, it may hardly be doubted that the tendency in the United States—particularly the recent tendency—is strongly in the direction of municipal control of water works.

In "The Manual of American Water Works," '89-'90, are

* "Manual of American Water Works," 1889-1890; page K.
† Bemis's "Municipal Monopolies," page 27. § Ibid.

contained statistics relative to the comparative cost of municipal and private works per family, as well as the family rates and meter rates which are paid to municipal and private water works. These statistics relate to about 800 cities in the United States and Canada, the rates being those in force in 1889, and being taken from the printed schedules sent to "The Engineering News" by the various works.

On page li, of the introduction, is a table showing the averages for different groups of States, of total rate per family and total cost per family.

TABLE III.

Averages of Total Rate Per Family.

(From "The Manual of American Water Works, 1889-90.")

	Public.	Private.	Dif.	Per Cent. of Dif.
New England..........	$23.42	$28.12	$4.70	20
Middle Atlantic........	19.36	26.94	7.58	39
South Atlantic.........	23.79	30.20	6.41	27
South Central	31.6	36.88	5.28	17
North Central	18.78	25.92	7.19	38
Northwestern	20.77	28.46	7.69	37
Southwestern	32.53	39.64	7.11	22
Pacific	29.32	49.96	20.64	71
United States..........	21.55	30.82	9.27	43
Canada	21.07	31.43	10.36	50

Averages of Total Cost Per Family.

	Public.	Private.	Dif.	Per Cent. of Dif.
New England.........	$118.60	$109.18	$9.42	8
Middle Atlantic........	110.12	121.73	11.61	11
South Atlantic..........	67.87	61.51	6.36	9
South Central.........	117.83	89.84	27.99	42
North Central.........	85.89	89.89	4.00	5
Northwestern	58.37	97.37	39.00	68
Southwestern	126.32	91.03	35.29	28
Pacific	62.22	275.88	213.66	343
United States..........	102.09	117.28	15.19	15
Canada	125.16	72.67	52.49	42

This table shows that the average cost per family of the plant of public water works is $102.09, as against $117.28 for private water works. This comparison, however, is hardly a fair one, inasmuch as private water works in the group of States called the Pacific group is very large, owing, doubtless to the inclusion of the cost of some irrigation works used in connection with those for city supply.

Leaving one side the cost of plant per family in the Pacific States, we find that for the remaining seven groups the average cost per family for public works is $102.53; for private works, $98.95, a difference of $3.58, or 3.5 per cent., in favor of the private works. The fact would seem to be, therefore, that private works cost less per family than public works, where the water is devoted merely to the ordinary uses of city life.

Notwithstanding this higher cost of public works per family for plant, the table of the total rates per family shows that the rate per family for private works is higher than the rate per family for public works.

In the United States this average for all works is $26.88 per family, that for public works being $21.55, and that for private being $30.82.

In Canada practically similar conditions exist, notwithstanding the fact that the average cost per family of all public works is $125.16, while that of private works is $72.67; the average rate per family for public works is $21.07, and that for private water works is $31.43.

The conclusion reached by the author of the introduction to "The Manual of American Water Works," '89-'90, is stated on page lii, where he says:

> "There is but one conclusion. Private works charge as high rates as they can in consistency with business principles. If they have high cost works, they generally make good use of the fact by charging high rates; but there is no trace of a fixed relation between the two. The latter is shown by the South Central group, where the private works have cost 42 per cent. less than the public, and the charges are 17 per cent. higher for the former than for the latter; and in contrast we have the Northwestern group, with their private works costing 68 per cent. more than their public, and their rates but 37 per cent. higher."

The author goes on to show the fact that money is often raised by taxation to pay either a part or the whole of the interest on the bonded indebtedness on public works does not account for the lower rates charged by public works. This, in the author's opinion, is offset by the hydrant rental which is almost invariably paid to private companies, the money for which is always raised by taxation.

What is true of family rates is also true of meter rates. In nearly every State the private water works charge higher meter rates than do the public.

The following extract from the report for 1898 of the Illinois Bureau of Labor Statistics, page 41, is pertinent:

"Reviewing the facts gathered concerning water works plants in Illinois, it appears that there are in all 165 plants in the State, 35 of which are under private and 130 under municipal ownership; of these, 82 have been examined and scheduled for these tables, 13 of which are private and 69 public plants; that in the matter of the relative size of the plants considered, while both the largest and smallest are municipal, there is substantial conformity in the representation of both classes; that in general the bonded indebtedness incurred in the construction of municipal plants is in process of gradual extinction as a result of municipal management; that some differences appear in the distribution of cost of production in the two groups, the principal of which are that a smaller proportion of that cost is expended by municipal plants for general expenses and a larger proportion for wages and for repairs and renewals than by private plants; that cities having plants of their own make a much more liberal use of water for municipal purposes than those which purchase city water from private companies; that the operation of private water companies is almost uniformly profitable, and their prices to the municipality usually much higher than to private users; that the establishment of municipal plants operates to reduce the cost of water service to the city in almost all cases, and in some to extinguish it altogether and produce a revenue besides, but the municipal plant does not ordinarily afford lower prices to private users; that the highest success in operation is found in the largest plants; finally, that while the exceptional cases are not of sufficient weight or number to materially disturb these observations, the real interest and instruction afforded by the tables is likely to be found in the specific study of individual plants, both exceptional and otherwise."

II.

England and Wales.

For England and Wales we have pretty full statistics with regard to the ownership of water works in "The Local Taxation Returns" for 1897, Vol. LXXV., of the Parliamentary papers for that year. These give the number of municipalities receiving income from water works, as well as those which receive no such income, for the year 1895-1896. In addition, we have "The Municipal Year Book," 1899, edited by Robert Donald, published in London by Edward Lloyd, Limited.

In this latter book, on page 373, will be found the statistics for "water supply," while on page 1 will be found a statement in regard to "Municipal Legislation in 1898 and 1899," which gives information with regard to the projects before Parliament for municipalizing the water supply.

By the "Local Taxation Returns" the various municipalities in England and Wales are grouped under three heads, namely, County Boroughs, which include the larger cities outside of the metropolis of London; Boroughs not County Boroughs, which, as a general thing, include the cities of smaller size; and Urban County Districts not Boroughs, which include, roughly speaking, municipalities of a kind similar to the American village.

Of the 64 County Boroughs, 43 are shown to receive income from water works, while 21 receive no such income.

In "The Municipal Year Book," already referred to, which purports to give the condition as existed in the latter part of 1898, it is stated that in all but 19 of these 64 County Boroughs the water supply is under public control. It is further stated that in all the large towns of Scotland, such as Glasgow, Edinburgh, Dundee, Aberdeen, Leith, Greenock, Paisley, Port Glasgow and Perth, the water supply is also in public hands.

Of the 224 Boroughs not County Boroughs, a number of which have a very small population, 126 received income from water works, while 98 received no such income in the year 1895-1896.

In "The Municipal Year Book" for 1899 it is stated that 139 of the Boroughs not County Boroughs in England and Wales had municipal water works.

Of the 766 Urban County Districts not Boroughs, 299 received income from water works, while 467 received no such income in the year 1895-1896.

In "The Municipal Year Book" for 1899, page 373, it is stated that notwithstanding in many instances private water works have had to be acquired by the municipalities at a high premium, and heavy annuity payments as a result fall on the rates, still, as a rule, municipalization has led to a reduction in charges, an improvement in the supply, or both. It is further stated that the success or advantage of municipal ownership cannot be tested by the returns of income and expenditure. In some towns the policy is adopted of making a profit out of the supply, in other cases a deficit is created by making the charges exceptionally low. In several instances the rental received for water has to be supplemented by a special water rate, in order to make ends meet, while on the other hand, some towns levy no water charge but include the cost in the general rates.

One of the best examples of successful municipal ownership is provided at Glasgow. Glasgow Corporation bought the old undertakings, spent $1,250,000 in introducing a new supply from Loch Katrine, and has reduced the charge from one shilling six pence per pound, to six pence, supplying the poorest houses free, while the daily supply has increased by 139 per cent. Further, the Corporation is now doubling its supply from Loch Katrine at a cost of over $1,000,000, without making any call upon the ratepayers. The profits of the Water Department are sufficient to meet the new charges.

In the statement in regard to "Municipal Legislation in 1898-1899," to be found at the beginning of "The Municipal Year Book," the following appears:

"Remarkable activity has been shown by the local authorities throughout the country in promoting bills for the next session of Parliament. The list almost creates a record. A glance through the bills gives a further indication that the local authorities, great and small, are determined to secure control, wherever possible, of all tramways, electric lighting schemes, water and gas supplies, and other common necessities. It is interesting to note that an unusually large number of Urban

District Councils are proposing to buy out the local gas and water companies before the capital of these undertakings is unduly swollen by the needs of an increasing population. * *

"Parliament will have before it this year a large number of important water schemes. The most comprehensive is that brought forward by the London County Council, which proposes once more to buy out the eight metropolitan water companies, and to obtain powers to bring an additional supply of water from Wales. Other great cities are also preparing for future emergencies. Leicester, Sheffield and Derby are all seeking powers to build additional water works and to take water from the Derwent. Enormous sums of money will be expended on these schemes, that promoted by the Derby Corporation being estimated at a million and a half sterling. Bury, Warrington and other towns are promoting private bills to increase existing water works, while other authorities are seeking powers to supply water to outside districts. Many bills have been drafted having for their object the purchase of water companies. In addition to the London County Council, the following Corporations are endeavoring to secure possession of the water supply:

"Southhampton, Falmouth, Stockport, Godalming and Maidstone, as well as the District Councils of New Mills, Burley-in-Wharfedale, Newhaven, Seaford, Horsforth, Bognor, Clay Cross. The action of the Maidstone Corporation is a proper sequel to the terrible epidemic, caused by a polluted water supply, which scourged the town last year."

III.

OTHER NATIONS.

Germany.

For Germany, we have an excellent book of statistics of the most important German cities, entitled "Statistisches Jahrbuch Deutschen Städte," which is compiled through the co-operation of the heads of the various statistical bureaus of the cities concerned. This book is issued annually, and from the seven volumes which have been issued up to the present time, we find that in 1897 of the 49 most important cities in Germany from which reports were received, only 3 did not own and operate their water works. These three were: Altona, Charlottenburg and Frankfort.

Your Committee has been unable to obtain any statistics as to the relative efficiency or cost of private and public works.

Such statistics, however, would seem to be unnecessary in view of the almost universally municipal character of the water works of the large cities.

Italy.

The statistics for Italy are not, perhaps, of any great value because of the fact that houses, even in some of the large cities, do not seem to be supplied with water pipes, the water supply being brought to fountains in the public streets or squares, and the water being carried from such public fountains to the houses.

We find, however, that in 1897 of the 66 cities having over 10,000 inhabitants, 28 received no income from water works, 18 received insignificant revenue, and 20 received small revenue.

(The statistics given have been taken from "Bilanci Comunali per L'anno, 1897," issued at Rome by the "Ministero Di Agricoltura, Industria E Commercio.")

France.

From reports received from United States Consuls in French cities by the Reform Club Committee on City Affairs, the following facts have been secured:

Of the 25 cities over 65,000 in 1896, 22 had water works owned and operated by the municipality; 1 city owned water works but leased them to private companies, and in 2 the works were both owned and operated by a private company.

Respectfully submitted,

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IV.

CONSTITUTIONAL REGULATION OF MUNICIPAL WATER FINANCE.

The Constitution of this State limits the indebtedness of any municipality to 10 per cent. of the assessed valuation of taxable real estate, but debt incurred for purposes of public water-supply is not included within this limit. So long, however, as the aggregate public debt exceeds the 10 per cent. limit no further indebtedness can be incurred for any purpose whatever except a water-supply. It is urged, therefore, that if a municipality exceeds the 10 per cent. limit for the purpose of enlarging its water-system, it will be prevented from undertaking any other class of public works for which it may be necessary to borrow money.

The Constitution recognized that an ample water-supply is an indispensable utility, and endeavored to prevent the control of this utility passing into private hands. The framers of the Constitution, however, did not and could not anticipate the actual situation as it has developed in our large cities, especially in the City of New York. Previous outlays of this and other municipalities for a public water-supply have been moderate in amount, and it was reasonable to suppose that any inconvenience to the public through the restriction of expenditures for other public works on account of exceeding the debt limit would, if it occurred at all, be only temporary and of small moment. Its intent is to prevent waste of the public money. But conditions have entirely changed. An enormous population has become concentrated in this City. The requirements of the public water-supply are far in excess of any hitherto known in the history of any American city. To meet these requirements in the most economical way requires the construction of works of vast capacity. To provide on a less adequate scale would very greatly increase the ultimate outlay needed, and the annual cost during the entire period. To secure the greatest ultimate economy, in order that the average cost of the water supplied may thereby be enormously decreased, and the earning power of the investment correspondingly increased, demands large investments during the next few years.

Wise economy and the public interest alike demand that the City should make this large immediate outlay. Moreover, the financial history of the City's ownership and control of its public water-supply have demonstrated it to be not merely a revenue-earning, but a profit-making enterprise, and that the use of the City's credit for such a purpose is not only not a burden to the taxpayer, but may, if it be deemed wise, be used to lighten his burdens.

No one will deny the wisdom of constitutional provisions to check or prevent the improvident use of a city's credit, but all will agree that a Constitution needs amendment which prevents a city from the wise and judicious use of its own credit to own and control its own water-supply—a demonstrated source of profit—save under the penalty of going without other needed improvements which make no pecuniary return to the City. Such a constitutional provision defeats the very purpose of its existence. The City of New York should not be subjected to the alternative of surrendering control of its water-system into private hands, or of stopping for several years other desirable public improvements.

The Committee on Legislation has reported a draft of a constitutional amendment which will permit the construction of public water-works without paralyzing other public improvements. (Report of Committee on Legislation, page 444.)

V.

Statutory History of the Ramapo Company and Legislative Obstacles to New York's Acquiring and Owning a Sufficient Water Supply.

The Ramapo Company.

This company was organized in New York in September, 1887, under the so-called Manufacturing Act of 1848 as amended.[1]

That act, among other things, authorized the formation of companies to supply cities with water for municipal purposes.[2] Such companies were given the right to acquire land and water rights for their business, including the right to acquire such land and water rights by condemnation in substantially the same way that railroad companies were authorized to acquire land.

The act provided, however, that no company should be organized under it for the purpose of supplying water for municipal purposes in the City of New York.[3] The law was amended so as to authorize any water company to furnish water to any city in the State, including New York City, and the City was authorized to enter into a contract for water supply with a private corporation.[4]

In 1890 the Corporation Law of the State was revised, and the laws relating to water companies were grouped as a part of the Transportation Law under the title of Water Works Corporations and the Manufacturing Act of 1848 was repealed.[5]

The present water works corporation act authorizes seven or more persons to form a corporation for the purpose of supplying water to any city or cities named in the certificate.

[1] Laws 1848, Chap. 40, as amended Laws 1880, Chap. 85, Sec. 1.

[2] The act authorizes the formation of companies for the purpose, among other things, of "accumulating, storing, conducting, selling, furnishing and supplying water for mining, domestic, manufacturing, municipal and agricultural purposes."

[3] Laws 1880, Chap. 85, Secs. 5 and 6, as amended by Laws 1881, Chap. 472.

[4] Laws 1883, Chap. 512; Laws 1884, Chap. 292; Laws 1884, Chap 386.

[5] Laws 1890, Chap. 566, Sec. 80 et seq.

The law requires that the written permit of the officers having charge of the water supply of the city or cities to be supplied with water, authorizing the formation of the company, must be annexed as part of the certificate of incorporation.

Such company is given extensive powers to acquire land necessary for its purposes by condemnation.[6] The company has no right to supply any other town or city than that mentioned in its certificate of incorporation, except upon filing an amended certificate.[7]

In 1895 the Legislature passed a special act giving to the Ramapo Company certain additional powers. The act is as follows:

CHAPTER 985, LAWS 1895.

An Act to limit and define the powers of the Ramapo Water Company.

Became a law June 11, 1895, with the approval of the Governor. Passed, three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

1. The Ramapo Water Company, heretofore incorporated under chapter forty of the laws of eighteen hundred and forty-eight, entitled "An act to authorize the formation of corporations for manufacturing, mining, mechanical or chemical purposes," and the amendments thereto, by a certificate of incorporation

[6] "Any corporation organized under this article shall have the right to acquire real estate or any interest therein necessary for the purposes of its incorporation and the right to lay, relay, refrain and maintain conduits and water pipes with connections and fixtures, in through or over the lands of others, the right to intercept and divert the flow of waters from the lands of riparian owners and from persons owning or interested in any waters and the right to prevent the flow of drainage of noxious or impure matters from the lands of others into its reservoirs or sources of supply. If any such corporation which has made a contract with any city for the supply of pure and wholesome water . . . shall be unable to agree upon the terms of purchase of any such property or rights it may acquire the same by condemnation." The only restriction stated in the act is that the company cannot take waters from the canals, canal reservoirs, or streams which have been taken by the State for the purpose of supplying the canal with water. Laws 1890, Chap. 566, Sec. 84.

[7] Laws 1890, Chap. 566, Sec. 85.

filed in the office of the Secretary of State the fourteenth day of September, eighteen hundred and eighty-seven, may acquire in the same manner specified and required in and by an act entitled "An act to authorize the formation of railroad corporations and to regulate the same, passed April second, eighteen hundred and fifty, and the acts amendatory thereof and supplemental thereto;" such lands and waters along the watershed of the Ramapo, and along such other watersheds and their tributaries as may be suitable for the purpose of accumulating and storing the waters thereof, and shall have the power of accumulating and storing, deducting, selling, furnishing and supplying water for mining, domestic, manufacturing, municipal and agricultural purposes, to any city, town and village and to other corporations, and to the persons that may lawfully contract therefor, and may lease its ponds, lakes and reservoirs for a term of years to any individual or corporation for the purpose of cutting ice thereon. Provided, however, that such company shall not sell, furnish or supply or otherwise allow the water power to be used for manufacturing or any other purpose as may be noxious, dangerous or offensive.

2. Said corporation, before constructing any parts of its works in any county in which it does business, or instituting any proceedings for the condemnation of real property therein, shall make a map of the route adopted and land to be taken by it in such county, which said map shall be certified by the president and engineer of the corporation, or a majority of the directors, and shall file the same in the office of the clerk of the county through which the route runs or in which the said lands are situate. Said corporation shall give written notice to all actual occupants of land so designated, and which have not been purchased by or given to it, of the time and place such map or maps were filed. Any such occupant or the owner of the land aggrieved by the proposed location may, within fifteen days after receiving such no-

tice, give ten days' written notice to such corporation and to the owners or occupants of lands to be affected by any proposed alteration, of the time and place of an application to a justice of the Supreme Court in the judicial district where the lands are situated, by petition duly verified, for the appointment of commissioners to examine the lands so designated. The petition shall state the objections to the route designated, shall designate the route to which it is proposed to alter the same, and shall be accompanied with a survey, map and profile of the route designated by the corporation, and of the proposed alteration thereof, and copies thereof shall be served upon the corporation and such owners or occupants with the notice of the application. The justice may, upon the hearing of the application, appoint three disinterested persons, one of whom must be a practical civil engineer, commissioners to examine the route proposed by the corporation, and the route to which it is proposed to alter the same, and after hearing the parties, to affirm the route originally designated or adopt the proposed alteration thereof, as may be consistent with the just rights of all parties and the public, including the owners or occupants of the lands upon the proposed alteration; but no alteration of the route shall be made except with the concurrence of the commissioner, who is a practical civil engineer, nor shall it cause greater damage or injury to lands or materially lengthen the route designated by the corporation, nor shall it substantially change the general line adopted by the corporation. The commissioners shall, within thirty days after their appointment, make and certify their written determination, which, with the petition, map and survey, and any testimony taken before them, shall be immediately filed in the office of the county clerk of the county in which the lands taken are situate. Within twenty days after such filing any party may, by written notice to the other, appeal to the General Term of the Supreme Court from the decision of the commissioners, which appeal shall be heard and decided at the next term held in the department in which the lands of the petitioners or any of them are situated, for which the same can be noticed according to the rules and practice of the court. On the hearing of such appeal, the court may affirm the route proposed by the corporation or may adopt that proposed by the petitioner. The commissioners shall each be entitled to six dollars per day for their services, and to their reasonable and necessary expenses, to be paid by the persons who apply for their appointment. If the route, as designated by the corporation, is altered by the commissioners or by the order of the court, the corporation shall refund to the petitioner the amount so paid, unless the decision of the commissioners is reversed upon appeal taken by the corporation. Said corporation shall not institute any proceedings for the condemnation of real property in any county until after the expiration of fifteen days from the service by it of the notice required by this section.

3. Said corporation may contract with any corporation in this State, public or private, to furnish water for any of the purposes in this act mentioned, and every corporation in this State is hereby authorized to enter into such contracts with said corporation for any length of time that may be deemed advisable.

4. Said corporation may lay pipes for the purpose of conducting water for the purposes of its business under any of the navigable waters of this State, provided they are laid so as not to interfere with the navigation of such waters.

5. This act shall take effect immediately.

Under the powers given by this act the Ramapo Company is given full power to contract to supply water not only to any municipality, but to any corporation public or private, with no requirement for filing an amended certificate or obtaining the consent of local authorities. The power to supply water for municipal purposes and in addition the power to supply water for commercial uses is given by this special act and is a power which no corporation can obtain except by special legislation and is an exclusive power of the Ramapo Company. The company is given broad powers of condemnation and practically the right to select such route as it may choose without fear of opposition, as the provisions of Section 2 of the act are such as to render it practically impossible for any one to comply with them within the time limited, and moreover the expense of such opposition is prohibitive.

Legislation Restricting the Right of the City of New York to Acquire Its Water Supply.

Under the Consolidation Act the City of New York had power to acquire the needed water supply by condemnation and there was no restriction upon this power.[8]

The first important limitation upon the powers of the City was the act passed in 1896 (referring to, though not naming, Suffolk County) by which the supervisors of the county were authorized to file with the county clerk a certificate stating that the waters within the county named in the certificate are necessary for the inhabitants of the county. Upon the filing of such certificate, the waters are exempted from condemnation by any person or corporation ex-

[8] Sec. 364 of the Consolidation Act provides that "where the Commissioner of Public Works shall have entered upon, taken or used or shall hereafter enter upon, take or use the water of any lake or any upland, or lands under water or water rights or privileges or any incorporate hereditament or any other property for the purpose of maintaining, preserving or increasing the supply of pure and wholesome water for the use of said city, said Commissioner is authorized . . . to acquire all rights, title and interests in and to such real estate by whomsoever the same may be held, enjoyed or claimed and to pay for and extinguish all claims or damages on account of such rights, titles or interest or growing out of such taking or using." Sec. 366 et seq. of the act provide for the procedure upon such taking.

cept upon written consent of a majority of the supervisors.[9]

The Charter of Greater New York expressly states that this act is not repealed by anything contained in the Charter.[10]

The powers of condemnation for water supply purposes given to New York are contained in Sections 472 and 484 of the Charter. The powers of the City of New York under the Consolidation Act are in form retained in Section 484, but are, in fact, modified and restricted by Section 472, which provides that the City shall not have power "to acquire or extinguish the property rights of any person or corporation in or to any water rights that, at the time of the initiation of the proceedings for condemnation, were in whole or in part devoted to the supply of the water works of the people of any other city, town or village of the State, or to the supply and distribution of water to the people thereof" or water used in any way for State canal purposes.

The restriction contained in this section is new. It was not a part of the general law or of the Consolidation Act. The effect is to render it impossible for New York City to acquire any watershed or water supply of which any portion, no matter how small, is used in supplying water to any city, town or village, and so, again, by legislation the power of New York to obtain its own water supply is curtailed, and the City has less power of condemnation than a private water company organized under the general law. Again, the City is required to dredge harbors on Long Island because it takes part of the fresh water flowing into the Sound.[12] So by legislation it is made increasingly difficult for the City to obtain its own water supply. Such legislation

[9] Laws 1896, Chap. 442.

[10] Charter Greater New York, Sec. 1619.

[11] Charter Greater New York, Sec. 472.

[12] Laws 1898, Chap. 469.

gives no protection to owners of water supply in thus restricting New York City so long as private companies are authorized to contract with the City for water supply and no restriction is put upon the powers of condemnation of such companies.

The City must have water, and so long as private companies have power to acquire by condemnation the water rights necessary to supply the City with water, there is no possible excuse for refusing to give this right to New York City.

SECTION V.

COMMITTEE ON MUNICIPAL FINANCE AND PUBLIC POLICY.

PART III.: OBJECTIONS TO WATER CONTRACTS WITH PRIVATE COMPANIES.

CONTENTS OF SECTION V., PART III.

OBJECTIONS TO WATER CONTRACTS WITH PRIVATE COMPANIES.

GENERAL OBJECTIONS TO A WATER CONTRACT FOR THE SUPPLY OF NEW YORK CITY.

I.

GENERAL OBJECTIONS.

Whatever views may be held with regard to the policy of private control of public utilities, there cannot be two opinions as to the folly of giving to a private company the control of the water supply for New York City. The financial history of the New York water supply, as well as the water supply of Brooklyn alike, demonstrates that, considered merely as a financial investment, city ownership and control is profitable and exceedingly advantageous. There is, therefore, no reason for reversing the policy which has been pursued for almost seventy years.

The general summary, on pages 591-602, of the financial results of public, as compared with private ownership of waterworks, shows (1) that although waterworks owned by private companies are usually built at a less cost than works owned by municipalities, the water rate to the consumer is less under municipal than under private ownership, due to the fact that under private ownership the profits of the works go into the pockets of the stockholders, whereas under municipal ownership they are largely used to lower water rates; (2) that there is an almost universal trend towards municipalization of water supplies, not only in the United States, but also in Canada, Great Britain, Germany, Italy and other foreign countries, and that in several countries municipal control is almost universal.

For New York now to resign in whole, or in part, the control of its water supply to a private corporation would be to go contrary to the tendency shown in the municipal history of all important countries, and also to resign for itself a profitable source of income.

Further, the experience of American as well as foreign cities shows that an abundant supply of water is more frequently provided under municipal than under private ownership. Indeed, this is so well understood and so universally considered in any discussion of municipal versus private operation, that it is generally accepted without contradiction. In many instances, where waterworks have passed from *private to public* control, the supply has been greatly increased, and in the few instances in which the works have passed from *public to private* control, there has seldom been any marked improvement. The importance of an abundant supply of water can hardly be over-estimated, and has been deemed so very important that in some cases works have been transferred to the municipality, almost wholly because a more abundant supply could thus be secured.

The facts show not only that municipalities furnish a more abundant supply than private corporations, but also that they supply purer and more wholesome water. The history of British cities upon this point is particularly strong. The various Parliamentary investigations, the results of which are published in the Sessional Papers of the United Kingdom, prove that municipal operation has almost invariably been accompanied by a lower death rate and less sickness. This fact is so well established and so rarely questioned that it has not seemed necessary to burden this report with statistical and other data in detail.

The experience of London, almost the only metropolitan city in the civilized world which does not own and operate its own waterworks, and therefore worthy of special notice, is most interesting and emphatic. The waterworks of London have been owned by private companies for centuries. Although it was intended when the companies were formed that there should be competition between them, it has practically been eliminated by the division of the city into different districts and the apportionment of each to a company. The present water rates are considerably higher than under municipal ownership in other cities. But the most important fact is that the water is impure and the supply wholly inadequate for the needs of the city. Almost every summer there is a water famine, in East London particularly, "which affects about one-fourth of the population of the entire city. Beginning in August, it lasts until October or

December, and during these months the water supply is often shut off eighteen or twenty hours out of the twenty-four, and each person is obliged to store what water he wishes to use in jars, pans, etc. Such a course is impracticable among the poorer classes—those who most need an abundant supply for sanitary purposes. Then, too, the quality of the water is such that after it has stood for some time it becomes positively distasteful and its stale odor is extremely disagreeable. So great is the famine that the public authorities loan thousands of jars and pans to the people, and even undertake to furnish a very limited supply of water from carts. Two cents a gallon was the usual price charged in 1898 by private persons who temporarily entered the field, owing to the great demand." *

These conditions are very suggestive, for while London is trying to escape from the avarice and selfishness of private corporations, it is proposed that the City of New York, which has an infinitely better supply, be handed over to a private corporation.

Indeed, it is an obvious proposition that cities should control their water systems, unless they are a heavy financial burden, and often this is more than outweighed by the necessity and importance of having a pure, wholesome and adequate supply of water. The health and welfare of a city can seldom be measured in financial terms.

This applies with particular force to New York, where municipal ownership has not only produced an adequate and wholesome supply of water, but has also made the works a source of considerable income. Thus sanitary, as well as financial considerations urge the rejection of the Ramapo contract and a continuance of the policy of municipal ownership.

The only possible objection that might be urged to this conclusion would be the impossibility of securing abundant sources of water supply by the City. But upon this point the report of the Engineering Committee is positive and definite. It shows that a supply ample to meet all demands for the next half-century can be got from a number of sources, at a cost far less than that of the proposed contract.

* Water Supplies of London and Philadelphia, Municipal Affairs, June, 1899.

II.

Objections to the Proposed Ramapo Contract.

Under ordinary circumstances there would be no occasion to discuss this contract, for there is little danger that this particular instrument will ever be executed; but in view of the fact that the contract was so nearly consummated, a brief reference to it is important as showing the kind of contract that the City authorities were willing to accept and the danger of private contracts.

The substantial features of the contract are that the Ramapo Company agrees at its own expense to build and maintain a system of water works by which it shall furnish the City of New York 200,000,000 gallons of water daily. This water is to be delivered to the City at its northern boundary at the point of intersection with the present Croton Aqueduct at "pressure due to an elevation of 300 feet above the mean tide level," and for this water the City of New York agrees to pay $70 per million gallons, and is to be put to no other or further expense in connection with the supply.

The delivery of water is to be begun in 1902, and is to continue for forty years. Various provisions are made in reference to an extension of time in case the work is delayed by strikes, legal proceedings or other causes not within the control of the company. The only bond required of the company is a bond for $100,000 for the faithful performance of the agreement. From the wording of the contract it is impossible to tell whether the City can compel the company to deliver water; an even more serious question than this is, whether the contract gives the City option to take as much of the 200,000,000 gallons of water as it needs, or whether it is an absolute agreement on the part of the City to take this water. By paragraph 3, of the contract, the company agrees to deliver to the City 200,000,000 gallons daily "subject to the right of the City to reduce the quantity of supply to such number of gallons as in his (Water Commissioner) judgment may be required, upon notice thereof to the party of the first part, except as hereinafter otherwise excepted, conditioned and provided."

By paragraph 5 the City of New York agrees to accept and "receive such water as it may require not exceeding 200,000,000 gallons of such water so delivered by said water company, ... and the City of New York hereby covenants and agrees to pay in regular quarterly payments to the said company, its successors and assigns the sum of $70 for each and every million gallons of such water so delivered not exceeding 200,000,000 gallons daily."

Upon such important points as the amount of delivery, the obligation of the City to take, and the pressure at which the water is to be delivered, the contract is ambiguous, and for this reason alone, if for no other, the contract should not have been approved. The contract gave the city no right to acquire the property at the expiration of the contract. At the end of the contract period the City would be just where it began, needing water and being obliged to get its supply by private contract.

SECTION V.

COMMITTEE ON MUNICIPAL FINANCE AND PUBLIC POLICY.

PART IV: THE PUBLIC FINANCIAL AND STATISTICAL RECORDS OF THE CITY'S WATER SUPPLY SYSTEM.

THE PUBLIC FINANCIAL AND STATISTICAL RECORDS OF THE CITY'S WATER SUPPLY SYSTEM.

The cost of the City's water system is not shown upon the books of the Comptroller, or the Water Department, in any single account, or set of accounts, kept with that end in view.

There are, for example, with the object of showing the amount of disbursements on account of each bond authorization, twenty bond accounts of bonds issued at different times under different statutes and resolutions during the construction of the City's water works.

During the period of construction, disbursements were made for extensions and maintenance from appropriation or tax accounts. There were forty tax or appropriation accounts. Disbursements for interest on account of bonds issued for water purposes in the main were made during the said period out of the general account of the City, or the general appropriation account of the City for interest on the City debt.

In no one place were gathered the financial facts as to the cost of construction, cost of maintenance and operation, or interest; nor were there gathered in any one place the financial facts as to the City's revenue from the operation of its works for the whole period.

This system followed the practice which has been in vogue for more than half a century of keeping the accounts in the Comptroller's office under the titles of particular issues of bonds, or particular appropriations, in order that at any moment the Comptroller's office may know the condition of that particular fund. This system, however, breaks down so far as giving real information as to the financial status of the City's investment in any particular enterprise, such, for example, as its water works, its docks or parks. This system, if it is to be continued, should be supplemented by proper bookkeeping methods, which shall present briefly and clearly the exact financial condition of the City's investment in each of its public works, so that an intelligent man may readily know the business status as to each of the City's public enterprises.

The Comptroller of the City of New York has ample authority under the law to prescribe the bookkeeping methods of every one of the City's departments; and one of the most necessary, practical and practicable reforms which should be at once instituted is the introduction of an uniform method of bookkeeping in the various City departments, which would present in a clear and compact shape the financial facts above noted. These accounts, so made up and regularly audited by and filed with the Comptroller, would enable the City's chief financial officer to present to the public a complete and accurate picture of the city's financial condition and of the condition of any public enterprise of the city at any time.

The elaborate and painstaking investigation into the financial condition of the Croton water system, which required several months of continuous labor on the part of the committee aided by the cordial co-operation of the Comptroller and his assistants, has laid the foundation for such reports hereafter as to the City's investment in its water works. It is now entirely feasible to open a set of accounts in the Comptroller's office, which shall enable the citizen, without being either an actuary or an expert accountant, to understand the financial status of the City's investment in its water works.

The financial history of the City in respect of its water supply demonstrates that the revenues received from the consumers of water will within a reasonable time pay for the entire construction cost of any plant that may be needed for any additional supply, including expenses for interest, maintenance and operation. In any investment hereafter made by the City to increase its supply of water there should be a provision that the City's revenue from such additional supply in excess of the cost for interest, maintenance and operation, should be devoted to amortize the bonds issued for such additional supply.

The official reports of the City's water supply should furnish the data that would enable one at any time, without laborious study, to ascertain just how this great department of the City's business is managed. The reports of the Water Department of the City of Brooklyn before consolidation gave some of this information for that City. The methods followed in the Brooklyn reports should be elaborated at some points and supplemented at others, to correspond with the best practice in other cities, and their principle followed in the reports of the Water Supply of the greater city.

As a matter of fact, there are practically no summaries of any sort, for the City as a whole, and the data by boroughs are meagre. We should expect to find, but do not, statements for the *whole city,* showing the total amount of water supplied; the average daily supply per capita; the total quantity delivered by gravity, by pumping and by repumping, the total metered and unmetered consumption; (all the foregoing by months as well as for the year); the number of miles of mains, by sizes and materials; the number and kind of fire hydrants, and the number of street valves, by diameter; the number of meters by sizes and style or make; the number of service taps, including size and material; the total cost of constructing the works, divided into cost of land and water rights, storage reservoirs, aqueducts and other main conduits, pumping stations, distributing reservoirs and the street distribution system, which last includes mains, valves and hydrants; bonded indebtedness at various rates of interest, with total interest charges; sinking funds; and a classified summary of both the expenditures and receipts of the whole department, the former to include all the items mentioned under cost, with some in addition, and the latter to show clearly the receipts from different classes of consumers.

Under the different boroughs, we should expect to find, but are for the most part disappointed, all the above items, carried out in more detail, and many others. Of the others, the following may be named, all of which are lacking for some or every borough: Size of the various drainage or collecting areas, with monthly statistics of rainfall at the most important reservoirs or pumping stations, rainfall, amount stored, utilized and wasted for each drainage area, and for each separate collecting reservoir; chemical and biological analysis of the water from each source, and from different reservoirs, so far as related to the conservation of quantity; chemical and physical tests of the most important supplies used in construction and operation, particularly of cement and coal*; detailed operations and cost of the various pumping stations and of the street distribution, meter and accounting departments; a variety of information bearing on the waste of water, particularly variations in seasonal and day and night drafts, and in daily drafts during extremes in temperatures.

In the Croton system, the length, position and size of the water pipes are largely matters of tradition and not of record. So, also, are the location of the gates by which water for large districts may be turned on or shut off. The length of pipe laid, with mention of its diameter, is returned without information as to its position; the locality of pipes of various diameters is noted without information as to length; executed and unexecuted contracts, with costs and locations, are given, without the length or size of the pipe laid or quantities of material delivered.

We find practically no data of any kind, as to meters, in any annual report for Manhattan and the Bronx since 1894, nor in the reports of the City since consolidation, except a bare statement of the number in use each year, and the aggregate revenue derived that year from water sold by meter measurement. There is no statement of the quantity of water consumed by meter, nor of the rate charged.

The domestic consumption is not separated from the business consumption by means of comparative data showing the relative number of metered and unmetered service-taps, the classification of meters by business use, capacity, etc., and the increase and distribution of service taps in proportion to population, street frontage, number and height of buildings, pipe-mileage.

The disbursements are not so divided and classified as clearly to show their specific purpose. In the case of salaries, the

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* There is an excellent chemical and bacteriological laboratory connected with the Brooklyn works, which has attained a national reputation; but the results of its analysis are not published in the annual reports of the present water department. Water analysis for the other boroughs, or at least for Manhattan and the Bronx, are made and published by the Department of Health.

nature of the services for which they were paid is not made clear, hence it cannot be learned whether or not they are in due proportion.

Without going into further details, it is already sufficiently plain that there is great need of a change from the present unscientific and confusing methods in the records of the water supply department.

Some twelve or thirteen years ago the New England Water Works Association adopted a scheme for a statistical summary for water works reports, which covers the subject very thoroughly. It has been used ever since by a number of cities, not confined to New England, and has the double advantage of meeting the wants of any given locality and of making comparisons with works in other cities, both easy and valuable.

Furnishing water for the sanitary and productive necessities of the City of New York is a business in which not only the money invested, but the receipts, with the annual expenditures for maintenance, interest and the sinking fund are counted in the millions. It should be conducted under the safeguards found necessary in all commercial enterprises. It is necessary and advisable that it should be so conducted that temptation to peculations from the City Treasury be removed, that knowledge permitting improvements and economies in management may be gained, and that the people of the City, who are the joint owners of the concern, may be familiar with its financial status.

SECTION VI.

REPORT OF THE COMMITTEE ON FIRE PROTECTION AND INSURANCE.

REPORT OF THE COMMITTEE ON FIRE PROTECTION AND INSURANCE.

To the Committee on Water Supply of the Merchants' Association of New York, M. E. Bannin, Esq., Chairman:

GENTLEMEN:

This committee was instructed to examine into and report upon the sufficiency of the existing water-system of the City, with reference to fire protection and insurance rates. The rates charged for fire insurance are in proportion to the risk, into which the element of sufficient water supply enters to a considerable degree. The absence of a proper supply undoubtedly causes higher rates, which mainly concerns those who pay those rates, and not the insuring companies.

The distribution of water for general purposes and the quantity available are technical subjects which have been adequately treated by the Engineering Committee and do not, therefore, require detailed examination by this committee.

The subject of an auxiliary salt water pipe line for fire protection is fully treated by the Engineering Committee. It is therefore not considered nor reported upon by this committee.

We have, however, made independent inquiry as to details affecting the Fire Department, with the following results:

We learn that there are only incomplete data as to the size and condition of the water-mains in many of the streets of this City and also as to the pressure therein; and that therefore the amount of water at the command of the Fire Department, in case of an extensive fire in some parts of the City, is more or less uncertain.

The fire hydrants, apparently, have not been placed in all cases with a full knowledge of the size of the mains from which their supply must be drawn. In consequence, the total area of hydrant taps in some localities exceeds that of the street mains from which they draw. Therefore, at times when engines are coupled to those hydrants their draught exceeds the supply capacity of the mains, hence a shortage of water results. This was the case in the Windsor Hotel fire. There was an abundant volume of water in large mains not connecting with hydrants, and therefore inaccessible. The engines were coupled to hydrants in some of the cross streets supplied only by four-inch mains, and, therefore, were unable to deliver an efficient stream.

Inquiry has been made as to the extent to which this condition exists. It has been learned that the facts are only imperfectly known. There does not exist, so far as our committee has been able to ascertain, any accurate map of the water-distribution system of this City. We are informed that the Water Department has partial maps, which have been prepared during recent years when changes in the underground system made it possible to learn details which were otherwise not known. We are further informed that these maps are not in such form as to be readily accessible, and that frequently six months elapse after changes of pipes and hydrants have been made before the Fire Department obtains the data from the Water Department. It has been found necessary, therefore, by the Fire Department to supply itself, as far as possible, with information as to the laying of street mains irrespective of the records of the Water Department. For this purpose firemen are detailed to inspect and report upon the laying of water pipes when trenches are opened for that purpose. From these reports the Fire Department has hitherto constructed partial records supplementary to the incomplete maps which it has been able to procure from the Water Department. In practice, however, this makeshift system does not entirely supply the information desired.

The Fire Department has at times found that the location of hydrants had been changed without its knowledge, thereby misleading fire companies when responding to calls and necessitating delays in extinguishing fires.

A more serious defect, however, is lack of knowledge as to the location of the water gates controlling the supply in different districts. These affect both the volume and the pressure of water available at various points, and their proper distribution and management would materially aid in furnishing a sufficient supply of water for the use of fire engines.

This committee learns that the Fire Department has little information upon this subject, and has no control over the use of such gates as are known to exist. Therefore it is unable, in case of need, to procure the concentration of water-supply at the place and at the time most needed. The whole subject is entirely within the control of the Water Department.

The Fire Department has no authority whatever over the placing of hydrants, and is therefore unable to secure their distribution in the most advantageous way for the uses intended, or to cause their attachment to mains which would furnish an ample valume of water. As a result, the hydrants, which are of an antiquated type, are to some extent badly distributed and often attached to mains of insufficient capacity.

Certain causes which frequently disable hydrants without the knowledge of the Fire Department, arise from the fact that the care of hydrants is entrusted to the Water Department instead of the Fire Department. The hydrants are used for other than fire purposes—for street sprinkling and to a limited degree for various private purposes. They are therefore handled at times by laborers and others and are not properly closed by them; the valves and fittings are loosened and unseated by improper handling and the screw threads are destroyed by carelessness in replacing the caps. In consequence leaks ensue which prevent proper drainage of hydrants after closing and leave them filled with a body of water liable to freeze in cold weather.

There is no effective co-ordination between the two departments in the matter of speedily repairing defective hydrants. It has been found necessary by the Fire Department systematically to inspect the condition of the hydrants and report those found defective to the Water Department, to which belongs the duty of keeping them in good order. Repairs are not always made promptly, but it is not alleged that this delay is caused by negligence. The fact remains, however, that the Fire Department is embarrassed by frequent injury of hydrants and has no control over the conditions that cause the embarrassment.

This committee is of the opinion that as to the Borough of Manhattan, any apparent deficiency in the supply of water for fire purposes at the present time is due more to lack of capacity in the distributing system than to an insufficient quantity. This lack of capacity arises principally from insufficient size of mains, improper distribution of hydrants, excessive area of hydrant taps in proportion to the area of the mains to which they are attached, improper care of hydrants, and improper hydrants.

None of these conditions would be changed by increasing the total water-supply, so long as its distribution is impeded by small street mains through which a sufficient volume of water cannot be forced. The remedy, therefore, is improvement of the distribution system in order that the water available may be conveyed to the places where needed.

The records of the Water Department should be more detailed, more promptly completed, and more accessible than at present. Especially should they include complete maps of the distributing system, upon which should appear all changes as soon as made. Copies should be available to any responsible person desiring them, and in particular should be supplied periodically, at short intervals, to the Fire Department.

We are of the opinion that the public hydrants, being intended primarily for purposes of fire protection, should be wholly under the control of the Fire Department, not only as to care, but as to location.

The volume of water available through hydrants for purposes of fire protection being of the first importance, and this volume depending upon the size of the street main to which the hydrant is attached, the Fire Department should have discretionary power to make taps in such mains and at such points as would best serve the needs of fire protection.

It is vitally important, in our estimation, that wherever hydrants are connected with the mains the work should not be covered in until the Fire Department has inspected the joint and the connection with the main. It has too frequently happened that hydrants have been attached to the smaller of two available mains, thus depriving the City of the maximum fire protection. A loss of millions of dollars may be the result. The trouble lies in the fact that the department having expert knowledge of what is required is not employed for examining the work before it is covered in out of sight, where it will remain undetected until a valuable property, like that of the Windsor Hotel, is in ruins. At present this whole work is in charge of men who know nothing whatever of hydraulics or the employment of water for extinguishing fire, and the men who do know, the officers of the Fire Department, have no control.

The damage to hydrants through improper use should be guarded against by providing special hydrants or taps for the use of street sprinklers and similar purposes and the use of fire hydrants should be restricted solely to the Fire Department.

It has been suggested that efficient fire protection requires an increased supply of water under high pressure due to gravity. It is the opinion of fire experts with whom we have consulted that this condition is not practicable or desirable, for the reason that pressure of the degree proposed would be in excess of the resisting power of a large part of the distributing system and of practically all the plumbing in the City. The immediate effect, therefore, of providing a new supply and applying it directly for purposes of fire protection under these conditions would be to destroy practically all of the existing plumbing and require an enormous outlay to replace it.

Respectfully submitted,

W. C. LeGendre,
Chairman;
R. W. G. Welling,
W. A. Marble,
E. O. Richards,
J. R. Sheffield,
Fire Protection and Insurance Committee.

New York, July 31, 1900.