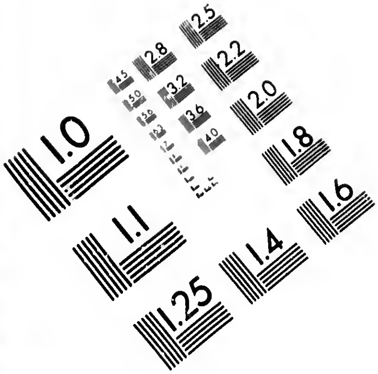

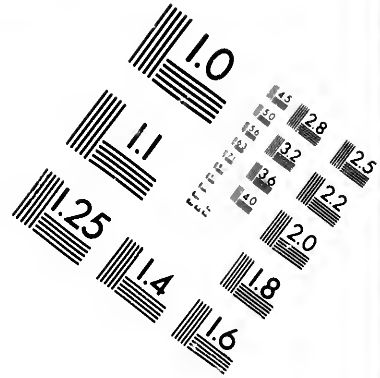

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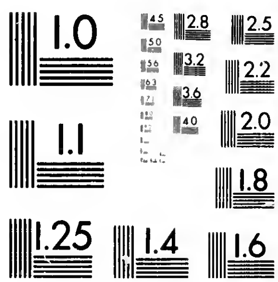

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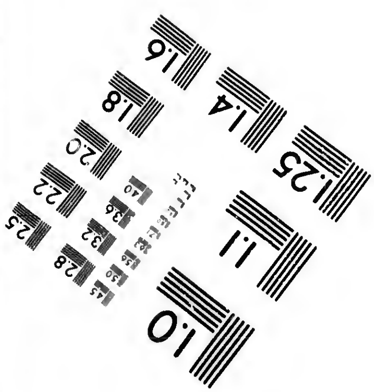

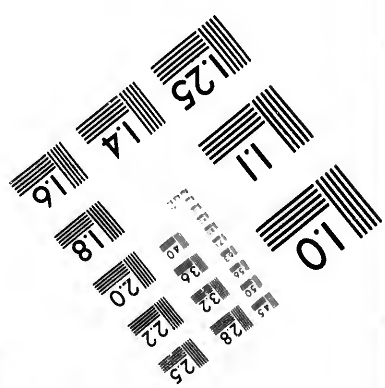

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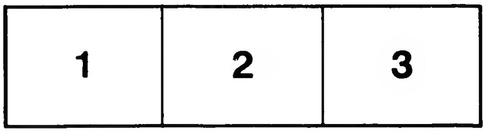
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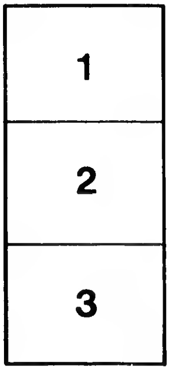
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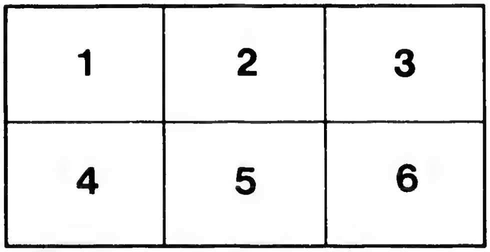
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THE

WATER SUPPLY

OF THE

CITY OF TORONTO,

CANADA.

BY JAMES MANSERGH, CIVIL ENGINEER,

VICE-PRESIDENT OF THE INSTITUTION OF CIVIL ENGINEERS, MEMBER OF THE INSTITUTION OF MECHANICAL ENGINEERS, FELLOW OF THE GEOLOGICAL SOCIETY AND OF THE ROYAL METEOROLOGICAL SOCIETY, ETC., ETC.

WESTMINSTER,
January, 1896.

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TORONTO WATER.

WESTMINSTER, January 31st, 1896.

To His Worship the Mayor and Members of the Council of the Corporation of the City of Toronto:

GENTLEMEN,—

On the 10th September, 1894, I had an unofficial visit from Mr. Alderman Shaw at my Chambers in Westminster when the question of public water supply generally was talked over, and at his request I had the pleasure of informing him about some of the undertakings I had then in hand and on the work of the Royal Commission which had recently reported upon the supply of water to Greater London and of which I had been a member.

At the same time Mr. Shaw explained to me the character of the works now furnishing water to Toronto from Lake Ontario by pumping, the rising of the pipe on Christmas Day in 1892, and the alternative suggestion for obtaining water by gravitation from Lake Simcoe.

At the close of this interview Alderman Shaw asked me if I would write him as to the probable cost of such an alternative scheme in a broad general way, and if not if I would state the fee I should require for visiting Toronto, investigating the whole matter, and reporting thereupon.

As the result of this conversation I wrote him my letter of the 16th November, 1894, which has been before you.

I heard nothing more of the matter (except an acknowledgment of mine above referred to) until the 15th of September, 1895, when I received a call from Mr. Coady, the City Treasurer, bringing a telegram from Mr. Shaw enquiring if I would visit Toronto immediately and asking my fee for so doing.

Mr. Coady explained that the pipe had again floated to the surface in the Harbour and that there was considerable excitement in the City in consequence of the fouling of the water, which was the inevitable consequence of such an accident.

It was quite impossible for me to leave England immediately because of important work which had to be arranged in connection with the deposit of plans for the next session of Parliament, and because I had several uncompleted reports in hand which must be cleared off if I were to be absent for some weeks.

These matters and the time occupied in finally arranging terms delayed my departure from London until the 26th October, and my arrival in Toronto until Saturday, the 2nd of November.

On Monday forenoon, the 4th, I had an interview with Mr. Keating in his office, when he described generally the existing arrangements, and in company with him, Mr. Fellowes, and my son I visited and traversed the Island and inspected the Pumping Station.

In the afternoon I attended a meeting of the Special Committee appointed to confer with me, and read, and subsequently handed in, a statement which I had prepared setting forth the information I desired to be supplied with in addition to that mentioned in my letter of the 16th November, 1894, which had been repeated in one sent to Mr. Coady to Liverpool, dated October 1st, 1895.

At that meeting it was arranged at my request that I might be put into direct communication with your officials in all departments, so that time might not be lost in passing everything through the hands of the Committee, and this was a great convenience, for almost on every day during my stay I had occasion to trouble one or other of these gentlemen, from all of whom I may here state I received immediate and most courteous attention.

From that day forward to the time of my leaving on the 20th November I was engaged in acquiring information on the subject matter of the reference to me, and I was agreeably surprised to receive the major part of the documentary evidence, mainly from your Engineer's office, with less delay than I had reason to expect.

Meanwhile I paid two visits to Lake Simcoe, going on the first occasion to the north or outlet end near Orillia, and on the second to the south and east.

We were exceedingly fortunate on the latter of these excursions in getting the loan of Mr. E. B. Osler's steam launch which was about to be laid up the very next day. But for his kindness in allowing us to use this boat much more time would have been spent and inconvenience incurred in seeing all the southern shore to the east of Black River, the lake as far as the north end of Georgina Island, Cook's Bay, and the lower end of the Holland River.

I also inspected very carefully the southern slope of the range of hills lying between Lake Simcoe and Toronto, especially the watershed areas and small lakes which Messrs. MacAlpine and Tully recommended as a source of supply for Toronto in their Report of February 14th, 1887.

On the 8th of November I went through the western entrance to the

Harbour on a trip with your Engineer along the Humber Bay to near the mouth of the Humber River and Mimico Point, then back by the existing intake south of the Island and on to Scarborough Heights, and on the following day we went along the new cut which has recently been made from the Harbour to Ashbridge's Bay.

In addition to these inspections I visited Rosehill Reservoir and the High Level Pumping Station, and acquainted myself generally with the area embraced within the City boundaries, and I had interviews as occasion required outside the Engineer's department with Dr. Sheard, your Medical Officer, Professor Shuttleworth, Mr. Maughan the Assessment Commissioner, Mr. Coady and others.

Before leaving I had also a second meeting with the Special Committee, and reported that the information they had instructed your officials to place at my disposal had practically all been provided, and that I had arranged for the remainder to be forwarded to me, if possible to New York, during the week which would elapse between my leaving Toronto and sailing, so that I might have the opportunity of writing without loss of time if anything further were needed.

That meeting was attended by Mr. Macdonald, the Secretary of the Georgian Bay Canal Company, who handed me some papers and who afterwards showed me at the office of his Company, a plan of the Canal and a model of part of the country lying between Lake Ontario and Lake Simcoe.

Mr. Macdonald was also good enough to give me a copy of the Charter of the Georgian Bay Ship Canal and Power Aqueduct Company of 1894, and to lend me a report of Mr. Kivas Tully's on the route of the Canal, dated 1858, which I made some notes from and returned to him the following day.

Having cleared away these preliminaries, I am now in a position to deal with the problem upon which my advice has been sought, viz.:—

"*What is to be in the future, the source of the water supplied to the people of Toronto?*"

The alternatives are as you know:—

1. Lake Ontario . . . . Pumping.
2. Lake Simcoe . . . . Gravitation.
3. Oak Ridge Lakes and Rivers Don and Rouge. . Gravitation.

Other sources have been mentioned and are referred to in Mr. Keating's Report of October 30th, 1893, which I will describe as *supplemental* rather than *alternative*, because it cannot be contended that these sources would be adequate to provide the whole of the water required in Toronto for all time.

These are:—

(*a*) Wells sunk in the gravel beds north of the City.
(*b*) Springs and artesian wells in the Township of Erin.

(*a*) With regard to the first of these supplemental sources, I found that some correspondence had passed between Messrs. O'Brian and Gault and Mr. Keating about the time of my arrival in Toronto, and on the 14th of November I requested Mr. Keating to ask these gentlemen the three following questions, viz.:—

1st. How much water are you prepared to supply to Toronto ?
2nd. At what level would it be delivered ?

On the 20th November the following reply was received by Mr. Keating, and handed to me.

Toronto, November 20th, 1895.

Dear Sir,—

Re BRIAR HILL WATER SUPPLY.

We have yours of the 14th instant, and we beg to enclose you herewith a memorandum briefly stating the facts regarding this project. To answer your questions *seriatim*:—

(*a*) It is confidently expected that a supply of at least two millions of gallons per day can be delivered, and possibly much more.

(*b*) The level at which the water would leave our premises is approximately 200 feet above the Rosehill Reservoir.

(*c*) The price per 1,000 gallons would be fixed at less than the cost to the City of supplying a like quantity by any otner means.

As you know our clints have refrained from putting in a plant until the City should express its willingness to take water from this source. The City is practically the only customer for it, and until the Council declares its willingness to buy the water or the works, on the supply being developed, there is no encouragement to our clients, as prudent men, to expend money in further development.

It seems to us to fall within the scope of Mr. Mansergh's duty to report to the Council on the advisability of securing such a supply as this, as an auxiliary or reserve supply, and a means of increasing the fire pressure, etc.

On the City being led by a favorable report from him to take action in regard to this source of supply, our clients would meet them in every reasonable way, whether by selling the land as it is, or leasing it, or by completing.

under arrangement with the Council, the development and establishment of a supply system.

Yours truly,

(Signed) O'BRIAN & GAULT.

E. H. KEATING, ESQ.

The letter was accompanied by a "Memorandum concerning the proposed auxiliary supply of water for the City of Toronto from the source known as "Briar Hill," under the heads of Character, Location, Quantity, Quality, and Cost.

It is not, I think, necessary to give this Memorandum in full; the supply is admittedly suggested merely as auxiliary, the information given is of the vaguest and most speculative character, and some of the remarks exhibit a want of knowledge of the subject, which detracts from the value of the proposal.

Thus, in speaking of the quantity procurable from the source, the following sentence occurs: "The situation and the abundance of the water precludes the idea of its being a mere rain or natural drainage catchment."

On this, I hope, I might say without offence that it is a delusion, and that if the water is *not* the product of rain but is supernaturally produced, then it is something of which I have had no prior experience, and am utterly incompetent to advise you about, but it surely will be time enough to investigate such a freak of nature when Lake Simcoe and Lake Ontario have failed.

From what I have learned, however, of the geological structure of the southern slope of the ridge between the two lakes I have no doubt that water must be found in many places issuing as springs, or may be obtained by driving or sinking, under quite normal and natural conditions; and possibly Briar Hill is one of the most favourably situated of these.

I think, however, that nothing more need be said about this proposal, because I cannot believe you invited me to come from England to consider an insignificant addition of 10 per cent. to your present means of supply.

ERIN DISTRICT.

(*b*) The Erin district I did not consider it was worth my while to visit

Mr. Keating describes having seen there three or four springs of bright and very hard water, issuing at an elevation of about 1,000 feet above Lake Ontario, and at a distance from the centre of the City, as the crow flies, of about 36 miles.

The suggestion that this source might be available for Toronto seems to have come from a Mr. Vanderlip, who pointed out the site of an abandoned boring sunk some years ago with the hope of finding oil.

At a depth of 80 or 90 feet water was struck, and rose to the surface, but the search for oil having been unsuccessful, the boring was abandoned, and its site is now marked only by a small puddle.

I have little doubt that similar conditions might be discovered in any number of places around Toronto, and I agree entirely with Mr. Keating that the project of seeking water in so precarious a source, the bringing of which would involve the laying of a conduit nearly 40 miles in length, cannot seriously be entertained.

The risks and contingencies involved in sinking and driving in search of underground water are exceedingly great under the most favourable gelogical conditions.

For instance, in the chalk formation which stretches from the Sussex coast of the South of England, right away under, and for many miles to the North of London, no one can predict with confidence the quantity of water which can be obtained by given works in any specific locality, although it is well known that the whole mass of the chalk is more or less saturated with water, from its base on the impervious gault up to certain easily ascertainable heights—a thickness in many places of several hundreds of feet.

I do not believe for a moment that anything like the quantity of water ultimately to be required can be obtained from this source, and to lay a pipe so great a distance for a mere supplemental supply would be a foolish expenditure of capital.

If there were not inexhaustible quantities of water of good quality in sight upon the surface, within the same distance, it might be excusable to spend time and money in investigating this source more closely, but under the circumstances I am clear that the suggestion may be dropped out of further consideration.

RIDGE LAKES SCHEME.

I now come to the Ridge Lakes and Don and Rouge Rivers Scheme of Messrs MacAlpine and Tully.

These watersheds were seriously suggested in 1887 by Engineers of position as sufficient and suitable sources for the supply of Toronto for as long a period as it is ever needful to look forward to. Their estimate of the cost of works was temptingly low, and the quality of the water was said to be pure and wholesome.

This proposal consequently calls for careful examination and consideration, and this I have given, to the extent to which, in my opinion its merits deserve.

I have read through the report more than once—it professes to be only preliminary and therefore very close criticism may possibly be deprecated,—but I was at once struck with the general tone of lukewarmness, not to say apology, with which it is compiled.

My impression is that its writers were not very enthusiastic in favour of their scheme, nor much disappointed that they have never been asked to carry out the instrumental examinations necessary to determine the actual areas of the various watersheds, the positions of the storage reservoirs, or the locations of the pipe lines.

I must, however, deal with the report in a general way as I find it, and afterwards give my opinion of the scheme based upon my examination of the lakes and the watersheds of the several rivers proposed to be utilised.

The simplest way will be to take up *seriatim* the points I noted in reading, and the first of these I find on page 5, where it is stated that the water to be procured is "pure and wholesome."

On the next page I find it is suggested that all the water should be passed through mechanical, and, if found necessary, chemical filters.

This caused me a little surprise as it suggested that the pureness and wholesomeness were not the natural condition of the water, but were to be obtained by a process of more or less elaborate engineering and doctoring.

I have no fault to find with the interesting description of what may be called the natural history of water found upon the earth, given on pages 6 and 7, and I agree with the conclusions arrived at in the middle of page 7, viz.:—that "For a public water supply the water should be selected having the following characteristics in the highest degree possible, viz.: first, purity, next softness, and next limpidity."

After the enunciation of this sound doctrine, one would not have expected that the water to be obtained by this scheme might need both "mechanical *and chemical filtration*."

Lower down on the 7th page we find how it is that this elaborate treatment may be found necessary, for "the Analyst has reported that the waters of the Ridge Lakes as they are now found are objectionable, on account of the amount of vegetable matter present therein."

On reading this, I looked forward to find how the Analyst exactly put it, and found that he entered on a lengthy investigation into the quality as tested by the standards formulated by the chemists Wigner, Mutur, Tidy and Wanklyn, and that his final conclusions are stated as follows:—

Page 29. "The water of the Ridge Lakes is very impure and entirely unfit in its present condition for drinking purposes."

Then after setting out that the organic matter they contain, is almost exclusively of vegetable origin, and, therefore, very greatly less objectionable than if it were due to excremental or sewage pollution, the Analyst says on page 31, "But after giving all due weight to considerations of this nature, the fact remains that the water of these lakes is loaded with organic matter, no doubt vegetable in its origin, to a degree that renders it quite unfit for drinking."

With these expressions of opinion before them I do not wonder that the Reporters recommended a very perfect system of filtration.

I cannot find that any of the waters of the Rivers Don and Rouge or their tributaries were analysed, but I do not suppose that these would have been found to differ materially from the average quality of the water of the lakes.

Let us now go back and examine the hydrology and engineering of the scheme.

First as to the drainage areas, these are given in round figures and must be taken as more or less approximate.

That of the lakes stated at 9½ square miles in the table on page 9, is only 1-16th of the whole area dealt with, viz., 151 square miles.

In the absence of reliable contoured plans it is not possible on existing data to cheque this figure, and in view of the opinion I arrived at on my inspection of the "locus," I have not deemed it necessary to ask you to incur the expense of having instrumental surveys put in hand.

Second, as to "Daily Discharge," it is not definitely set out in the Report how this has been arrived at.

The only rainfall returns are a few figures given on the top of page 9, and these appear to apply only to the sheds feeding the lakes.

The average annual fall of rain and snow for the years 1841 to 1871 is given as 36.63 inches. If the observations were accurately made and recorded this is a sufficiently long term to work upon.

In England we should calculate from the mean of such a period that the rainfall of the minimum or driest year would be 24.42 inches, and that the average of the three driest consecutive years (which is the period upon which such calculations are based) would be 29.30 inches.

The Report states that the driest year of the 31 years in question was 1848, when the rainfall measured was 26.80; it does not give the average of three consecutive dry years, but I think it would not be safe to take this at more than 30 inches.

From that quantity I should be disposed to deduct 15 inches for evaporation; it is a figure not infrequently used in Great Britain and I think it quite justified here, because what is recorded as rainfall is rain *plus* snow reduced to water, and the evaporation from snow is frequently very great indeed.

In prosecuting my enquiries around Toronto, especially into the question of the present abnormally low water level of the lakes, I have learned that although there was a large quantity of snow last winter, its melting conduced very slightly to the swelling of the rivers and the replenishing of the lakes, mainly because there were no heavy warm rains which melted and carried the snow away rapidly, but that on the contrary it was quietly and insensibly evaporated into the atmosphere.

Deducting then 15 from 30 we get 15 as the number of inches of rainfall upon the watersheds which could be impounded if natural lakes existed, or artificial reservoirs were constructed of sufficient aggregate capacity to hold the water this fall upon the sheds would produce.

To put this into the shape adopted by Messrs. MacAlpine and Tully, viz., "Daily Supply,"—or as I should prefer to call it "Daily Yield"—we get 151 square miles by 15 ins. by 40,000 gallons*=90,600,000 gallons a day as against 79¼ millions, given in the table on page 9, with a provision of 4,443 million gallons of storage.

But in my opinion this provision is entirely inadequate and insufficient; it is not 50 times the daily quantity obtainable, and I should not think of providing less than 200 days' storage with such a rainfall as prevails here, in order to utilise the whole of the water, and be certain of maintaining the full supply during a period of drought.

Then further, the Reporters take credit for obtaining 8½ million gallons a day from the six Ridge Lakes, although they give no figure for storage in the corresponding column of the table.

I confess to having been very much puzzled to understand in what way it was contemplated to make use of the lakes.

On page 8 I found the following passages: "The supply from these lakes forms an admirable adjunct to the scheme, as the lakes will form a very large storage at small cost, sufficient to retain all the rain and snow, without allowing any to run to waste, and also enough to hold over the surplus from one year of larger rainfall to another of lesser rainfall."

Again "The supply from the lakes alone would be an average of 8½ million gallons a day for the whole year, and, if desired, by retaining the water in the lakes, 12 or 15 millions of gallons daily can be furnished to the City through the summer season from this source.

* The quantity due per day to one inch of rainfall per annum per square mile.

Nowhere is anything said about raising artificially the present normal top water level of the lakes or of drawing the water down below that level, and that neither of these is intended to be done, is borne out by the absence from the table on page 9 of any figure for storage.

Whence then the 8½ million gallons a day throughout the year or the 12 or 15 millions during the summer are to be obtained, I entirely fail to see.

If no water is to be stored in the lakes, that is if a certain depth in feet above or below the present normal surface is not to be alternately filled and drawn upon, then the only supply available during the summer months would be the dry weather yield of the watersheds, which I am satisfied, from what I have seen, may fall to 15 cube feet per minute per 1,000 acres for weeks together which is equivalent, to 821,000 gallons a day instead of the 12 or 15 millions stated in the report.

If I were to assume that 4,443 millions of gallons of storage could be provided as stated by the Reporters by the construction of the reservoirs on the sites they have indicated (which I very much doubt), then I should put the full reliable daily capability of supply of the works at about 56 million gallons a day, arrived at in this way:—

One two-hundredth of 4,443,000,000 gallons storage equals	22,215,000
Average flow of rivers with 151 square miles of drainage area at 25 cube feet per minute per square mile	33,975,000
	56,190,000

Works.—Of course it is not to be expected that in a preliminary report such as I am criticising, anything very definite can be said about works, but I cannot help calling attention to a passage or two which attracted my notice on page 19, as follows:—

"If the gravity project shall receive the favourable consideration of the Municipal Government we would recommend that the works necessary to bring in the water from the west branch of the Don (10 millions of gallons daily) shall be first commenced, and built with as much alacrity as the case admits, so that it may meet the immediate demand for an increased supply instead of increasing the pumping works.

"The expenditure will be $210,000, or about one-fourth of the sum estimated by the Superintendent for a supply of 8 millions by pumping.

"The necessary surveys and plans can be prepared in three months, and the works constructed in four to six months.

"The lower storage reservoir, containing from 200 to 300 millions of gallons, would be 9½ miles from Rosehill Reservoir.

"The conduit pipe connecting them would have a capacity for delivering from five to ten thousand gallons per minute into the City distribution."

I will venture to test this a little in detail so as to be able to form a judgment on the correctness of the estimate.

In order to procure 10 million gallons a day, I find from the table on page 9, that 494½, say 500 million gallons of storage, are to be provided. (I do not accept this as accurate but will use it for the purpose of my argument.)

Further, to deliver this quantity to Rosehill reservoir, a pipe 9½ miles in length must be laid.

From the levels I have on plans furnished to me, I assume that the head of this pipe in order to draw down the reservoir fully, must be about 400 feet above Toronto datum, whilst the delivery end at Rosehill will be 216, giving 184 feet fall in the 9½ miles, or about 1 in 272. If the true hydraulic gradient between these points can be obtained (that is if no higher ground intervenes), a pipe of 27 inches diameter will be required to deliver the 10 million gallons a day or 7,000 a minute.

Such a pipe, 9½ miles long, could not, I believe, be laid for the $210,000, as this would only allow $4.18 per foot. I shoud prefer to call the cost at least $7 a foot, which is a low estimate, if sluice valves, air cocks, washouts, and easements are included. On this basis, the pipes alone would cost $350,000, or $140,000 more than the Reporters' estimate, will be the whole outlay, including the 500 million gallons of storage. What the cost of this would be, it is not easy to say without definite information upon the configuration and geological structure of the site.

From what I have observed personally and learned by enquiry, I cannot assume, however, that the facilities for reservoir construction, will be more favourable or the works less costly in the township of Vaughan, than in an average case in England.

The same care must be exercised, and the same expense must be incurred in dealing with water stored to a considerable depth, in order to prevent leakage and avoid disaster, and I cannot see why my home experience should not be utilised in estimating the cost of a reservoir to hold 500 million gallons.

If I do this, I should put it down at $500,000.

Adding this to the $350,000 for the conduit and 15 per cent. to the whole for engineering and contingencies, we get a total of $977,500 or nearly five times the estimate of Messrs. MacAlpine and Tully.

Now as to the time in which it is stated that all this work could be carried out, viz., from four to six months.

I have heard of the lightning speed at which the Canadian Pacific and other railways on the American continent have been executed, but I have yet to learn that hydraulic works of a reliable and stable character have ever been, or can be rushed in this way, and I venture to suggest that not four to six months, but more nearly four to six years would be needed to build these reservoirs.

From these criticisms you will learn that my opinion is, that neither in respect of its capability of supply, nor the cost at which it can be executed. is this scheme to be relied upon.

I think that in every respect the figures are misleading, and I believe that if the Reporters had made detail surveys and working drawings, their estimates would have been modified so as to approximate to the figures I have named.

It might, however, have turned out that notwithstanding this, the project would have been a desirable one, if the quality of the water could for all time have been relied upon.

This, however, I believe is not the case.

If Toronto is ever to grow so that the quantity of water obtainable from these watersheds is needed, then by that time all this district will have been much more closely settled and densely populated than it is at present, with the inevitable result of the pollution of the streams by sewage and foul manures.

Even in their present condition, these sheds would never be selected now-a-days at home. Only open mountain pastures, unploughed and unmanured, and with practically no population, are considered good enough as collecting grounds for town supplies, and where a river, like the Thames, is still utilised, the whole of the conditions bearing upon the use of its waters must be distinctly understood before it can be set up in comparison with the scheme under consideration. From my own intimate knowledge of the Thames, I can say that the two are in no sense comparable.

After a full consideration of this proposal, I unhesitatingly condemn it.

Lake Simcoe—Gravitation.

Lake Ontario—Pumping.

I now come to the real question at issue, viz.: Is the future supply of water to Toronto to be obtained by pumping from Lake Ontario or by gravitation from Lake Simcoe?

What the answer to this question is to be will depend upon two main factors, viz.:—

First.—The quality of the water procurable from each source, and

Second.—The relative cost of obtaining it.

I will deal with them in this order:—

Quality of the Waters of Lake Ontario and Lake Simcoe.

Upon this point my opinion must necessarily be formed partly by a consideration of the general conditions affecting each of these waters, but mainly upon the chemical analyses and biological examinations which have been made from time to time by your own officers.

In order to obtain this information in a systematic form, I had an interview with Dr. Sheard and Professor Shuttleworth on the 8th November, and on the same day I wrote the following letter:—

[Copy.]

Queen's Hotel, November 8th, 1895.

Dr. Sheard:

My Dear Sir,—

I shall be much obliged if you will be good enough, in concert with your colleague, Professor Shuttleworth, to furnish me with the following information:—

1st. A tabulated statement in chronological order of the chemical analyses which have been made during the last 10 years of the water of Lake Ontario at the waterworks intake, south of the island.

2nd. A similar statement of the bacteriological examinations for such period as these have been made.

3rd. Chemical and biological results in the same form of the waters of Lake Simcoe, the Ridge Lakes, and the Rivers Don and Rouge, referred to in the 1887 Report of Messrs. McAlpine and Tully.

4th. Similar information, if such exists, of the water of Lake Ontario at Mimico Point and Scarborough Heights, and of any other sources which have been seriously suggested for the supply of the City.

To all these analyses I shall be much obliged if you will add any observations made as to taste, colour or odour, and your opinions generally as to their individual and relative suitability for the supply for all purposes to a community such as that of Toronto.

I have already requested, through the Special Committee, to be furnished with analyses (C. & B.) of the waters of the Niagara river, and I explained this afternoon how the samples should be taken.

Yours very truly,
(Signed) JAS. MANSERGH.

Since my return home I have received a report, dated December 5th, 1895, signed by both these gentlemen, and a separate note from Dr. Shuttleworth, on the water of the Niagara river, dated 23rd November, 1895.

Both these are printed as appendices and marked A and B.

I have submitted these reports to Dr. Edward Frankland, F. R. S., who has probably had a larger experience in the analysis of water and in advising upon public supplies than any chemist now living, and with him I have talked the matter over in all its bearings, the result being to fortify—on the points referred to him—the opinion I had myself substantially arrived at.

Curiously enough the two lakes we are dealing with stand, the one Simcoe, at the head, and the other, Ontario, at the foot of the great system of inland seas occupying the centre of the North American continent; thus, on the water parting of the ridge between Simcoe and Ontario, a child with a toy spade could cause a little stream to flow either by a twenty miles run into Ontario or to follow a course by way of Huron, Erie, and the Niagara river of 800 miles.

The watershed into Simcoe is 1,100 square miles and into Ontario 270,075.

The average daily discharge from Simcoe by the River Severn is probably 660 million gallons; from Ontario by the St. Lawrence 150,000 million gallons.

The drainage area of Simcoe is sparsely populated and the lake has upon its banks but a few small towns, so that the organic pollution is now very small indeed and will probably never be serious.

I am not in a position to say how the population of the rural part of the drainage area above Ontario compares ratably with that of Simcoe, but there are upon the banks of the great lakes a number of large cities* and

*As you are aware the largest of these cities, Chicago, is now carrying out works which will have the effect of diverting its sewage from Lake Michigan (and ultimately the St. Lawrence River) into the Mississippi.

other populous places, and upon Ontario stands Toronto itself, which, from its proximity to the intake, I regard as more important by far than all the others put together.

Making a broad mental comparison of these relative conditions one would judge that, under normal circumstances of wind and weather, the waters of the two lakes should be very similar when viewed from a purely chemical standpoint, but Dr. Frankland advises me that the analyses show distinctly that the water of Simcoe is in this sense "very decidedly inferior to that of Ontario."

He also says that "the water of the Niagara River as it enters Lake Ontario is of excellent chemical quality, for, although it has received the sewage of Buffalo and other places, the immense volume of water with which this is mixed renders its effect upon the chemical, as distinguished from the bacteriological character of the water, inappreciable."

It is, however, nowadays considered by all the authorities that the bacteriological condition of a water intended for dietetic purposes, is probably of greater importance than its chemical composition.

In this respect, under normal conditions, there is nothing to choose between the two waters, and if I had not seen the result of an examination made by Dr. Shuttleworth when the Ontario water was in quite an abnormal condition, I might have assumed that, balancing everything, it was at all times slightly the better of the two.

On that occasion, January 19th, 1894, a very heavy sea was running with much floating ice, and the whole condition was one of quite exceptional disturbance, and, in consequence, the number of organisms was increased from an average of 104 to 7,880, this being, no doubt, due to the stirring up of the mud by the action of the waves.

To the unitiated these numbers may sound very alarming, and I, therefore, append a footnote (*) containing a few passages from the Report

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*Mr. Wm. Crookes, F.R.S., put in a statement containing the following facts, spoken to by high French and German authorities:—

Bacteria in—

Aerated waters	10,000	to	75,000	per cubic centimetre.
Milk	1,000,000	to	7,200,000	"
Lyons sausage	1,890,000	to	6,654,000	per gramme.
Flour	35,000	to	200,000	"
Oatmeal	400,000	to	500,000	"
Cheese	5,500,000	to	8,500,000	
Butter	10,000,000	to	20,000,000	

N.B.—A cubic centimetre of water weighs one gramm .

of the Royal Commission on London water of 1893, which shows that there may be present in foods or drinks a very large number of micro-organisms without any harm being done.

Dr. Sheard and Professor Shuttleworth were, no doubt, quite right in keeping out of their comparative tables the particulars of this exceptional observation, because, as they say, the figures "would exercise a dominating influence which would quite overwhelm any conclusion which might otherwise be formed as to the average condition of the water at the lake stations."

As dealing in a practical way with the whole question, I cannot, however, ignore the fact that, occasionally and for short periods, the bacteriological condition of the water is such as to make it inadvisable to send it "into supply" in its raw state.

No doubt an enormous majority of the organisms found by Dr. Shuttleworth in January, 1894, were perfectly harmless, but the fear is that there might be among them an occasional pathogenic microbe or spore capable of doing harm.

In view of this contingency I have from the first been inclined to advise that the water of Lake Ontario should be filtered, and in his Report to me Dr. Frankland emphatically supports this view.

In fact, he goes further and says: "As regards filteration, I should strongly advise this to be adopted, *whichever source* is selected. If the water is not filtered I should, on the whole, prefer Lake Simcoe; if it is decided to filter, then I should prefer Ontario."*

My own view is that the Simcoe water need not be filtered at present. No examination of it has been made at a time of unusual disturbance, as in the case of Ontario; if it were made, there is little doubt a very much greater number of organisms than the average would be found, but there is, in my opinion, little fear that any of them would be pathogenic.

Instead, therefore, of going to the cost of filtering the water, I think at the outset it would be quite sufficient to construct a service reservoir to hold 100 million gallons, which should always be kept full (except in fire or other emergency), so that when the water was not quite right the City could be supplied from the reservoir for three or four days without drawing any from the lake.

Experience would soon show if further precautions were necessary. I am of opinion that not for a great many years, if ever, would they need to be taken.

*The effect of filtration is to remove 99 per cent of *all* the organisms whether harmful or harmless; and as only one of the former may exist among thousands of the latter the chances of its passing through the filter are exceedingly remote. The bacillus of typhoid, which is probably the only one to be feared, has, I believe, never yet been isolated and recognized in the water of Lake Ontario.

On the question of quality, nothing more need be said than to repeat in a sentence that if the Simcoe water is dealt with as I have just described, and if the Ontario water—drawn from the present intake—is filtered, both of them, as delivered to consumers will be high-class waters of unimpeachable character, with practically nothing to choose between them.

I am now, therefore, in a position to take up the discussion of the second factor, which is to determine what my answer shall be to the question put upon page 23, viz., the question of "relative cost."

RELATIVE COST OF OBTAINING WATER BY GRAVITATION FROM LAKE SIMCOE AND BY PUMPING FROM LAKE ONTARIO.

The first stage in this enquiry will be to formulate the bases upon which the comparison of cost is to be founded.

To do this we must at the outset determine the quantity of water to be ultimately provided, and in using the word "ultimately" I mean, of course, the termination of a period in the future up to which it will be reasonable to attempt to forecast the growth of the population.

We must also assume a certain rate at which this growth is to go on.

Having made this forecast of the number of people to be supplied in any year up to the ultimate time, we must then fix upon a quantity per head per day which shall be amply sufficient to meet all the usual demands for domestic, sanitary, and commercial purposes.

It would be folly to pretend that it is possible to predict the future of Toronto with any degree of accuracy; all that can be done is to make a reasonable assumption as to its future progress, based upon its growth in the past and upon all the conditions likely to operate in determining it.

During my stay in Toronto and on the voyage home, I took every available opportunity of learning the views of those who I thought were probably more or less competent to form an opinion, but I was referred by the Committee to the gentleman whom they considered the highest authority, viz., Mr. Maughan, the Assessment Commissioner.

By him I was furnished with a table of the population of the City from 1870 to 1895, and he was good enough to give me two or three opportunities of talking the matter over with him, both before and after he had written me the following letter.

November 7th, 1895.

DEAR SIR,—

You have requested me to furnish you with an estimate of the probable annual increase of population which may reasonably be expected for the future in the City of Toronto.

After giving the matter due consideration, and taking into account all the facts of which I am cognizant, I am of opinion that such increase will be at the rate of about two per cent. per annum.

Yours truly,
(Signed) N. MAUGHAN,
Assessment Commissioner.

James Mansergh, Esq.

The following is the table above referred to :—

TABLE No. 1.

POPULATION OF TORONTO FROM 1870 TO 1895 FROM ASSESSMENT ROLL.

Year.	Population.	
1870	54,736	
1871	57,020	
1872	62,647	
1873	67,995	
1874	68,678	
1875	71,693	
1876	67,386	
1877	70,867	
1878	73,813	
1879	75,110	
1880	77,034	
1881	86,415	
1882	89,945	
1883	102,537	Yorkville (5,211 people) annexed.
1884	108,689	Brockton 745, Riverdale 2,936.
1885	115,210	
1886	122,122	
1887	130,060	The annex and E. Rosedale annexed.
1888	143,716	Dovercourt annexed.
1889	164,986	Parkdale annexed, 4,583.
1890	172,410	
1891	167,439	
1892	170,651	
1893	169,099	
1894	167,653	
1895	174,309	

It will be seen that these figures form a very unsatisfactory basis to found a forecast upon, first, because during the whole 25 years' period, the area upon which the population was located did not remain the same, but was extended on five different occasions. Second, because during the times when the areas were identical, the fluctations in the growth were very considerable.

Thus in the—

Four years from 1870 to 1874 it was 25.47 per cent.
Four years from 1874 to 1878 it was 7.48 per cent.
Four years from 1878 to 1882 it was 21.85 per cent.

and in the whole twelve years between 1870 and 1882 it was 64.32 per cent.

Between 1882 and 1890 the City boundaries were extended so as to take in the out districts of Yorkville, Brockton, Riverdale, The Annex, East Rosedale, Dovercourt, and Parkdale; and the population of the City, which prior to these extensions had been in 1882 89,945, became in 1890 172,410, being an increase of 91.07 per cent. in the eight years.

How much of this increase was due to extension of area, and how much to real growth of population, I have no means of ascertaining.

In the five years from 1890 to 1895—during which period no extension of the City limits has been made—the population has grown from 172,410 to 174,309, or 1,899, which is equivalent to 1.10 per cent., or about one-fifth per cent. per annum.

This is a very different state of things from that which prevailed between 1870 and 1882 when the average annual increase was at the rate of 4¼ per cent., or 21 times as great.

In the light of these figures, and taking into account the opinions I have obtained other than Mr. Maughan's, my own impression is that his estimate for the future is a somewhat sanguine one.

I propose, however, to adopt the two per cent. per annum in my calculations, because it was agreed on all hands that Mr. Maughan was the man best qualified to form an opinion upon the point.

I sincerely trust that his forecast may be found correct as years go by, for if it is, then the City of Toronto has indeed a prosperous and brilliant future before it.

On this assumption then I have prepared the following Table No. 2 which gives the estimated population in each year up to 1945, beginning with the round figure of 175,000 in 1895.

TABLE No. 2.

Population, Estimated.

Year.	Population.	Year.	Population.	Year.	Population
1895	175,000	1912	245,042	1930	349,980
1896	178,500	1913	249,943		
1897	182,070	1914	254,942	1931	356,980
1898	185,712	1915	260,040	1932	364,120
1899	189,425	1916	265,242	1933	371,402
1900	193,214	1917	270,545	1934	378,830
		1918	275,957	1935	386,406
1901	197,078	1919	281,476	1936	394,134
1902	201,020	1920	287,106	1937	402,018
1903	205,040			1938	410,058
1904	209,140	1921	292,848	1939	418,258
1905	213,324	1922	298,705	1940	426,624
1906	217,591	1923	304,679		
1907	221,942	1924	310,773	1941	435,158
1908	226,381	1925	316,988	1942	443,860
1909	230,908	1926	323,328	1943	452,738
1910	235,527	1927	329,794	1944	461,792
		1928	336,390	1945	471,028
1911	240,237	1929	343,118		

This Table is made out as will be seen for a term of 50 years from 1895.

The Royal Commission which had under consideration two years ago the supply of water to London, discussed at great length the question of how long a period it was desirable to look forward to, and finally came to the conclusion to take 40 years, feeling that "every addition to the period adds enormously to the chances of serious error in the computation of probable future population."

I think it may fairly be assumed that such chances of error are greater in the case of Toronto than of London but for reasons which later on I may again refer to, I have decided to deal with 50 years and even to put a little addition on to that, as will be found in the sequel.

It may be a surprise to some who have not looked into the figures to learn that a growth of 2 per cent. per annum means that in 1945 the population would be 471,028 and in 1948, half a million.

If the growth of the City between 1870 and 1882, viz., 4¼ per cent. per annum were projected forward to 1948 the population would then be over 1,400,000.

Some of the persons I discussed the matter with, were optimistic enough to assert that a similar rate of increase (4¼ per cent.) might not unfairly be looked forward to in the future, whilst others who agreed that 2 per cent. per annum was a perfectly reasonable assumption, were taken aback at finding that there would, on that basis, be 500,000 people in Toronto in 1948; and there and then expressed their belief that it would never attain to such a position.

These considerations are sufficient to illustrate and emphasize the imprudence of dogmatising either on the future rate of growth or on the period during which such rate is likely to be maintained.

It is, however, absolutely necessary for the purposes of this report that I should assume something on each of these points, and for the reasons I have given, I take a growth of 2 per cent. per annum for a term of 50 years.

In doing this I feel very confident that I am erring—if erring at all—on the side of excess.

Having taken these steps I must now discuss the question of the quantity of water that ought to be provided daily per head of the population.

It is a matter of common knowledge that in the United States, Canada, and other of the Colonies, the consumption per head is very much greater than it is in England.

How this comes about I have never been able satisfactorily to ascertain.

Taking the year 1894 for which I have been furnished by Mr. Keating with the quantity pumped upon every day, giving an aggregate for the year of 6,589,492,142 gallons or an average of 18,053,403 gallons per day, and dividing that quantity by Mr. Maughan's population for the same year, viz., 167,653, I find that the daily allowance per head is 107.7 gallons.

This is assuming that the whole population is supplied from the public works, and none at all from private sources, which is a little unlikely, and, therefore, the 107.7 is probably somewhat less than the actual figure.

Let us see how this compares with home consumption.

The recent Royal Commission found that, in the year 1891, the average daily quantity supplied per head in Greater London was 32.68 gallons, and after hearing much evidence from all sides, and fully considering the matter, they fixed on 35 gallons as an ample quantity for all purposes, domestic, sanitary, trade and ornamental, and, I think it may safely be stated, that this is more than the average consumption in the whole of the United Kingdom.

How it comes about that over three gallons have to be provided in Toronto, for one in London, I cannot positively say, but I have a shrewd suspicion that by far the greater part of the excess is due to misuse or waste in one way or another.

In all countries there are, no doubt, certain localities, the homes of special industries, in which abnormally large quantities of water are required for the processes carried on; such for example as the ironmaking district, on and near the banks of the Tees in the north-east of England.

There, out of a consumption equal to 52 gallons per head of the population, 39 are sold by meter for trade purposes, leaving 13 for domestic supply.

This, however, is quite an exceptional case, and in cities like London, Birmingham, Manchester and Sheffield, the meter consumption ranges from 6 to 10 gallons per head, leaving for the domestic supply from 13 to 25 gallons.

The larger of these figures is, now-a-days, never exceeded, and very rarely reached, in laying the estimates of consumption before Parliamentary Committees; it is, in fact, admitted on all hands to be a very full and ample provision for all domestic and sanitary purposes.

So far as I have been able to judge the conditions of life and the habits of the people in Canada and the United States, do not differ so materially from those prevailing at home, as to lead to a greatly increased user of water, and I am clear that if the 25 is raised to 30, that is a very liberal provision.

How then are the 77.7 gallons provided in excess of this quantity disposed of ?

I did my best to ascertain this whilst in Toronto, obtaining the information from the Treasurer's department.

According to the books the quantity of water sold by meter in 1894 was 683 millions of gallons, but I was told that owing mainly to the presence of sand in the water, the meters could not be maintained in good working order, and were believed to register on the average in favour of the consumer to the extent of 25 per cent.

Assuming this to be the case (it is a rather strong assumption), the 683 millions would be increased to 854 millions, which, divided by 365, gives an average meter consumption of 2,340,000 gallons per day.

Again dividing this by the 1894 population (2,340,000÷167,653) we get 14 gallons per head per day, the difference between this figure and 77.7—say 63 gallons—remaining still to be accounted for.

Now I find from the table of daily pumping in 1894 that the greatest excess over the average supply (dealing with months) occurred in February; this excess being due, probably, to the deliberate running of taps to prevent freezing of the service pipes and fittings, and amounting to 11 gallons per day in addition to the 63.

The demand over the average in the summer months amounts to only 5½ gallons per day.

To complete the statement of useful facts obtained from the table (this is far too voluminous to print), I may add that the least quantity of water was pumped in the months of November and December, that is, in cool weather, either entirely without frost, or with frost so slight as not to induce consumers to leave their taps open. In those months the average daily supply per head was 97 gallons; but it would not be right to put down domestic and sanitary during these months at 30, because the use of water for baths, street watering and sewer-flushing would all be materially less at such a time; the unrecognised waste would therefore be going on much as usual.

I am certain that if the proper steps are taken, all this can be remedied and the consumption per head for all purposes, be brought down to 50 gallons a day. It would cost money to do this, in providing self-registering meters for localising the waste; and in instituting and maintaining an effective staff of day and night inspectors, and other workmen to discover and remedy defective fittings, services and possibly mains, but the cost would be recouped in a comparatively short time.*

*Since my return to London I have received a publication of the State Board of Massachusetts in which I find a report by Mr. Dexter Brackett on the supply of water per head of the population in the Boston Metropolitan District. After giving a large amount of information with regard to other United States cities, and much detail as to the quantities used in different parts of the Boston district, Mr. Brackett sums up by stating his view as to the allowance per head which should be made in the future, and this he puts at 100 American or 83·3 Canadian gallons.

This is made up as follows :—

For domestic use—35 gallons, although he says that the legitimate demand at present is 30 gallons.

For trade purposes—35 gallons, the quantity in 1892 being

22·60 sold by meter.
7·67 estimated, not measured.
30·27

For public purposes—5 gallons. Under this head is given the following table :—

Public buildings, schools and hospitals	2·30	gallons.
Street sprinkling	1·00	"
Flushing sewers, public urinals	·10	"
Ornamental and drinking fountains	·25	"
Fires	·10	"
Total for public purposes	3·75	"

I must, however, not now dwell further on this point, as I have thought it best to make the comparison between the Gravitation and Pumping schemes on the assumption that the quantity of water to be provided per head shall remain practically as at present. To be quite precise, I intend to take 100 gallons per head per day instead of the 107.7 before mentioned, feeling assured that the progressive reduction in the quantity pumped, shown by Schedule No. 6 in the City Engineer's Report of 1894, will be continued, and that, with very little trouble, the diminution to 100 gallons can be reached and maintained.

I now, therefore, insert Table No. 3 which gives the quantity of water to be provided in each year up to 1948, when it will be seen that it amounts in round figures to 50 million gallons a day.

It will be observed that in the first of these items, 16·6 per cent. is added, in the second 15·62 per cent., and in the third, 33 per cent.

Adding these very liberally rated items together, we get 75 gallons, and to make up his 100. Mr. Brackett deliberately adds 25 gallons *for Waste.*

This is an admission either of bad work in mains and fittings, or inefficient supervision, which I am much surprised to see, and which, with all respect, I may say is hardly creditable to the Waterworks staff.

But let us apply these figures to the case of Toronto.

The 35 gallons domestic, and
5 " public, I will put together

making 40, their equivalent in Canadian gallons being 33·5.

Metered and unmetered trade water in Boston is 35 American, or say 30 Canadian gallons. I have made out that this quantity in Toronto is 14, but that is by adding 25 per cent. for incorrect meter recording which should be reduced considerably, say to 5 per cent., when the sand is kept out of the water, thus bringing the figure *down to 11·5.*

Adding this to the 33·5 we get 45 gallons for all legitimate uses, that is, without waste, and why waste should exceed 5 gallons I cannot conceive. To call it 21 (Canadian) as Mr. Brackett does, is absolutely inexcusable, in the face of the results of English experience in hundreds of towns (where the supply ranges between 20 and 30 gallons for all purposes) where meters are not used for domestic supply, where the water is laid on constantly under pressure, and where there is no stint or restriction whatever on the freest and fullest legitimate use.

I repeat, therefore, that from 45 to 50 gallons ought to suffice for Toronto.

On my way home I visited Philadalphia and was most courteously received by Mr. Trautwine, the recently appointed Engineer-in-Chief of the Water department, who showed me all over his works.

He confirmed what I had previously learned, that the water pumped per head per day amounted to 150 Canadian gallons, but he could give no explanation whatever as to how it was disposed of otherwise than by waste. Mr. Trautwine has a fine opportunity of showing what can be done to remedy this state of things in a city where every drop of water has to be pumped.

In my opinion, unless there is an abnormally high trade user, he should not rest content until he has saved half the pumping charges.

The effecting of this economy would enable the authorities to filter all the water, a treatment which it needs very badly indeed.

TABLE No. 3

QUANTITY OF WATER TO BE PROVIDED.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
	Gallons.		Gallons.		Gallons.
1895......	17,500,000	1913	24,994,300	1931......	35,698,000
1896.....	17,850,000	1914......	25,494,200	1932......	36,412,000
1897......	18,207,000	1915......	26,004,000	1933......	37,140,200
1898......	18,571,200	1916......	26,524,200	1934......	37,883,000
1899.....	18,942,500	1917......	27,054,500	1935......	38,640,600
1900......	19,321,400	1918......	27,595,700	1936......	39,413,400
		1919......	28,147,600	1937......	40,201,800
1901......	19,707,800	1920......	28,710,600	1938......	41,005,800
1902......	20,102,000			1939......	41,825,800
1903......	20,504,000	1921......	29,284,800	1940......	42,662,400
1904	20,914,000	1922	29,870,500		
1905... ..	21,332,400	1923......	30,467,900	1941......	43,515,800
1906...	21,759,100	1924......	31,077,300	1942......	44,386,000
1907......	22,194,200	1925......	31,698,800	1943......	45,273,800
1908......	22,638,100	1926......	32,332,800	1944......	46,179,200
1909......	23,090,800	1927.....	32,979,400	1945......	47,102,800
1910.....	23,552,700	1928......	33,639,000	1946......	48,044,800
		1929	34,311,800	1947......	49,005,700
1911......	24,023,700	1930.....	34,998,000	1948......	49,985,800
1912......	24,504,200				

I am now in a position to commence the description of the two schemes, and to set out an estimate of their cost, and will deal first with the

GRAVITATION SCHEME FROM LAKE SIMCOE.

At the outset I must state that I have found (as was to be expected in a comparatively new country) that the maps and plans procurable were on very small scales and manifestly wanting in accuracy, and that some of them were practically useless, because they had no scale on at all. Further, that none of them showed surface levels or contours from which the areas of watersheds, etc., could be accurately ascertained.

I may say that I was doubtful that this would be the case on making enquiries of map sellers in London, and therefore, in my offer to come out I distinctly stated that such surveys as were necessary should be made under my direction at the cost of the Corporation.

On my arrival, however, I found that at the stage which the water question had then reached, it was clearly inadvisable to spend the time, and to incur the very great expense that would be necessary to obtain all this information; as for present purposes, the existing plans might be made to suffice.

Under these circumstances, all areas and the lengths of tunnels and conduits must be considered as approximate only, whilst being sufficiently near the truth to admit of the schemes being fairly compared.

Lake Simcoe is situated almost due north from Toronto, and its centre is about 53 miles from the shore of the Bay, near the Pumping station.

In the Reports I have seen, its area is given as 300 square miles, but as measured on the four miles to an inch map accompanying the Report of a Committee dated August, 1891, I make it only 260, including the Islands.

Its height above mean sea level is stated to be 720 feet, and that of Lake Ontario 247, so that it has a superior elevation over Ontario of 473 feet.

The area of country draining naturally into the Lake is about 1,100 square miles, the principal streams conveying the water from this area into the Lake being the Holland River, the Black River, and the Talbot, with some others of which I cannot find the names.

For a considerable number of years rain gauges have been kept at Barrie, Orillia, and Georgina Island, and assuming these records to be reliable the rainfall upon the watershed can be arrived at with sufficient accuracy for present purposes.

Taking the 20 years from 1875 to 1894

The Barrie gauge shows an annual mean of.. ..	29.75 ins.
The Orillia	32.98 ins.
The Georgina Island	29.53 ins.
The mean of the three being	30.75 ins.

Taking the average of the three highest yearly records at each gauge. I find

The maximum annual fall to be	38.94 ins.
The minimum annual fall to be	22.10 ins.
And the mean of the three driest consecutive years	27.76 ins.

As these three gauges are at a low level as compared with the average elevation of the whole watershed, probably the 27.76 may fairly be increased to about 29.20 to arrive at the true fall on the average of three dry years. If from this be deducted 14.20 for evaporation and absorption, the collectable rainfall would be 15 inches per annum, which would produce an average daily discharge of 660 gallons.

There might be a small addition to this volume, on account of the rain falling upon the Lake itself, but as the evaporation from the water surface might approach very nearly to the rainfall, it is usual under such conditions to neglect it, and I do so in this case.

In a year of maximum rainfall the average daily discharge from the shed may reach to something between 900 and 1,000 million gallons.

It is manifest from these figures that Lake Simcoe is competent to supply water to Toronto for all time, but I assume that, in all fairness, the water cannot be diverted from its natural outlet by way of the Severn River into Georgian Bay, without the riparian owners having some grounds of claim for such diversion. Probably they could not make out a very strong case of "injuriously affecting," because the quantity to be taken for waterworks purposes would never be more than a small fraction of the natural discharge from the Lake, but this question should not be quite overlooked.

Point of Abstraction.

From my inspection and enquiries in and about the southern end of Simcoe, I am of opinion that the intake or head of an abstracting aqueduct may be located at about one mile and a quarter east of the east end of Snake Island, and three-quarters of a mile or 1,320 yards from the southern shore of the Lake.

The aqueduct in the Lake would be a steel pipe laid in a dredged channel for some distance from the shore, and protected by substantial crib work further out, where laid merely on the bed.

At a very short distance south of the shore line, this pipe would connect in a proper penstock chamber or gate house to the head of a brick and concrete aqueduct having its invert about 700 feet above sea level.

Up to the penstock chamber from the Lake, the work would be constructed in open cutting, but thence forward it would be in tunnel.

The section upon which I have laid down this tunnel was taken along Yonge Street from Toronto to about two miles north of Holland Landing, thence in a north-easterly direction to near Jersey, and then north again to Lake Simcoe. (Appendix D.)

Its exact location at the present moment is a matter of small importance; tunnelling will be necessary, practically, from the Lake side whatever line is adopted; the length might be somewhat shortened by taking a straight course between its two extremities, but this would not necessarily diminish the cost of the work, because it might at the same time reduce the facilities for carriage of materials, the housing of workmen, etc., etc.

It may be as well that I should distinctly state here that in setting out the line, gradient and sectional area of this tunnel, I am providing merely for the supply of 100 gallons a day of water to 500,000 people (or 50 gallons a head for one million), and thus proposing to construct an aqueduct that will deliver 50 million gallons in 24 hours into a service reservoir at a sufficient elevation to supply under adequate pressure, the whole of the City.

I do not intend to be led away into hypothetical discussion of the question of providing power for all sorts of fanciful purposes that may be suggested.

I am of opinion that it is no part of the duty of the Corporation to enter into speculations of this character, and I am quite clear that it is not my business, under the terms of my engagement, to consider any of the power schemes which have been of late so persistently advertised in the City.

I will, however, before closing this Report, state shortly how much power can be obtained by delivering the 50 million gallons of water under a given head, greater than is needful for water works purposes only, and the additional outlay which will be required to make this power available.

Tunnel. The tunnel excavation then, would be got out of such a size as to admit of being lined with a composite structure of concrete and brickwork, having a curved invert, curved and battered sidewalls and a segmental arch, its height being 8 feet 3 inches and its width at springing level 7 feet.

Its gradient would be 1 in 4,000, and its discharging capacity up to springing 5,660 cubic feet per minute, or nearly 51 million gallons per day.

As set out on the section, the length of this tunnel would be 33 miles, its outlet end being situated about a mile and a half south of Richmond Hill, and I have shown upon it 18 shafts, so that with the two ends it could be worked from 38 faces giving an average of 1,544 yards of driving from each face.

(This tunnel would be about a mile longer than that recently constructed at New York to augment in connection with a very large new reservoir now in hand, the supply of water to that city from the Croton Valley.)

The invert level of the tunnel at the low end would be 655.40.

At this point the ground falls away to the south, and a length of 5,000 yards of iron pipes would have to be put in to cross the valley. To convey the whole 50,000,000 gallons with a fall of 1 in 356, four 32-inch pipes would be needed, but at the outset, only two of these would require to be laid, as they would together discharge 7,000,000 gallons a day more than is at present used, and at the contemplated rate of growth a third pipe would not be necessary until 1913.

At the end of this first syphon higher ground is again reached, and a length of 3,000 yards of "Cut and Cover" conduit of the same cross-section, gradient and construction, as the tunnel may be erected (competent, of course to deliver the 50,000,000 gallons) at a little over the cost of the two 32-inch pipes.

Then would begin the second syphon 7,600 yards in length of two 32-inch pipes, terminating in a new service reservoir to be located near Eglington, having its top water at 547 feet above sea level or 300 feet above Lake Ontario.

COST OF GRAVITATION SCHEME.

I have made an estimate of the cost of, these works, which does not however, represent the whole outlay that would have to be incurred, because for obvious reasons I have not included in it the following items, viz.:—

1st. The purchase of the easement along the line of tunnel, cut and cover and pipes; land for the gate house, shafts, caretakers' houses and Eglington Reservoir; and for the deposit of the material excavated from the tunnel and trenches.

2nd. The compensation which might become due to the riparian owners upon the River Severn on account of the diversion of some of the water from that river into Toronto and ultimately into Lake Ontario.

I cannot, of course, say that any claim would be made on this account, but it certainly would in England.

Estimate of Cost of the Gravitation Scheme from Lake Simcoe.

Description of Work.	$	$
Intake.		
6-ft. steel pipe, 1,320 lin. yds.	198,000	
Valve chamber, penstocks, screening apparatus, &c., and keeper's house	17,500	
		215,500
Tunnel.		
58,667 lin. yds. of tunnel	7,110,395	
Shafts on ditto	182,760	
		7,293,155
First Cut and Cover.		
800 lin. yds.		86,750
First Syphon.		
4 lines of 32-in. pipes, each 5,000 lin. yds	650,000	
River crossings	25,000	
Inlet and Outlet Chambers	5,000	
		680,000
Second Cut and Cover.		
3,000 lin. yds.		292,080
Second Syphon.		
4 lines of 32-in. pipes, each 7,600 lin. yds	988,000 yds.	
River crossings	25,000	
Inlet chamber	2,500	
Outlet to reservoir	5,000	
		1,020,500
High Service Reservoir, to hold 100 million gallons . ..		500,000
Provide for 6 houses		12,000
Mains to connect High Service Reservoir with Rose Hill and distributing system in lower part of City .		335,000
		$ 10,434,985
Contingencies, engineering and supervision, 15 per cent., say		1,565,015
Total . . .		$ 12,000,000

In order to compare clearly the burden which the carrying out of this gravitation scheme and the spending of this sum of twelve million dollars would put upon the ratepayers with that imposed by a continuance of the existing system of pumping from Lake Ontario, it will manifestly be necessary to calculate the amount of the total annual charge which the spending of the capital will involve by adding together the interest, the sinking fund, and the working expenses in each case.

From Mr. Coady, the Treasurer,I have learned that the City can borrow money for public works at 3½ per cent. per annum, with the obligation to set aside a sinking fund invested at 3 per cent., competent to pay off the capital in 40 years, and that these two items)including the cost of investment) may be taken for my purpose at 5 per cent. per annum.

If this gravitation scheme were at once adopted it would, of course, take some time to prepare plans, acquire lands, and enter into contracts, but, if we assume that the works were fairly started at the beginning of 1897, all these preliminaries, with the getting together of plant, the erection of huts, shops and stores, etc., etc., would, I believe, entail the expending of something like a million dollars in 1896.

The entire completion of the intake works, the tunnel, and the first pair of iron pipes in the two syphons shown on the section, the "cut and cover" and the Eglington reservoir, could not, in my opinion, be ensured before the end of 1900, the rate of expenditure in each year being as follows:—

In 1896	$1,000,000
In 1897	1,500,000
In 1898	2,500,000
In 1899	3,000,000
In 1900	3,058,150
In 1912	470,925
In 1932	470,925

and the setting aside of the sinking fund commencing as soon as any interest is due.

I am not sure that this is the case, but it will simplify the calculations to assume that it is, and if I am not quite right, your own Accountant will be able quite readily to amend the figures.

The following Table, No. 4, speaks for itself, and shows in the last column, No. 5, the charge which it will involve year by year up to 1948.

TORONTO WATER—GRAVITATION.

Year.	Capital Expenditure during the year.	Interest and Redemption 5 per cent.	Annual Working Expenses.	Total Annual Charge. — Sum of Columns 3 and 4.
1	2	3	4	5
	$	$	$	$
1895	....	....	....	....
1896	1,000,000	25,000	64,449	89,449
1897	1,500,000	87,500	65,786	153,286
1898	2,500,000	187,500	67,196	254,696
1899	3,000,000	325,000	68,642	393,642
1900	3,058,150	476,454	70,116	546,570
1901	....	552,908	5,000	557,908
1902	....	552,908	5,000	557,908
1903	....	552,908	5,000	557,908
1904	....	552,908	5,000	557,908
1905	....	552,908	5,000	557,908
1906	....	552,908	5,000	557,908
1907	....	552,908	5,000	557,908
1908	....	552,908	5,000	557,908
1909	....	552,908	5,000	557,908
1910	....	552,908	5,000	557,908
1911	....	552,908	5,000	557,908
1912	470,925	564,681	5,500	570,181
1913	....	576,454	5,500	581,954
1914	....	576,454	5,500	581,954
1915	....	576,454	5,500	581,954
1916	....	576,454	5,500	581,954
1917	....	576,454	5,500	581,954
1918	....	576,454	5,500	581,954
1919	....	576,454	5,500	581,954
1920	....	576,454	5,500	581,954
1921	....	576,454	5,500	581,954
1922	....	576,454	5,500	581,954
1923	....	576,454	5,500	581,954
1924	....	575,454	5,500	581,954
1925	....	576,454	5,500	581,954
1926	....	576,454	5,500	581,954
1927	....	576,454	5,500	581,954
1928	....	576,454	5,500	581,954
1929	....	576,454	5,500	581,954
1930	....	576,451	5,500	581,954
1931	....	576,454	5,500	581,954
1932	470,925	588,227	6,000	594,227
1933	....	600,000	6,000	606,000
1934	....	600,000	6,000	606,000
1935	....	600,000	6,000	606,000

GRAVITATION—*Continued.*

Year.	Capital Expenditure during the year.	Interest and Redemption 5 per cent.	Annual Working Expenses.	Total Annual Charge. — Sum of Columns 3 and 4.
1	2	3	4	5
	$	$	$	$
1936	....	575,000	6,000	581,000
1937	....	512,500	6,000	518,500
1938	....	412,500	6,000	418,500
1939	....	275,000	6,000	281,000
1940	....	123,546	6,000	129,546
1941	....	47,092	6,000	53,092
1942	....	47,092	6,000	53,092
1943	....	47,092	6,000	53,092
1944	....	47,092	6,090	53,092
1945	....	47,092	6,000	53,092
1946	....	47,092	6,000	53,092
1947	....	47,092	6,000	53,092
1948	....	47,092	6,000	53,092

I have not included in the annual charges anything for the rates and taxes which I assume would be levied upon the Corporation by the various parishes through which the aqueduct would pass. At home this is a very serious item of annual expense, and is year by year becoming more onerous.

If the works are carried out in a sound and substantial manner, the cost of their maintenance and upkeep after completion should be a very small annual sum.

Two men would be required at Lake Simcoe and the gate house at the head of the tunnel, and four or five more along the line and at its termination in the service reservoir, and these should all occupy houses adjoining tunnel shafts, fitted with telephones, so that ready communication would be possible from the gate house at Lake Simcoe, throughout the line, to Eglinton reservoir, and on to the City Engineer's Office.

I have inserted in the Table such sums as I think would cover the wages, repairs, and incidental charges during the term dealt with.

By the Table it will be seen that the charges commence in 1896 with a sum of $89,449, and go on increasing up to 1935, when they would amount to $606,000. After that they drop in six years to $53,092, because the large capital outlay at the outset would be paid off.

After the smaller amount had similarly come to an end by the operation of the sinking fund in 1973 the only charge would be the $6,000 for the men engaged on the aqueduct, if at that date the whole of the works are still in satisfactory order, and if the City has not grown so as to require extensions. Upon this point I will speak later on.

PUMPING SCHEME—LAKE ONTARIO.

In making provision for the ultimate supply of fifty million gallons a day from this source, an essential difference is apparent in the period over which the expenditure of Capital can be spread from that which would be necessary—and has been described—in the case of the gravitation works bringing water from Lake Simcoe.

In the latter it is manifest that the only possible course would be to construct a tunnel capable of bringing the full quantity at *one operation*; it could not be done by instalments, and therefore the major part of the great outlay of twelve million dollars must necessarily be incurred within a limited time and at the very outset.

This would entail a very heavy burden in the payment of interest, and in the accumulation of a sinking fund, during forty years, that is, in the lifetime of a single generation.

On the other hand although a good round sum would have to be spent within the next few years in order to put the pumping scheme into a condition fairly comparable with the gravitation, yet the bulk of the capital required to provide the fifty million gallons a day can be spread over 49 years instead of 5, and the total amount to be spent on works would not be more than 47½ per cent. of the twelve millions required for the alternative.

Although there is this very large difference in Capital cost, it is, however, not all to the good, for as everybody knows the carrying on of the pumping operations will entail a very heavy annual charge.

In order to make clear the exact difference I have prepared the following Tables, Nos. 5a and 5b, which show how and when Capital would have to be spent, what it would cost in interest and sinking fund, and what would be the working expenses year by year to meet the growing demand of the community.

In a small Table apart, No. 6, I have shown in parallel columns just the respective amounts which would have to be paid for the water in each year for a period of 53 years, the total of the gravitation column being $23,967,447, and of the pumping column $15,383,406, a difference in favour of the latter of $8,584,041.

Another advantage of the pumping scheme would be that after the initial expenditure has been incurred, further money need not be spent until it is actually required by the growth of the population.

If, for instance, the rate of increase for the next ten years should be, as in the past five years, only one-fifth per cent. per annum, instead of the two per cent. assumed in the Tables, it is clear that a new pumping station and machinery would not have to be erected in 1901, and that the working expenses would be very much less.

On the other hand, once the money has been spent on the gravitation scheme, the interest, etc., must be paid, and if this payment were to fall on a population numbering few more than the present, the burden would obviously be an intolerable one.

To set against all this, it will no doubt be argued that if the present generation are willing to accept this burden, their successors would come in for a legacy of enormous value, because the whole water supply of the City would be obtained at a mere nominal annual sum, after the capital was paid off.

No doubt this would be the case, if, after growing up to half a million, the City were suddenly to stop its march of progress; but if, on the contrary, it were to continue to increase, capital would again have to be spent, just as at the commencement of the first fifty years, and an additional and similar burden of interest and sinking fund would be again accumulated.

This must be clearly realised, or a total misapprehension of the position will be created.

The same thing is going on in every growing City at home; just when the water account is beginning to show a favourable balance, then further capital expenditure must be faced.

In order to put this matter clearly I have prepared a Diagram Appendix F, in which the respective annual charges for the gravitation and pumping schemes are graphically shown up to 1975, on the basis of a duplication of the original gravitation works when this becomes necessary, and an extension of the pumping works to meet a continuing demand at 2 per cent. increase per annum.*

*Of course it must be understood that in all the following estimates I am not including any existing debts, or the cost of administration, or of distributing works which would be common to the two schemes.

TABLE No. 5A

TORONTO WATER—PUMPING.

Details of Capital Expenditure.

Description of Work.	1896.	1897.	1901.	1906.	1916.	1922.	1925.	1932.	1936.	1939.	1944.	Totals.
	$	$	$	$	$	$	$	$	$	$	$	$
E. Keating's scheme, tunnel under bay and pipe across Island	200,000	286,000	....	....	...	....	....	....	....	....	....	486,000
Subsiding reservoir	50,000	60,000	....	....	...	....	....	....	....	....	....	110,000
Filter beds	460,000	500,000	....	182,500	182,500	....	182,500	182,500	....	182,500	182,500	2,055,000
Pumping plant to filters	....	50,000	....	10,000	10,000	....	10,000	10,000	....	10,000	10,000	110,000
Tramway across Island	....	15,000	....	....	....	....	....	...	....	....	....	15,000
New Pumping Station and high duty pumping engines	....	...	155,000	....	....	140,000	....	....	155,000	....	....	450,000
Eglinton reservoir	100,000	150,000	....	....	....	....	....	....	....	....	....	250,000
New Mains.												
(Appendix E.)												
36-ins. main from Bathurst and College to Rose Hill reservoirs	135,500	....	....	.. .	....	....	....	...	....	....	....	135,500
36-ins. main Eglinton reservoir to Rose Hill reservoir	....	89,250	....	....	...	....	....	....	....	....	....	89,250
20-ins. main from new 36-ins. main laid in 1896, to high level pumping station	....	27,000	....	....	....	....	....	....	...	....	....	27,000
24-ins. rising main high level pumping station to Eglinton reservoir	...	108,000	....	....	....	....	....	....	....	....	....	108,000
24-ins. main Eglinton reservoir to high level district.	....	108,000	.. .	....	....	....	....	....	...	...	....	108,000
36-ins. main from pumping station to Rose Hill reservoir	....	.. .	170,000	.. .	....	340,000	....	....	170,000	....	....	680,000
24-ins. main Rose Hill to Eglinton	....	. ..	80,000	....	....	160,000	....	....	80,000	....	....	320,000
	945,500	1,393,250	405,000	192,500	192,500	640,000	192,500	192,500	405,000	192,500	192,500	4,943,750
Contingencies, engineering and supervision, 15 per cent.	141,825	208,987	60,750	28,875	28,875	96,000	28,875	28,875	60,750	28,875	28,875	741,562
Totals	1,087,325	1,602,237	465,750	221,375	221,375	736,000	221,375	221,375	465,750	221,375	221,375	5,685,312

Wages.	
15	
$	
.....	
24,000	
24,480	
24,970	
25,467	
25,978	
26,498	
27,029	
27,569	
28,121	
28,682	
29,256	
29,842	
30,437	
31,046	
31,668	
2,302	
2,947	
3,605	
4,277	
4,963	
5,662	
6,377	
7,104	
7,846	
8,602	
9,374	
0,162	
0,966	
1,784	
2,619	
3,474	
4,342	
5,228	
6,133	
7,057	
7,976	
8,958	1
9,937	1
0,935	1
1,953	1
2,992	1
4,053	1
5,133	1
6,237	1
7,362	1
8,510	1
9,678	1
0,871	1
2,090	1
3,311	1
4,598	1
5,890	1
7,207	14

Wages.	Total cost of pumping at Main Station. — Sum of Columns 12, 13, 14 and 15.	Total cost of pumping at High Level Stations.	Total cost of pumping and filtering on Island.	Total annual working expenses, Main and High Level Pumping Stations and filtration — Sum of Columns 16, 17 and 18.	Capital expenditure during the year.	Interest and Redemption 5 per cent.	Total annual charges. — Sum of Columns 19 and 21.
15	16	17	18	19	20	21	22
$	$	$	$	$	$	$	$
......	......	......	......	......	......	......	......
24,000	54,449	10,000	7,500	71,949	1,087,325	27,183	99,132
24,480	55,586	10,200	7,650	73,436	1,602,237	94,422	167,858
24,970	56,792	10,404	7,803	74,999	......	134,478	209,477
25,467	58,030	10,612	7,959	76,601	......	134,478	211,079
25,978	59,292	10,824	8,118	78,234	......	134,478	212,712
26,498	60,586	11,041	8,280	79,907	465,750	146,122	226,029
27,029	56,854	11,262	8,446	76,562	......	157,766	234,328
27,569	58,300	11,487	8,615	78,402	......	157,766	236,168
28,121	59,830	11,717	8,787	80,334	......	157,766	238,100
28,682	61,266	11,951	8,963	82,180	......	157,766	239,946
29,256	62,798	12,190	9,142	84,130	221,375	163,300	247,430
29,842	64,355	12,434	9,325	86,114	......	168,834	254,948
30,437	66,019	12,682	9,511	88,212	......	168,834	257,046
31,046	67,572	12,936	9,701	90,209	......	168,834	259,043
31,668	69,226	13,195	9,895	92,316	......	168,834	261,150
2,302	76,917	13,459	10,093	94,469	......	168,834	263,303
2,947	72,715	13,728	10,295	96,738	......	168,834	265,572
3,605	74,392	14,002	10,500	98,894	......	168,834	267,728
4,277	76,179	14,282	10,710	101,171	...	168,834	270,005
4,963	78,094	14,568	10,924	103,496	......	168,834	272,330
5,662	79,958	14,859	11,142	105,959	221,375	174,369	280,328
6,377	81,774	15,157	11,365	108,296	......	179,903	288,199
7,104	83,715	15,460	11,592	110,767	......	179,903	290,670
7,846	85,693	15,769	11,824	113,286	.....	179,903	293,189
8,602	87,801	16,084	12,060	115,945	......	179,903	295,848
9,374	89,758	16,406	12,301	118,465	......	179,903	298,368
0,162	91,871	16,734	12,547	121,152	736,000	198,303	319,455
0,966	86,059	17,069	12,798	115,926	......	216,703	332,629
1,784	87,876	17,410	13,054	118,340	......	216,703	335,043
2,619	89,534	17,758	13,315	120,607	221,375	222,237	342,844
3,474	91,325	18,114	13,581	123,020	....	227,772	350,792
4,342	93,150	18,476	13,853	125,479	......	227,772	353,251
5,228	95,119	18,845	14,130	128,094	.....	227,772	355,866
6,133	96,917	19,222	14,413	130,552	....	227,772	358,324
7,057	98,855	19,607	14,701	133,163	......	227,772	360,935
7,976	100,812	19,999	14,995	135,806	......	227,772	363,578
8,958	102,961	20,399	15,295	138,655	221,375	233,306	371,961
9,937	104,905	20,807	15,601	141,313	.....	238,841	380,154
9,935	107,010	21,223	15,913	144,146	......	238,841	382,987
1,953	109,144	21,647	16,231	147,022	......	238,841	385,863
2,992	111,447	22,080	16,556	150,083	465,750	223,302	373,385
4,053	113,555	22,522	16,887	152,964	......	167,707	320,671
5,133	115,822	22,972	17,225	156,019	.....	127,651	283,670
6,237	118,139	23,432	17,570	159,141	221,375	133,185	292,326
7,362	120,636	23,901	17,921	162,458	......	138,720	301,178
,510	122,916	24,379	18,279	165,574	......	127,076	292,650
,678	125,371	24,866	18,645	168,882	......	115,432	284,314
,871	127,877	25,363	19,018	172,258	......	115,432	287,690
,090	130,580	25,871	19,398	175,849	221,375	120,966	296,815
,211	132,927	26,388	19,786	179,101	.....	126,500	305,601
,398	135,704	26,916	20,182	182,802	......	120,966	303,768
,890	138,419	27,454	20,587	186,460	.....	115,432	301,892
,807	141,343	28,003	21,800	190,346	.....	115,432	305,778

TABLE No. 5 B.

TORONTO WATER

Year.	Population.	Daily demand for water at 100 gallons per head.	MAIN PUMPING STATION. Quantity pumped during the year.	Quantity pumped by High-duty Engines.	Quantity pumped by Low-duty Engines.	Tons of Coal used per annum by High-duty Engines at 1·2 tons per million gallons pumped.	Cost of Coal for High-duty Engines at $2 50-100 per ton.	Tons of Coal used per annum by Low-duty Engines at 2 tons per million gallons pumped.	Cost of Coal for Low-duty Engines at $4.00 per ton.	Cost of carting Coal at 8 cents per ton.
1	2	3	4	5	6	7	8	9	10	11
		Impl. gallons.	Impl. gallons.	Impl. gallons.	Impl. gallons.		$		$	$
1895	175,000	17,500,000	.....	.....	.....	......	......	......	......	......
1896	178,500	17,850,000	6,533,100,000	5,748,100,000	785,000,000	6,898	17,245	1,570	6,280	677
1897	182,070	18,207,000	6,645,555,000	5,824,855,000	820,700,000	6,990	17,475	1,642	6,568	690
1898	185,712	18,571,200	6,778,488,000	5,921,368,000	857,120,000	7,105	17,762	1,714	6,856	705
1899	189,425	18,942,500	6,914,012,500	6,019,762,500	894,250,000	7,224	18,060	1,788	7,152	721
1900	193,214	19,321,400	7,052,311,000	6,120,171,000	932,140,000	7,344	18,360	1,864	7,456	736
1901	197,078	19,707,800	7,193,347,000	6,222,567,000	970,780,000	7,468	18,670	1,942	7,768	752
1902	201,020	20,102,000	7,337,230,000	7,321,930,000	15,300,000	8,786	21,965	30	120	705
1903	205,040	20,504,000	7,483,960,[illegible]	[illegible]8,360,000	75,600,000	8,890	22,225	152	608	723
1904	209,140	20,914,000	7,654,524,[illegible]	7,[illegible]17,424,000	137,100,000	9,020	22,550	274	1,096	744
1905	213,324	21,332,400	7,786,326,000	7,586,466,000	199,860,000	9,103	22,758	400	1,600	760
1906	217,591	21,759,100	7,942,071,500	7,678,206,500	263,865,000	9,214	23,035	528	2,112	779
1907	221,942	22,194,200	8,100,883,000	7,771,753,000	329,130,000	9,326	23,315	658	2,632	798
1908	226,381	22,638,100	8,285,544,600	7,889,829,600	395,715,000	9,468	23,670	792	3,168	821
1909	230,908	23,090,800	8,428,142,000	7,964,522,000	463,620,000	9,558	23,895	928	3,712	838
1910	235,527	23,552,700	8,596,735,500	8,063,[illegible],500	532,905,000	9,677	24,192	1,066	4,264	859
1911	240,237	24,023,700	8,768,650,500	8,16[illegible]	603,555,000	9,798	24,495	1,208	4,832	880
1912	245,042	24,504,200	8,968,537,200	8,292,[illegible]	675,630,000	9,952	24,880	1,352	5,408	904
1913	249,943	24,994,300	9,122,919,500	8,[illegible]3,774,[illegible]	749,145,000	10,049	25,122	1,498	5,992	924
1914	254,942	25,494,200	9,305,383,000	8,481,253,000	[illegible]4,130,000	10,177	25,442	1,648	6,592	946
1915	260,040	26,004,000	9,491,4[illegible],000	8,[illegible]0,[illegible]0,000	[illegible]900,000	10,309	25,772	1,800	7,200	968
1916	265,242	26,524,200	9,707,857,[illegible]	8,7[illegible],2[illegible]200	[illegible],000	10,475	26,187	1,958	7,832	994
1917	270,545	27,054,500	9,874,892,500	8,816,71[illegible]	[illegible]	10,580	26,450	2,116	8,464	1,015
1918	275,957	27,595,700	10,072,430,500	8,933,075,500	1,139,[illegible]	10,720	26,800	2,278	9,112	1,040
1919	281,476	28,147,600	10,273,874,000	9,051,734,000	1,222,140,000	10,862	27,155	2,444	9,776	1,064
1920	287,106	28,710,600	10,508,079,600	9,201,489,600	1,306,590,000	11,041	27,602	2,614	10,456	1,092
1921	292,848	29,284,800	10,6[illegible]8,952,000	9,296,232,000	1,392,720,000	11,155	27,888	2,783	11,132	1,115
1922	298,705	29,870,500	10,902,732,500	9,422,157,500	1,480,575,000	11,306	28,265	2,962	11,848	1,141
1923	304,679	30,467,900	11,120,783,500	......	......	13,345	33,362	......	......	1,067
1924	310,773	31,077,300	11,374,291,800	......	.....	13,649	34,123	......	......	1,092
1925	316,988	31,698,800	11,570,062,000	......	.....	13,884	34,710	.....	......	1,110
1926	323,328	32,332,800	11,801,472,000	......	......	14,161	35,402	......	......	1,133
1927	329,794	32,979,400	12,037,481,000	......	.....	14,444	36,110	......	......	1,155
1928	336,390	33,639,000	12,311,874,000	......	......	14,774	36,935	.. ..	......	1,182
1929	343,118	34,311,800	12,523,807,000	.....	......	15,029	37,573	......	......	1,202
1930	349,980	34,998,000	12,774,270,000	.....	......	15,329	38,323	......	......	1,226
1931	356,980	35,698,000	13,029,770,000	......	... .	15,636	39,090	......	......	1,251
1932	364,120	36,412,000	13,326,792,000	.....	......	15,992	39,980	......	......	1,279
1933	371,402	37,140,200	13,556,173,000	......	......	16,267	40,668	.....	......	1,301
1934	378,830	37,883,000	13,827,295,000	......	......	16,595	41,488	.....	......	1,328
1935	386,406	38,640,600	14,103,819,000	......	.. ...	16,925	42,313	......	......	1,354
1936	394,134	39,413,400	14,425,304,400	......	.....	17,310	43,275	....	......	1,385
1937	402,018	40,201,800	14,673,657,000	.....	.....	17,609	44,023	......	......	1,409
1938	410,058	41,005,800	14,967,117,000	......	......	17,960	44,900	......	......	1,437
1939	418,258	41,825,800	15,266,417,000	......	.....	18,319	45,798	......	......	1,465
1940	426,624	42,662,400	15,614,438,400	......	.....	18,737	46,843	......	......	1,499
1941	435,158	43,515,800	15,883,267,000	....	......	19,060	47,650	......	......	1,525
1942	443,860	44,386,000	16,200,890,000	...	......	19,441	48,603	......	......	1,555
1943	452,738	45,273,800	16,524,937,000	.....	......	19,830	49,575	......	......	1,586
1944	461,792	46,179,200	16,901,587,200	......	......	20,282	50,705	......	......	1,622
1945	471,028	47,102,800	17,192,522,000	......	......	20,632	51,580	......	......	1,650
1946	480,448	48,044,800	17,536,352,000	......	......	21,043	52,608	......	......	1,683
1947	490,057	49,005,700	17,887,080,500	.. ...	......	21,464	53,660	......	......	1,717
1948	499,858	49,985,800	18,294,802,800	......	......	21,954	54,885	... ..	......	1,756

ATION.

oal an- ow- ies per l- ed.	Cost of Coal for Low-duty Engines at $4.00 per ton.	Cost of carting Coal at 8 cents per ton.	Total cost of Coal per annum. — Sum of Columns 8, 10 and 11.	Cost of lubricants, waste, packing, general supplies, gas, insurance, etc., etc. at $225 per annum per million gallons a day pumped.	Cost of repairs to engines, etc., at $125 per annum per million gallons a day pumped.	Wages.	Total cost of pumping at Main Station. — Sum of Columns 12, 13, 14 and 15.	Total cost of pumping at High Level Stations.	Total cost of pumping and filtering on Island.	Total annual working expenses, Main and High Level Pumping Stations and filtration — Sum of Columns 16, 17 and 18.	Capital expenditure during the year.	Interest and Redemption 5 per cent.	Total annual charges. — Sum of Columns 19 and 21.
	10	11	12	13	14	15	16	17	18	19	20	21	22
	$	$	$	$	$	$	$	$	$	$	$	$	$
	......	......	......	......	......	......	......	......	......	......	......	......	......
	6,280	677	24,202	4,016	2,231	24,000	54,449	10,060	7,500	71,949	1,087,325	27,183	99,132
	6,568	690	24,733	4,097	2,276	24,480	55,586	10,200	7,650	73,436	1,602,237	94,422	167,858
	6,856	705	25,323	4,178	2,321	24,970	56,792	10,404	7,803	74,999	......	134,478	209,477
	7,152	721	25,933	4,262	2,368	25,467	58,030	10,612	7,959	76,601	......	134,478	211,079
	7,456	736	26,552	4,347	2,415	25,978	59,292	10,824	8,118	78,234	......	134,478	212,712
	7,768	752	27,190	4,434	2,464	26,498	60,586	11,041	8,280	79,907	465,750	146,122	226,029
	120	705	22,790	4,523	2,512	27,029	56,854	11,262	8,446	76,562	......	157,766	234,328
	608	723	23,556	4,613	2,562	27,569	58,300	11,487	8,615	78,402	......	157,766	236,168
	1,096	744	24,390	4,705	2,614	28,121	59,830	11,717	8,787	80,334	......	157,766	238,100
	1,600	760	25,118	4,800	2,666	28,682	61,266	11,951	8,963	82,180	......	157,766	239,946
	2,112	779	25,926	4,896	2,720	29,256	62,798	12,190	9,142	84,130	221,375	163,300	247,430
	2,632	798	26,745	4,994	2,774	29,842	64,355	12,434	9,325	86,114	......	168,834	254,948
	3,168	821	27,659	5,093	2,830	30,437	66,019	12,682	9,511	88,212	......	168,834	257,046
	3,712	838	28,445	5,195	2,886	31,046	67,572	12,936	9,701	90,209	......	168,834	259,043
	4,264	859	29,315	5,299	2,944	31,668	69,226	13,195	9,895	92,316	......	168,834	261,150
	4,832	880	30,207	5,405	3,003	32,302	70,917	13,459	10,093	94,469	......	168,834	263,303
	5,408	904	31,192	5,513	3,063	32,947	72,715	13,728	10,295	96,738	......	168,834	265,572
	5,992	924	32,038	5,625	3,124	33,605	74,392	14,002	10,500	98,894	......	168,834	267,728
	6,592	946	32,980	5,736	3,186	34,277	76,179	14,282	10,710	101,171	...	168,834	270,005
	7,200	968	33,940	5,851	3,250	34,963	78,004	14,568	10,924	103,496	......	168,834	272,330
	7,832	994	35,013	5,968	3,315	35,662	79,958	14,859	11,142	105,959	221,375	174,369	280,328
	8,464	1,015	35,929	6,087	3,381	36,377	81,774	15,157	11,365	108,296	......	179,903	288,199
	9,112	1,040	36,952	6,209	3,450	[illegible],104	83,715	15,460	11,592	110,767	......	179,903	290,670
	9,776	1,064	37,995	6,333	3,519	37,846	85,693	15,769	11,824	113,286	.....	179,903	293,189
	10,456	1,092	39,150	6,460	3,589	38,602	87,801	16,084	12,060	115,945	......	179,903	295,848
	11,132	1,115	40,135	6,589	3,660	39,374	89,758	16,406	12,301	118,465	......	179,903	298,368
	11,848	1,141	41,254	6,721	3,734	40,162	91,871	16,734	12,547	121,152	736,000	198,303	319,455
	......	1,067	34,429	6,855	3,809	40,966	86,059	17,069	12,798	115,926	......	216,703	332,629
	......	1,092	35,215	6,992	3,885	41,784	87,876	17,410	13,054	118,340	......	216,703	335,043
	......	1,110	35,820	7,132	3,963	42,619	89,534	17,758	13,315	120,607	221,375	222,237	342,844
	......	1,133	36,535	7,275	4,041	43,474	91,325	18,114	13,581	123,020	....	227,772	350,792
	......	1,155	37,265	7,420	4,123	44,342	93,150	18,476	13,853	125,479	......	227,772	353,251
	......	1,182	38,117	7,569	4,205	45,228	95,119	18,845	14,130	128,094	....	227,772	355,866
	......	1,202	38,775	7,720	4,289	46,133	96,917	19,222	14,413	130,552	....	227,772	358,324
	......	1,226	39,549	7,874	4,375	47,057	98,855	19,607	14,701	133,163	......	227,772	360,935
	......	1,251	40,341	8,032	4,463	47,976	100,812	19,999	14,995	135,806	......	227,772	363,578
	......	1,279	41,259	8,193	4,551	48,958	102,961	20,399	15,295	138,655	221,375	233,306	371,961
	......	1,301	41,969	8,356	4,643	49,937	104,905	20,807	15,601	141,313	....	238,841	380,154
	......	1,328	42,816	8,524	4,735	50,935	107,010	21,223	15,913	144,146	......	238,841	382,987
	......	1,354	43,667	8,694	4,830	51,953	109,144	21,647	16,231	147,022	......	238,841	385,863
	......	1,385	44,660	8,869	4,926	52,992	111,447	22,080	16,556	150,083	465,750	223,302	373,385
	......	1,409	45,432	9,045	5,025	54,053	113,555	22,522	16,887	152,964	......	167,707	320,671
	......	1,437	46,337	9,226	5,126	55,133	115,822	22,972	17,225	156,019	....	127,651	283,670
	......	1,465	47,263	9,410	5,229	56,237	118,139	23,432	17,570	159,141	221,375	133,185	292,326
	......	1,499	48,342	9,599	5,333	57,362	120,636	23,901	17,921	162,458	......	138,720	301,178
	......	1,525	49,175	9,791	5,440	58,510	122,916	24,379	18,279	165,574	......	127,076	292,650
	......	1,555	50,158	9,986	5,549	59,678	125,371	24,866	18,645	168,882	......	115,432	284,314
	......	1,586	51,161	10,186	5,659	60,871	127,877	25,363	19,018	172,258	......	115,432	287,690
	......	1,622	52,327	10,390	5,773	62,090	130,580	25,871	19,398	175,849	221,375	120,966	296,815
	......	1,650	53,230	10,598	5,888	63,211	132,927	26,388	19,786	179,101	.....	126,500	305,601
	......	1,683	54,291	10,810	6,005	64,598	135,704	26,916	20,182	182,802	......	120,966	303,768
	......	1,717	55,377	11,026	6,126	65,890	138,419	27,454	20,587	186,460	......	115,432	301,892
	......	1,756	56,641	11,247	6,248	67,207	141,343	28,003	21,800	190,346	.....	115,432	305,778

TABLE No. 6.

Toronto Water.—Yearly Charges of Gravitation and Pumping Schemes Compared.

Year.	Gravitation.	Pumping.	Year.	Gravitation.	Pumping.
1895	....	....	1922	581,954	319,455
1896	89,449	99,132	1923	581,954	332,629
1897	153,286	167,858	1924	581,954	335,043
1898	254,696	209,477	1925	581,954	342.844
1899	393,642	211,079	1926	581,954	350,792
1900	546.570	212,712	1927	581,954	353,251
			1928	581,954	355,866
1901	557,908	229.029	1929	581,954	358,324
1902	557,908	234,328	1930	581,954	360,935
1903	557,908	236,168			
1904	557,908	238,100	1931	581,954	363,578
1905	557,908	239,946	1932	594,227	371.961
1906	557,908	247,430	1933	606,000	380,154
1907	557,908	254.948	1934	606,000	382,987
1908	557,908	257,046	1935	606,000	385,863
1909	557,908	259,043	1936	581,000	373,385
1910	557,908	261,150	1937	518,500	320,671
			1938	418,500	283,670
1911	557,908	263,303	1939	281,000	292.326
1912	570,181	265,572	1940	129,546	301,178
1913	581,954	267,728			
1914	581,954	270,005	1941	53,092	292,650
1915	581,954	272,330	1942	53,092	284,314
1916	581.954	280,328	1943	53,092	287,690
1917	581,954	288,199	1944	53,092	296,815
1918	581,954	290,670	1945	53,092	305,601
1919	581,954	293,189	1946	53,092	303,768
1920	581,954	295,848	1947	53,092	301.892
			1948	53,092	305,778
1921	581,954	298 368	Total.........	23,967,447	15,383,406

Total water supply from 1896-1948 = 605,144 million gallons.
Total cost, gravitation $23,967,447 = 3·96 cents. per 1,000 gallons.
Total cost, pumping $15,383,406 = 2·54 " " "

RECOMMENDATION.

I think there is no necessity to labour the matter further.

I have no difficulty myself in advising you which scheme to adopt. My natural inclination and predilection would be in favour of the Simcoe Scheme; but under the special circumstances of the case I RECOMMEND YOU TO ADHERE TO YOUR PRESENT SOURCE.

As I have already said, the considerations that impress me very strongly are the following:—

1st. No one can predict with any certainty what the future of Toronto is going to be; it may never grow beyond two hundred thousand inhabitants.

2nd. The Simcoe Scheme should not be designed and carried out on less broad lines than I have set out; it would never do to construct a tunnel over 30 miles long with a smaller carrying capacity than 50,000,000 gallons a-day, for it would be such a terrible business to have to make another alongside in a few years' time if the City were to increase faster than has been estimated.

3rd. But to do this work involves a very heavy expenditure *all at once*, which would saddle the Toronto of to-day with a burden it ought not lightly to be called upon to bear.

4th. On the other hand, the Pumping Scheme can be proceeded with tentatively, and extensions be made just as and when they are needed.

5th. Further, if the Gravitation Scheme is executed, and 50,000,000 gallons a day be brought to the City, there will be no inducement to diminish the extravagant waste which must now be going on.

6th. But if you continue to pump I am satisfied that by adopting the proper methods the quantity of water to be supplied may be reduced 40 to 50 per cent. with a corresponding reduction in pumping expenses, and a long postponement of the spending of capital on new stations and machinery.

7th. The gravitation scheme will certainly involve the construction at the outset of the hundred million gallons reservoir at Eglinton, because it is the only way of avoiding using "riley"* water, but it will not be necessary to make the 12 acres of filters in connection with the pumping immediately, but will suffice to build the subsiding reservoir, and, perhaps one-third of the filters.

8th. You may banish from your minds any idea that the Simcoe Scheme should be carried out because of the power that the water will bring with it. This is a will-o'-the-wisp and a delusion.

* A local word meaning "turbid."

Power can be manufactured in Toronto more cheaply in other ways.

I promised in an early part of this Report to tell you how much power could be got out of the 50 million gallons a day, and at what cost, and I will now proceed to do so.

Utilization of Water for Power.

A reference to the section (Appendix D) will show that the level of the water surface in Lake Simcoe is taken at 720 feet above the sea, and the invert of the aqueduct at the gatehouse is 700.

The difference or head of 20 feet is required to allow a margin for the level of the water being lowered in exceptionally dry seasons, and to force the water through the 6 feet pipe laid in the lake.

In the tunnel between the gatehouse and its low end near Richmond Hill there is a fall of 44.60 feet, making the invert at that point 655.40.

This fall is required to give a velocity (about 139 feet per minute) sufficient to dicharge 50,000,000 gallons in 24 hours with the water running up to springing level.

There is not, therefore, any head left available for power down to the low end of the tunnel, because it has all been used up in getting the water to that point.

The top water of the proposed high-service reservoir at Eglington is 547 feet, giving a fall in the two syphons and the length of aqueduct in "cut and cover" work of 108.40 feet.

Similarly, all this fall is needed to pass the 50,000,000 gallons a day through the iron pipes and conduit to the reservoir; *the water therefore reaches the reservoir without any head which can be used for power*, the size of the pipes with the available gradient being adjusted on the most economical lines for water supply purposes only, that is to say at the outset two 32-inch cast-iron pipes would be laid, competent to discharge together 25,000,000 gallons a day, and in 1912 and 1932 a third and a fourth 32-inch pipe would be put down.

Now, in order to obtain any power out of the water, it is manifest that it must be delivered at the reservoir under some *surplus head or pressure* more than is needed simply to discharge it into the reservoir.

The only way in which this can be done is to lay pipes so much larger than the four 32-inch that they will pass the same quantity in the same time and still have that surplus head.

What I have set out, then, and shown on the section, is a continuation of the tunnel gradient, viz., 1 in 4,000, giving the height at the reservoir as 643.70 feet, and I find that with this fall two 69-inch steel pipes would be required in order to pass the 50,000,000 gallons in 24 hours into the Eglinton reservoir with a surplus head available for power of 96.70 feet.

Of course, it must be understood that these pipes would be laid underground on the same line as would otherwise be occupied by the 32-inch, and that in speaking of 643.70 I am speaking of the height, at the reservoir, of the hydraulic gradient and not the actual level at which the pipes will be laid.

In other words, if a vertical standpipe were erected at the Eglinton reservoir 96.70 feet high above its top water level, the water coming down the two 69-inch pipes would rise to the top of it and still discharge 50,000,000 gallons a day into the reservoir.

The gross power thus obtained is as follows:—

Gallons per minute. lbs. feet.

$$\frac{34{,}722 \times 10 \times 96}{33{,}000} = 1{,}010 \text{ H.P.}$$

Now, let us see what cost has been incurred in securing this 1,010 horse power *gross*.

Manifestly, if the water power is to be so valuable as has been made out, the sooner it can be brought into use the better, and, therefore, by the time the tunnel—competent to bring 50,000,000 gallons a-day—is finished, the 69 inch pipes should also be ready to convey the water on to Eglinton.

My estimate of the cost of the two lengths of syphon, each having two 32-inch iron pipes, and of the intervening length of "cut and cover" is . . . $1,349,650 and of the two 69-inch pipes . . . $3,049,800.

At 5 per cent. the annual charge on the former is . . $67,482
and on the latter $152,490
showing an excess for the power pipes of $85,008
that is to say that up to the year 1912 the additional cost to the City of having laid the larger pipes would be $85,008 per annum.

Then if we divide the $85,008 by 1,010, we get the cost per annum of one-horse-power, viz., $84.

But I must carry this discussion a little further.

The 1,010 h.-p. cannot be made use of without a machine, and the most suitable machine would, no doubt, be a turbine.

If there is a demand for power at Eglinton, *there* would be the place to utilise it; but as this is unlikely, I have assumed that the turbine would drive a dynamo, and that by an electric lead the power would be conveyed to about the centre of the City (near the University), a distance of 3½ miles, where by means of another electrical motor it could be used for doing work.

I believe the best plan would be for the turbine to actuate dynamos giving current at a very high voltage, say, 5,000 volts, this to be transmitted to the place of utilisation and transformed down to 500 or 200 volts, as might be deemed expedient.

The net maximum power available after this last transformation might possibly reach 600 h.p. (Electrical), but would probably not exceed 500.

The cost of turbines, dynamos, mains, transformers and road work would be, at a low estimate, $130,000.

The fullest possible use of this power would be in a factory working, say, 18 hours a day, some electrolytical process or similar thing, situated exactly on the spot where the power is delivered.

If, however, the power were used for working trolley cars, the demand for energy would fluctuate greatly from minute to minute, and its average value would probably not be more than half the maximum.

But further, if the power were used for electric lighting, the average would in winter be about one-fourth of the maximum, and over all the year round not more than one-eighth.

To take it at the very best, the net available power in Toronto could not exceed 600 h.p., but, as I have already explained, the *gross* power of 1,010 h.p. has cost $84 per h.p. to get to Eglinton, and this would, of course, be increased in the ratio of 600 to 1,010, or to $141 for the *net* power.

But this is not all, for the transformation and transmission will cost $130,000, which at 5 per cent. would be $6,500 per annum, making $11 per h.p. more, bringing the total cost per h.p. to $152.

I believe in Toronto it does not cost two-fifths of that price as at present produced.

I fear a great deal of misapprehension has been created in Toronto by the wild and groundless statements which have been made broadcast in the press and at public meetings convened by interested and ignorant partizans.

If people would only consider the difference between having a gigantic natural waterfall like Niagara, so placed that its power can be utilised on the spot, with the proposition *here* to bring water over 40 miles in an artificial channel, to be constructed at enormous cost, and remember what I have stated about the fall required to bring the water along that channel, they would soon realise the folly of the whole idea. I understand that the Niagara Power Company is offering one electrical horse power to the City of Buffalo for 18 dollars per annum; if this is compared with the cost I have worked out above, I think it will be admitted that upon this point nothing more need be said.

General Desciption of Pumping Scheme Recommended.

Perhaps it would be well that I should recapitulate distinctly and in a few sentences how I think the pumping scheme, taking the water from Lake Ontario, should be added to in order to ensure a thoroughly reliable supply of water of admirable quality at all times.

1st. The intake pipe must be relaid on the lines suggested by Mr. Keating, and already approved by you.

I have carefully considered the position of the intake and am of opinion that taking all the circumstances into consideration it cannot well be improved.

For those who are not thoroughly acquainted with the locus, let me explain that the intake is in the open lake 2,250 feet beyond the southern shore of the island and 2½ miles in a straight line from the present pumping station.

That the Island with its eastern and western extremities incurving to wards the Toronto shore, forms practically an enclosed harbour a mile and a quarter wide from north to south and over two miles long from east to west.

The two narrow entrance channels are situated the one at the north-west corner of the harbour and the other near the south-east corner, and each is two miles and a half from the intake.

The sewers discharge of course along the city shore or the north side ot the harbour and the deposit of solids takes place mainly on a narrow strip immediately adjacent and can rarely if ever occur outside the harbour.

There is therefore under ordinary conditions no chance of the water at the intake being fouled by sewage, especially as the normal current (and all currents are very slack) must be in an easterly direction and away from the intake.

2nd. A small steam pumping station should be erected near the Shore Crib on the island. to lift the water about seven feet into two subsiding tanks to hold each eleven million gallons.

The water would be delivered into one end of these tanks and be drawn by an overflow from the other (on to the filter), depositing the matter held in suspension during its slow passage through them.

I propose to keep these tanks and the filters *up and to pump* the water, because I believe if they were kept down so that the water could *gravitate* into them, the cost of construction would be greatly increased, and some power would in any case be required to drain the filters.

Power will also be wanted for sand washing, and heat would have to be provided for warming the low buildings to be erected over the filters to prevent freezing.

3rd. Filter beds must ultimately be provided to the extent estimated for, but they may be erected by degrees as shall be deemed necessary by the Engineer in concert with the Medical Officer and Analyst.

4th. The new pipes and tunnel to the Pumping Station projected by Mr. Keating must also be carried out.

With regard to the tunnel, Mr. Keating should consider if it might not be better to lay it parallel to the surface of the rock at a shallower depth than is shown on his section, and to line it with cast-iron plates forming a circle in cross-section with internal flange joints, excavating as nearly as possible to the size of the outside of the plates, and grouting the space with cement under pressure, and filling the panels between the flanges.

5th. The compounding of the low-duty engines, as proposed by Mr. Keating, should be done, and such extensions be made from time to time as are needed to meet the demand for water.

6th. Rising mains will have to be laid to Rosehill and on to Eglinton as described and when required.

7th. A new service reservoir must be constructed at Eglinton with its top water at 300 feet above Ontario (547 feet above sea level) to hold 50,000,000 gallons.

8th. As time goes on and new rising mains are laid the high-level pumping station may be done away with.

SEWAGE.

I cannot close this Report without saying a few words upon the sewage question, although it does not come within the terms of my instruction.

To justify this intrusion, I may say that for over thirty years I have been constantly engaged in the designing and carrying out of important works of sewage collection, interception and treatment, or I would not have ventured without invitation to make any observations on the subject; and such as I do make will be of quite a general character.

During my stay in Toronto I did not meet a single individual who had a word to say in justification of the existing state of things, excepting that it would cost a very large sum of money to remedy it.

To discharge all the sewage of 175,000 people in its crude state into a tideless and practically stagnant harbour is obviously a very wrong thing to do, and every rational man must condemn it.

If Toronto is ever to take the high position as a residential City, which its climate and other natural advantages would justify, this blot must be wiped out. All the world over people are becoming more alive to the importance of safe sanitary surroundings, and more critical in fixing upon a place of permanent residence; and a common enough question to be asked now-a-days is: Where does the sewage go to, and where does the water come from?

I am quite prepared for adverse criticism upon my advice respecting the water, on account of the bald answer which could be given at Toronto to this question. I am quite satisfied however, that if what I have recommended is carried out, there is no risk whatever of harmful pollution of the water to be supplied: but, at the same time, everyone must admit that if the sewage were removed right away there would not remain a ground even for the slightest sentimental objection.

The offence arising from the stirring up of the foul mud in front of the wharves by the steamboats in hot weather, is, I know, very great, and the discomfort caused to the people carrying on their business on the waterside, must at times be almost intolerable, not to speak of injury to their health.

But I know there is no necessity whatever to argue the question, and that it is merely the cost which stands in the way of a remedy being found. On this I would say that: If you determine to indulge in the luxury of Simcoe water, I fear the diversion of the sewage from the harbour will be relegated to the dim future.

If you adhere to Ontario, several good things will follow, viz. :—

1st. You will be better able to undertake the sewage work;

2nd. You will see the desirability of stopping the waste of water, in order to save money to spend upon that work, and to reduce the cost of its execution, by diminishing the volume of sewage; and

3rd. You will desire to remove entirely the last trace of uneasiness with regard to the intake.

Currents in Lake Ontario.

Appendix G, consists of a reproduction of a chart of Lake Ontario, showing the results of a large number of float experiments published by the United States Department of Agriculture, Weather Bureau.

I have inserted this because I found there was an impression among certain well-informed people in Toronto that the stream of the Niagara River was continued directly across the Lake to Scarborough Heights, where it was deflected partly to the right and partly to the left, so as to produce, in addition to the main easterly stream, a subsidiary but persistent current westwards, and that the constant washing away of the cliff by this impingement produced the material which had formed the island.

I think it is clear from this chart that no such constant westerly current exists, but that the immense volume of water brought in by the river takes what would appear to be its natural course in the direction of the Lake outlet by the St. Lawrence River.

The effect of this course is that the upper part of the Lake is, in its normal condition, a practically still pool or back water, influenced only by the inflow of the comparatively small streams west of Toronto and by the wind.

Although, therefore, its level is maintained mainly by Niagara, there is in the 30 miles stretch of quiet water betwixt the mouth of that river and the intake, ample opportunity for the complete sedimentation and disappearance of the organisms found in the river itself, as shown by their relative numbers, namely, 2,205 and 104.

In conclusion, I desire to thank Mr. Alderman Shaw, the Chairman, and all the Members of the Special Committee appointed to confer with me, for the cordial manner in which they fell in with my views on the readiest way to get together the information I needed, and for their attention and kind assistance during my stay in the City.

I repeat also the expression of my obligation to Mr. Keating, Mr. Rust, Mr. Coady, Dr. Sheard, Professor Shuttleworth, and, in fact, all your officials for their sympathetic and ready help whenever I troubled them.

Last of all, I wish to thank the alert and intelligent representatives of the local press for allowing me to go about my work in peace and quietness so soon as they found that I seriously desired to avoid being interviewed, an experience contrasting very agreeably with the daily pestering I suffered from, when in another colony on a similar errand six years ago.

I am, Mr. Mayor and Gentlemen,
Your obedient Servant,
JAS. MANSERGH.

APPENDIX "A."

TORONTO, CANADA, December 5th, 1895.

James Mansergh, Esq., London, Eng.:

SIR,—

We have the honour to submit herewith the required information on the various matters referred to in your letter of November 8th, and which you specify as follows:—

1st. A tabulated statement in chronological order of the chemical analyses which have been made during the last ten years, of the water of Lake Ontario at the Waterworks intake, south of the island.

2nd. A similar statement of the bacteriological examinations for such period as these have been made.

3rd. Chemical and biological results in the same form of the water of Lake Simcoe, the Ridge Lakes, and the Rivers Don and Rouge referred to in the 1887 Report of Messrs. McAlpine and Tully.

4th. Similar information, if such exists, of the water of Lake Ontario at Mimico Point and Scarborough Heights, and of any other sources which have been seriously suggested for the supply of the City.

5th. Any observations made as to taste, colour or odor, and an opinion generally as to the individual and relative suitability of the various waters for the supply for all purposes to a community such as that of Toronto.

With regard to the first point, we have caused a search to be made in the official records of the Engineer's Department for all analysis made during the time mentioned, and from these have been enabled to present a fair enumeration. Prior to June 25th, 1891, the intake was located at the Bell Buoy, but since that date the water has been taken at a point 365 feet further out. This latter position we have designated the intake, while analyses prior to June, 1891, are referred to under the heading of Bell Buoy. We also give returns of analyses from water taken two miles, and eight miles from the shore of the island. There do not appear to be any records of chemical work from 1885 till 1890—except in 1887—when there was some public discussion as to a new source of water supply; and the last chemical analyses were made in December, 1892, subsequent exeaminations being of a biological character.

Biological examinations of lake water, from 1885 to 1890, were confined to one observation, by Professor Ramsay Wright, in 1887. This gentleman again reported in September, 1890, and Mr. J. J. Mackenzie made an examination in October, 18 and in September, 1892. In December of that year one of us commenced a series of bacteriological observations, which has been continued until the present time, and for the most part has been detailed in the Annual Report of the Board of Health, of which copies have been furnished you. The results are, however, summarized and continued in the present report.

The only chemical analyses of Lake Simcoe water, and that of the Ridge Lakes, appear to have been made in May, 1887, by Professor Ellis, and of Lake Simcoe alone by three other analysts in June, 1891. We have not been able to obtain any information of an official character respecting the Rivers Don and Rouge. Biological examinations of Lake Simcoe water were made by one of us on five occasions from October, 1893, to November, 1895. Records relating to the Rivers Don and Rouge are not procurable.

We have not been able to obtain any chemical analyses of the water of Lake Ontario at Mimico Point, nor are there any biological records. One analysis of the water at Scarboro' Heights is herewith submitted, but bacteriological records are wanting.

In the tabular statements which follow, a chronological order has been observed with reference to each locality. The figures given are mostly those of the original analyses, but in some cases (in which the results were stated in grains, per gallon, or parts per 100,000) they have been reduced to parts per 1,000,000, so that they may be more readily compared. In most cases the degree or organic impurity has been given by the various analysts as being in accordance with Muter's standard, and these original figures have been reproduced. In those instances in which such estimation was wanting, it has been calculated and supplied. We may remark that some of the analysts apparently calculate this degree by data other than those with which we are acquainted, and consequently their figures will not quite agree with ours. The rule we have adopted, and which we believe to be correct, is that of dividing the amount of ammonia, albuminoid ammonia, oxygen absorbed in 15 minutes and 4 hours by fixed divisors, and doubling all figures over 10 in the quotient. The latter step has evidently been omitted by some of the analysts, thus leading to the under-estimation of waters yielding high figures.

The following tables* of Averages of Analyses have been obtained from the data furnished by the individal examinations. The degree or organic impurity by Muter's scale, was not, however, ascertained by averaging the figures stated by the various analysts, but has been calculated, by the rule mentioned, from the average constituents.

N.B.—All these tables are not reproduced in this Report, but only those strictly pertinent to the enquiry

Although the analyses of the water at the Bell Buoy, and also at Parkdale intake, have been continued throughout, so that you might be made acquainted with all the facts at disposal, we do not think that either situation indicates correctly the character of the lake water generally, the Bell Buoy marks the line of shallow water, the depth being about 25 feet. From this point to the intake, 365 feet further south, there is an increase of 50 feet in depth, and shore influences are felt to a much less degree. Even in very stormy weather the limit of turbid water seldom extends beyond the Bell Buoy, but often reaches this mark. The Parkdale intake, which is situated in Humber Bay, about 1,000 feet from shore, is in only about 10 feet of water, which, during stormy weather, is liable to great disturbance, as also from the influence of the Humber River at times of flood.

In order, therefore, to bring the question at issue to its narrowest limits, the Bell Buoy and Parkdale waters may be excluded, and a comparison made of the organic impurity of the remainder.

According to Dr. Muter's scale they stand thus:—

Lake Ontario	.123,	Class I.
Intake	.147,	Class I.
Lake Simcoe	.380,	Class II.
Ridge Lakes	1.026,	Undrinkable..

By the scale devised by Dr. Tidy, based on the oxygen absorbed in three hours, it is impossible to give accurate estimations, as the determinations were made in four hours, but, using this standard as far as possible, the order of the waters will be as follows:—the water of Lake Ontario being practically within the limits of the first class (.500) on account of the slightly overstated figures.

Intake	.409,	of great organic purity.
Lake Ontario	.516,	of great organic purity.
Lake Simcoe	1.349,	of medium organic purity.
Ridge Lakes	2.782,	of doubtful purity.

Professor Wanklyn's classification, as to albuminoid ammonia, gives similar results:—

Lake Ontario	.061	Organically safe.
Intake	.088	Organically safe.
Lake Simcoe	.136	Dirty.
Ridge Lakes	.235	Dirty.

Reference to these standards renders unnecessary any opinion, on our part, as to the relative qualities of the waters in question, but it may be said that the low ratings thus assigned to Lake Simcoe water, and that of the

INTAKE.

365 Feet South of Bell Buoy. Depth, 42 Feet.

	March 30th, 1891. Ellis.	June 20th, 1891. Ellis.	New Intake, June 26th, 1891. Ellis.	July 4th, 1891. Heys.	July 12th, 1891. Heys.	July 24th, 1891. Heys.	July 29th, 1891. Heys.	August 28th, 1891. Heys.	October 3rd, 1891. Heys.
	1	2	3	4	5	6	7	8	9
Free Ammonia	·000	·026	·008	·008	·008	·004	·004	·012	·004
Albuminoid Ammonia	·070	·086	·075	·080	·078	·088	·080	·080	·096
Oxygen in 15 minutes	·350	·144	·107	·177	·135	·149	·160	·137	·126
Oxygen in 4 hours	·690	·539	·400	·300	·472	·414	·448	·331	·344
Chlorine	3·500	4·000	4·250	4·300	4·000	3·500	4·000	4·000	4·000
Nitrogen in Nitrates	....	....	....	....	....	....	....	....	....
Phosphoric Acid	....	....	....	....	....	....	....	....	....
Solids	120·000	134·000	130·000	115·000	130·000	135·000	140.000	140·000	140·000
Odor	....	None	None	None	None	None	None	None	None
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Hardness	....	....	....	....	....	....	....	....	....
Organic Impurity	·18	·162	·125	·135	·148	·146	·141	·14	·14

	Novem'r 7th, 1891. Heys	August 30th, 1892. Heys.	Septem'r 21st, 1892. Heys.	Septem'r 27th, 1892. Pyne.	Novem'r 25th, 1892. Pyne.	Decem'r 12th, 1892. Heys.	Decem'r 30th, 1892. Heys.	Intake. Average of 16 Samples.
	10	11	12	13	14	15	16	17
Free Ammonia	·008	·022	·004	·017	·010	·027	·007	·010
Albuminoid Ammonia	·096	·097	·120	·069	·071	·117	·110	·088
Oxygen in 15 minutes	·091	·301	·080	·142	·037	·136	·133	·150
Oxygen in 4 hours	·338	·550	·299	·334	·350	·305	·441	·409
Chlorine	4·000	5·000	3·750	4·000	3·600	3·500	3·750	3·946
Nitrogen in Nitrates	....	....	....	·308	....	....	·085	....
Phosphoric Acid	....	....	....	None	....	....	None	....
Solids	140·000	132·000	150·000	133·000	129·000	152·000	160·000	136·250
Odor	Slight	Faint	Slight	None	None	Peaty	Peaty	....
Appearance	Clear	Slightly Turbid	Slightly Turbid	Clear	Clear	Turbid	Slightly Turbid	....
Hardness	....	....	....	....	....	....	....	....
Organic Impurity	·14	·20	·156	·126	·107	·175	·166	.147

LAKE SIMCOE ANI

	Grape Island. Depth 40 feet. May, 1887. Ellis. 18	Snake Island. Depth 40 feet. May, 1887. Ellis. 19	Roche's Point. Depth 40 feet. May, 1887. Ellis. 20	Cook's Bay. Depth 40 feet May, 1887. Ellis. 21
Free Ammonia..............	.040	.040	.040	.080
Albuminoid Ammonia......	.100	.140	.120	.140
Oxygen in 15 minutes	.576	.548	.548	.656
Oxygen in 4 hours	1.356	1.592	1.512	1.496
Chlorine.......................	5.000	5.000	5.000	5.000
Nitrogen in Nitrates	.033	.033	.033	Trace
Phosphoric Acid	.000	.000	.000	.000
Solids	103.600	144.000	156.000	164.000
Odor	None	None	None	None
Appearance	Clear*	Clear*	Clear*	Clear*
Hardness, before boiling.	79.500	110.500	115.000	113.500
Hardness, after boiling ...	28.200	29.900	39.000	27.500
Organic impurity...........	.316	.36	.34	.38

	Georgina Island. 3 miles N. by W. Depth 30 feet. June 20th, 1891. Heys. 27	Georgina Island. 3 miles N. by W. Depth 30 feet. June 20th, 1891. Harrison. 28	Georgina Island. 3 miles N. by W. Depth 30 feet. June 20th, 1891. Pyne. 29	Georgina Islan 3 miles N. by Depth 30 feet. June 20th, 189 Pyne. 30
Free Ammonia..............	.060	Trace	.035	.029
Albuminoid Ammonia......	.145	.140	.159	.135
Oxygen in 15 minutes......	.522	.473	.698	.715
Oxygen in 4 hours	1.346	1.144	1.361	1.310
Chlorine.......................	2.500	1.000	5.200	5.000
Nitrogen in Nitrates	....	Trace	None	None
Phosphoric Acid	....	Slight trace	None	None
Solids	115.000	150.000	140.000	180.000
Odor	None	Not marked	....	....
Appearance	Clear	....	....	....
Hardness, before boiling.	....	....	....	....
Hardness, after boiling...	....	....	....	....
Organic impurity...........	.355	.342	.396	.368

* Color described as pale,

OE AND RIDGE LAKES.

...oint. ...eet. ...7.	Cook's Bay. Depth 40 feet May, 1887. Ellis. 21	W. Gwillimbury. Town line continued one mile from shore. Depth 40 feet. June 20th, 1891. Heys. 22	Mossington's Point 1,200 feet from shore. Depth 20 feet. June 20th, 1891. Harrison. 23	Jackson's Point. 2,000 feet from shore. Depth 25 feet. June 20th, 1891. Harrison. 24	Jackson's Point. 1 mile N. ½ E. Depth 40 feet. June 20th, 1891. Harrison. 25	Jackson's Point. 1 mile N. ½ E. Depth 40 feet. June 20th, 1891. Heys. 26
	.080	.060	Trace	Trace	Trace	.034
	.140	.134	.123	.140	.148	.146
	.656	.560	.513	.473	.473	.522
	1.496	1.500	1.184	1.144	1.158	1.422
	5.000	2.370	1.000	1.000	1.000	2.500
	Trace	....	Trace	Trace	Trace	....
	.000	....	Slight Trace	Slight Trace	Slight trace	....
	164.000	145.000	160.000	150.000	160.000	156.000
	None	None	Not marked	Not marked	Not marked	None
	Clear*	Clear	....	....	....	Clear
	113.500	....	....	....	....	....
	27.500	....	....	....	....	....
	.38	.36	.350	.342	.359	.355

...and. ...y W. ...et. ...1891.	Georgina Island. 3 miles N. by W. Depth 30 feet. June 20th, 1891 Pyne. 30	LAKE SIMCOE. AVERAGE OF 13 SAMPLES. 31	RIDGE LAKES. AVERAGE OF 8 SAMPLES. 32
	.029	.032	.102
	.135	.136	.235
	.715	.562	1.187
	1.310	1.349	2.782
	5.000	3.197	.500
	None	....	.144
	None	....	....
	180.000	147.969	140.250
	....	....	....
	....	....	....
	....	104.625	102.100
	....	31.150	34.487
	.368	.380	1.026

described as pale, greenish-yellow.

Ridge Lakes, is in part attributable to the more or less peaty character of these sources.

We have not had the opportunity of personal observation of the Ridge Lakes waters, but at certain seasons have noticed a slight vegetable odor and taste, in that of Lake Simcoe, towards the south shore. This is probably attributable to the swamp water of the Pefferlaw and Black Rivers which enters here, and to the Holland River, which carries its burden of marsh water into Cook's Bay. The water of Lake Simcoe, when viewed through a two-foot tube, is of a pale yellowish-green rather than a greenish-yellow colour, and that of the southern end of Cook's Bay is of a still greener hue.

In the case of the Ridge Lakes the proportion of albuminoid ammonia is one-twelfth that of the very large amount of oxygen absorbed in four hours, a quantity which, under such conditions, seems abnormally high, and together with the uniformly bad quality indicated by other means of estimation, condemns these lakes, taken together, as a source of potable water supply.

The tests for hardness in the different waters places them in the following order:—

Lake Ontario	..	94.3 parts per million, or 6.60 grains per gallon.
Ridge Lakes	..	102.1 parts per million, or 7.14 grains per gallon.
Lake Simcoe	..	104.6 parts per million, or 7.32 grains per gallon.

This difference in soap-consuming power, and consequent comfort in using, no doubt demands some consideration.

BIOLOGICAL EXAMINATION.

The following tables* embrace every available record, except one, which relates to an investigation made on January 19th, 1894, and which was in part designed for the purpose of ascertaining the condition of Lake Ontario, in mid-winter, during very stormy weather. Such a record has never been obtained, and was only procured with considerable difficulty and risk. A very heavy sea, with floating ice, was at this time running in the Lake, and the line of muddy water not only reached the Bell Buoy, but extended southward as far as the eye could reach—a state of things which is never noticeable during the season of navigation. The condition was that of exceptional disturbance, and was fully confirmed by the bacteriological examination of the samples of water obtained.

The records of this investigation have been purposely excluded from the foregoing tables, as they would exercise a dominating influence which would

N.B.—All these tables are not reproduced in this Report, but only those strictly pertinent to the enquiry.

quite overwhelm any conclusion which might otherwise be formed as to the average condition of the water at the Lake stations, as deduced by 39 determinations, extending over five years.

Another consideration which influenced us in omitting these details is that the biological records of Lake Simcoe water do not include any which cover stormy periods, either in winter, or at other seasons, so that a comparison of the two would thus be quite unfair and misleading. Even as it is, the water of Ontario is placed at considerable disadvantage, inasmuch as we have taken in a record of the stormy weather of August 15th, 1893, when the investigation was made for the special purpose of ascertaining the effect of a north-west blow.

In order that you may be acquainted with all the particulars, we herewith submit the bacteriological results of the examination made on January 19th, and for further particulars refer you to the Annual Report of the Board of Health, page 30, 1894.

One mile south of intake,	sample at 57 feet.. ..	290 cols.
Intake	sample at 72 feet.. ..	7,375 cols.
Intake	sample at 57 feet.. ..	7,880 cols.

The following statement of averages of the Lake Ontario and intake samples, and those from Lake Simcoe, show the comparative bacteriological position of each source of supply, as indicated by the number of organisms present.

Lake Simcoe	29 samples	87 cols.
Intake	27 samples	104 cols.
Lake Ontario, stations outside intake,	39 samples	129 cols.

Lake Simcoe water thus shows an advantage over that of the intake and Lake stations, but the difference in the numbers is not such as to be of any sanitary importance, and, as before explained, the disparity would be less evident if the records of the stormy period referred to were excluded. Both lakes take a very high position as furnishing bacteriologically pure waters, and, from this point of view, no exception can be taken to either.

Trusting that this Report may be found to fully comply with your instructions,

We are, yours faithfully,

CHARLES SHEARD, M.D
E. B. SHUTTLEWORTH.

Results of Biological Examinations of Water.

Intake.

Date.	Depth.	
1891—October 10	....	67 colonies per c.c.
" December 17	....	91 " "
1892—September	....	12 " "
1893—April 17	73 feet	376 " "
" July 13	"	15 " "
" July 21	"	68 " "
" August 15	"	20 " "
" August 22	"	65 " "
" August 31	"	117 " "
" September 13	"	140 " "
" October 16	"	152 " "
1894—August 7	66 feet	235 " "
1893—August 31	60 feet	93 " "
" September 13	"	40 " "
1894—August 7	57 feet	
		120 " "
1893—August 31	50 feet	
" September 13	"	70 " "
" October 16	"	53 " "
" November 25	"	150 " "
		53 " "
1895—October 26	"	
		145 " "
1893—August 31	40 feet	
" September 13	"	123 " "
" August 31	30 feet	83 " "
" September 13	"	107 " "
		48 " "
1892—December 17	20 feet	
		94 " "
1893—August 31	"	
		85 " "
1894—August 7	3 feet	190 " "

Average of 27 samples, 104 colonies per c.c.

The examinations of October, 1891, and September, 1892, were made by Prof. Mackenzie and those subsequently by Prof. Shuttleworth.

Results of Biological Examinations of Water.

Lake Simcoe.

Prof. Shuttleworth.

			Depth. Ft.	Col's.
1893.				
Nov.	1	Cook's Bay, line with De Grassi Point (750 ft.)....	9½	70
"	1	" " " " (")....	2	25
"	1	" " " " (1,500 ft)....	26	130
"	1	" " " " (")..	2	0
"	1	" 750 ft S.E. from Belle Ewart Ice-house.	22	100
"	1	" " " " "	2	25
"	1	" line with Ice house (half across Bay) ..	46	10
"	1	" " " (") ..	2	35
1894.				
Apr.	20	2,000 ft. out from Jackson's Point	45	360
"	20	" " "	24	255
"	20	" " "	3	400
June	15	" " "	43	65
"	15	" " "	24	105
"	15	" " "	3	65
"	15	¾ mile N. from Black River	20	140
"	15	½ mile from shore, off Morson's Well	52	85
"	15	" " off Mossington Point	48	120
"	15	" " " "	24	65
"	15	" " " "	3	55
Nov.	15	¾ mile N. from Black River	45	18
"	15	2,000 ft out from Jackson's Point..................	43	24
"	15	½ mile from shore, off Morson's Well..............	50	36
"	15	" " off Sedoar's Barn	50	38
"	15	" " off Huntley's Creek Bridge......	35	35
"	15	West end Snake Island (mid-channel)..............	15	38
"	15	Between Fox Island and Big Ceda Point	50	34
"	15	¼ mile E. of Big Cedar Point	50	26
1895.				
Nov.	11	2,000 ft out from Jackson's Point	1	75
"	11	Middle of Cook's Bay	1	102
		Average of 29 samples	—	87

APPENDIX "B."

LABORATORY, TORONTO, November 25th, 1895.

James Mansergh, Esq., London, Eng.:

SIR,—

In compliance with your request, I herewith submit a report on the chemical and biological character of the water of the Niagara River, obtained on November 15th, when in company with Dr. Sheard, Medical Health Officer.

The point selected was between Queenstown and the mouth of the river, at such a distance from the latter as to entirely preclude the possibility of any admixture of the water of Lake Ontario.

The river here is about 1,200 feet in width, and is said to be from 60 to 100 feet in depth, with a current of about 4 miles an hour. The samples were taken for chemical analysis at a depth of 10 feet from the surface, and at distances of about 170 feet apart, a like space intervening between the east and west shores. The six samples so obtained were afterwards uniformly mixed, and an analysis made, of which the following is the result:—

In parts per million.	
Free ammonia	.000
Albuminoid ammonia	.120
Oxygen absorbed in 15 minutes	.279
Oxygen absorbed in 4 hours	.422
Chlorine	3.560
Nitrogen in nitrites, etc.	.000
Phosphoric acid	.000
Total solids	135.000
Volatile solids	45.000
Odor at 100 F.	none

By Muter's scale the water will be within the limits of Class I. (.218), but by Tidy's classification it would probably just pass into the limits of medium purity (.422 in 4 hours, against .500 in 3 hours); and according to Wanklyn it must be placed among the "dirty" waters.

The following are the figures resulting from the biological examination, the samples running from the Canadian, or western, to the American, or eastern shore:—

1,960 cols. per cubic centimetre.
2,110 cols. per cubic centimetre.
2,590 cols. per cubic centimetre.
2,850 cols. per cubic centimetre.
2,070 cols. per cubic centimetre.
1,650 cols. per cubic centimetre.

This gives an average of 2,205 colonies, and it will be observed that the greatest number of bacteria were found in the water from the middle of the river (2,720) where the current is most rapid, with a less number in the slack water at the side (1,860 on the east, and 2,030 on the west).

The comparatively large number of colonies is probably attributable to the sewage of the City of Buffalo, which according to recent researches would be unaffected by the aëration in the Rapids and Falls.

I regret that your note requiring observation by the 2 ft. tube was not received in time, but I do not think that the colour of the water would be found to differ from that of Lake Ontario, and would probably be set down as pale greenish-yellow.

Yours faithfully,
E. B. SHUTTLEWORTH.

APPENDIX "C."

Before I left Toronto I went through, with Mr. Keating, a number of communications on the water question which had been received either by himself or the Committee, and which it was desired I should consider.

The following is a list of these papers:—

From—

1. Messrs Barber & Watson, as to forcing water through the intake pipe.

2. Mr. J. H. Oakley, as to a supply of underground water from an unnamed source, to be discovered by the divining rod.

3. Mr. George A. Chapman, being a suggestion to use the Grenadier Pond as a settling basin and reservoir.

4. Messrs R. T. Sutton & Co., as to making a channel from Hanlan's Crib, through the island, to the lake in a westerly direction.

5. Mr. A. E. Shipley, as to a supply from tributaries of the Humber and Credit.

6. Mr. Arthur Harvey, as to a new intake near Taylor's bath house.

7. Mr. H. Glazebrook, as to sinking 20 or 30 artesian wells in the suburbs of the City.

8. Mr. A. Davis. Offer to relay suction pipe.

9. Mr. Isaiah Ryder, suggesting that all that is necessary to make water supply perfect is to lay a new steel conduit in place of the wooden one.

10. Mr. Jas. Crowther. A strong recommendation of the Simcoe scheme, describing in glowing terms the advantages that all classes of the community are to derive from it, but *assuming apparently* that somebody else is going to pay for it.

11. Mr. J. A. Macdonald, Secretary of Georgian Bay Canal Company. Offer to supply the City with 18 million gallons a day for $98,500 per annum. annum.

I have perused all these papers and I think I may fairly classify them as—

(*a*) Suggestions for minor alterations of or additions to the existing works or cuts, some of which are now out of date as applying to repairs consequent on the rising of the pipe in September last;

(*b*) Proposals for obtaining supplies from streams at a distance or from underground sources near Toronto such as I have already dealt with;

(c) An offer to supply water to the City by a Company.

I think I need hardly occupy my own time in writing, or yours in reading, much about these proposals as they none of them affect in any way whatever the general tenur or conclusions of my report.

The only one that calls for any special comment is the offer made through Mr. J. A. Macdonald by the Georgian Bay Ship Canal and Power Aqueduct Company in the following letter:—

[Copy.]

Toronto, September 7th, 1895.

To the Council of the Corporation of the City of Toronto:

Gentlemen,—

I am instructed by the Directors of the Georgian Bay Ship Canal and Power Aqueduct Company to advise you that the Company have for many months been considering, in all its bearings, the question of a contract between the City and the Company for a domestic water supply for Toronto, and in view of the breakdown of the present system, the Company desires to withdraw all former offers, and submit the following as a basis for agreement:—

1. The Company will supply the Corporation with 18 million imperial gallons of water daily for $98,550 per annum, and at the same proportionate rate (one and a-half cents per 1,000 gallons) for any quantity that the Corporation may require up to 30 million gallons per day, and one cent per 1,000 gallons for all that may be required over 30 million gallons daily.

2. The Company will at the time of the execution of the agreement pay to the City Treasurer $226,000 to be expended in the purchase and laying of new feed-mains as heretofore recommended by the City Engineer, such mains to be the absolute property of the City.

The water to be delivered to the present City reservoir, or the Company will construct an additional reservoir or reservoirs (not more than two), at any elevation or elevations that the City may require, not exceeding 400 feet above Lake Ontario.

4. The water to be procured from Lake Simcoe by means of gravitation, and shall be of such standard or standards of purity as the City and the Provincial Board of Health may require.

5. The Company to have tl. new system in operation, and the City supplied not later than the 1st day of July, 1897, provided the agreement be entered into before the end of this year.

The agreement to be for a term of 35 years, the City to have the option of buying from the Company at the expiration of the said term of 35 years all the property and assets of the Company, real or personal, or both, that may be necessary for supplying the City with water.

7. The price to be paid by the City for the waterworks system, property, and rights of the Company, at the expiration of the said term, shall (if not arranged by mutual agreement) be determined by arbitration, and the Company shall only receive the then actual value of property or privileges, or both, to be taken by the City, and no allowance or consideration shall be made or given to the Company by virtue or reason of any privilege or franchise conferred upon the Company by the City, or agreement entered into between the City and the Company.

(Signed) J. A. MACDONALD,
Secretary.

By this letter it will be observed that the Company withdraw all former offers and undertake to supply water without any limit of quantity by gravitation from Lake Simcoe into reservoirs to be constructed at any elevation not exceeding 400 feet above Lake Ontario.

The price to be one and a-half cents per 1,000 gallons up to 30 million gallons a day, and one cent for any larger quantity.

They also propose to present to the City a "bonus for the right to supply water" on these terms, of $226,000, or 18 million gallons a day for two years and 107 days.

They also undertake to have the necessary works completed in 18 months from the date of the agreement.

The water to be of any such standard of purity as the City or the Provincial Board of Health may require.

The Company are to work the concession for 35 years and at the end of that period the City is to have the option of buying on terms set out in the 7th paragraph of the letter, which terms, I am bound to say, I do not understand, as the second part seems to contradict the first.

After considering this letter, I wrote to Mr. Macdonald on the 20th November, the day before I left Toronto, as follows:—

TORONTO WATER.

TORONTO, November 20th, 1895.

J. A. Macdonald, Esq.:

DEAR SIR,—

Your letter of September last offering, on behalf of your Company, to supply the City of Toronto with 18 million gallons of water a day for $98,000 has been handed to me for consideration and report. I shall be much obliged to you if you will inform me by what means this water is intended to be brought from Lake Simcoe to the service reservoir near the City. Is it by the canal of which you showed me the plan and profile yesterday, or by an independent tunnel and pipe? If the latter, upon what line would these be laid? Also what would be the cross section and gradient of the tunnel, and what the diameter and hydraulic gradient of the pipe?

Will you please reply to me before the 26th inst., to 144 W. 76th Street, New York City.

Yours very truly,
(Signed) JAS. MANSERGH,

To this letter I received the following reply:

TORONTO, November 23rd, 1895.

J. Mansergh, Esq., C.E., 144 West 76th Street, New York City:

DEAR SIR,—

Yours of the 20th inst. received. The Company propose to amend their offer in several particulars. One would be to give the City the option of taking its supply from the upper reaches of the west branch of the Humber River, amplified by the diversion of the waters of the Credit River. In either case there would be no tunnelling. The water would be conveyed to the service reservoirs near the City by means of steel pipes. If Lake Simcoe be determined upon, the Company would take advantage of its open cutting through the Ridges to be made for the Ship Canal and Power Aqueduct, and the pipes would be laid below the level of Lake Simcoe on a margin of land at the side of the open duct.

As to the diameter and gradient of the steel pipe, that will depend entirely upon the quantity we will require for the several municipalities that the Company will have to supply. We have already entered into a contract with the Township of York, and are now negotiating with a number of other municipalities.

We are most willing to give you all the data in our possession and control. We deeply regret that your report will not cover the Upper Humber and Credit sources, as no report on the possible sources of Toronto's water supply can be complete without embracing this water-shed.

Yours very truly,

(Signed) J. A. MACDONALD,

Secretary.

I hardly know what adjective to use in respect of this letter, but I desire not to be offensive, and I will therefore describe it as an "astute" letter, the sting of it being in its tail, for the last paragraph reads thus: "*We* deeply regret that your report will not cover the Upper Humber and Credit sources, as no report on the possible sources of Toronto's water supply can be complete without embracing this watershed."

It is very curious that, although Mr. Macdonald was invited two days after my arrival in Toronto to lay any information he desired on the water question before the Committee, he never mentioned the "Credit" until a few hours (as he knew) before I was leaving the City, when he did so in a casual and off-hand manner when I was examining the model in his office.

It is more curious still that at a public meeting a few days later than his letter of the 23rd he should (after groundlessly accusing Mr. Alderman Lamb of hurrying Mr. Keating off, to sail with me in the same boat to Liverpool, as if there were some conspiracy between us), have wound up by saying that my report would be incomplete because it would not touch on the "Credit," the greatest water-shed in the world!!

Surely if Mr. Macdonald had a spark of good feeling in him, or had believed honestly what he says about this water-shed, he could never have behaved in this fashion. He must have known—if he knows anything at all about water-sheds—that to fully examine these districts would take several weeks' work of a number of surveyors, and that he ought to have put them to the front immediately I arrived, instead of keeping "*the greatest water-shed in the world*" in his pocket until I had left the country.

I prefer to assume that Mr. Macdonald's mention of the "Credit" in his office was quite accidental, and arose out of a short conversation with two engineers who were present, and that it afterwards occured to him to use it in the mischievous way I have described.

Although, however, this letter, for some purpose or other, creates this diversion—Mr. Macdonald *does* tell me in answer to my enquiry how the water is to be brought from Lake Simcoe to Toronto. He says: "If Lake Simcoe is determined upon, the Company would take advantage of its open cutting through the Ridges to be made for the Ship Canal and Power Aqueduct, and the pipes would be laid below the level of Lake Simcoe on a margin of land at the side of the open duct."

Now, you will remember that in the letter of September 7th, 1895, the Company undertook to deliver water by gravitation from Lake Simcoe in *18 months* after an agreement was come to with the City, and we now know that before they can do this *the cutting for the canal must be made through the ridges and the water-pipe be laid alongside.*

Without professing to be absolutely accurate, I learn from Messrs. Hering and Gray's section, which is, I believe, very nearly on the same line, that the canal cutting will have a maximum depth of about 200 feet, and that for a length of nine miles it will average 100 feet in depth.

In this nine miles alone, the excavation to be made must amount to at least 40 million cubic yards, and the water conduit in order to have the proper gradient must be laid in this part at an average depth of 50 feet below top water of the canal.

I should not have said anything whatever about this work if I had not been called upon to consider the Company's offer to the City, but as it has been mentioned I may say that this enormous cutting for the canal, with the tunnel for the water conduit close alongside, and at a much lower level, is by no means a simple engineering undertaking, and it is utterly impossible that it can be executed in anything like the 18 months stated.

The whole proposal bears on the face of it evidence that it is not based on any substantial foundation, and I should suppose that no engineer of experience has ever been consulted about the details of the offer made to the City Council.

If this offer were accepted I am quité positive that the bargain would never be completed by the Company, and the whole business would end in a miserable fiasco.

Moreover, I advise distinctly that the supply of water to any City should never be entrusted to a Company, however serious and stable—it is essentially a municipal business—and wherever a competent, incorruptible and truly representative municipal authority exists, that body should administer and control the water supply in the sole interest of the ratepayers, and without increasing its cost by providing dividends to shareholders.

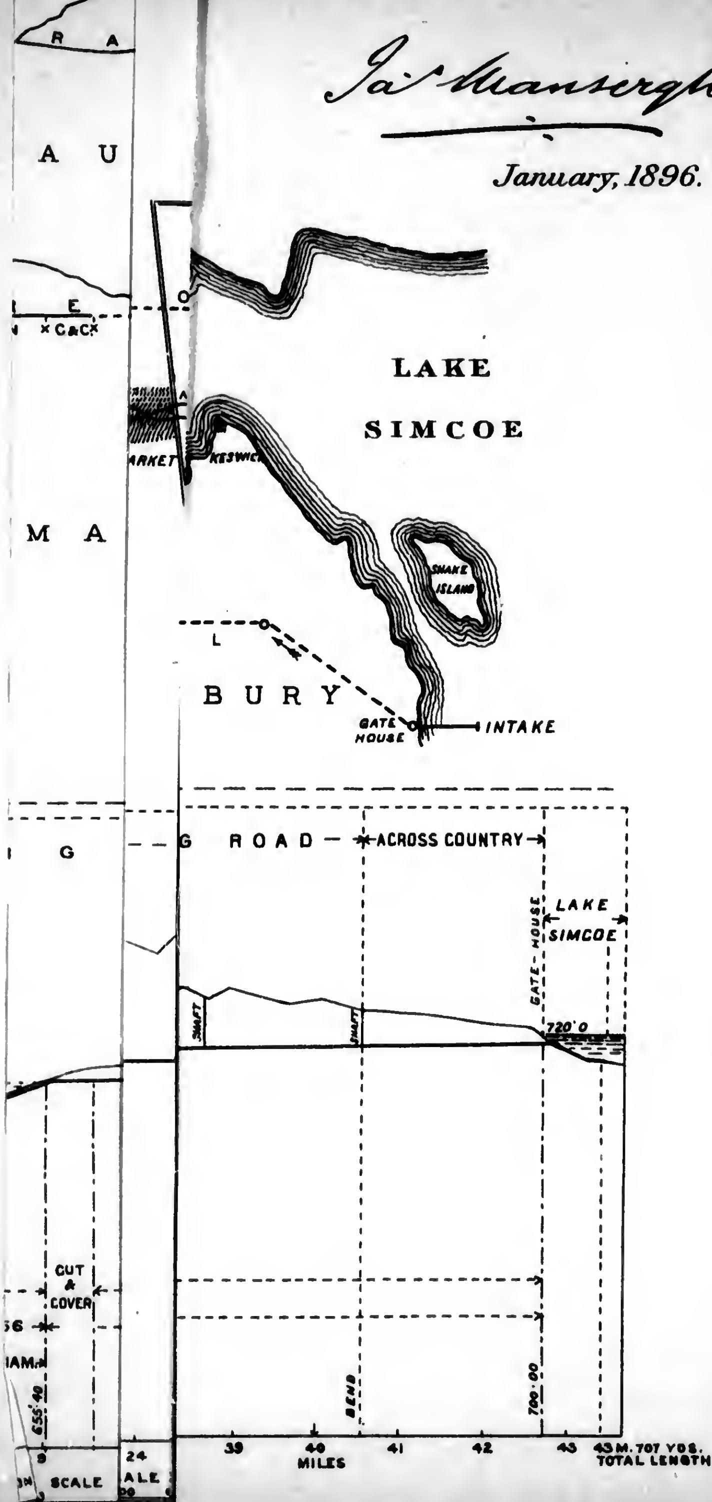
J. M.

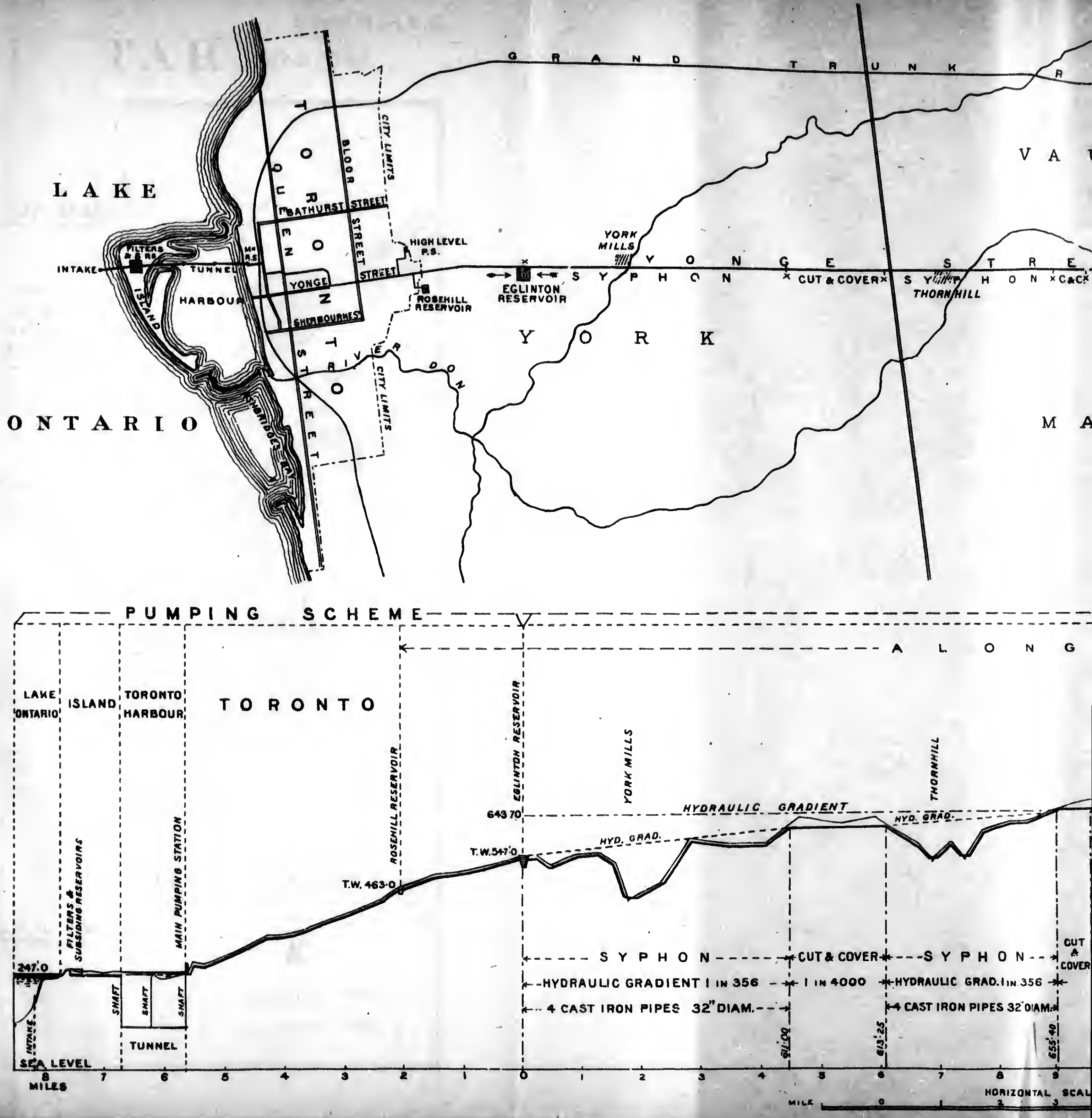
TORONTO WATERWORKS.

APPENDIX D.

Ja^s Mansergh

January, 1896.





LAKE
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TUNNEL
FILTERS & S.RS.
ISLAND
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TORONTO
QUEEN STREET
BLOOR STREET
BATHURST STREET
YONGE STREET
SHERBOURNE ST
CITY LIMITS
HIGH LEVEL P.S.
ROSEHILL RESERVOIR
EGLINTON RESERVOIR
RIVER DON
ASHBRIDGES BAY
GRAND TRUNK R
YORK MILLS
YONGE STREET
SYPHON
CUT & COVER
THORNHILL
C&C
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PUMPING SCHEME
ALONG
LAKE ONTARIO
ISLAND
TORONTO HARBOUR
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HYDRAULIC GRAD. 1 IN 356
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4 CAST IRON PIPES 32" DIAM.
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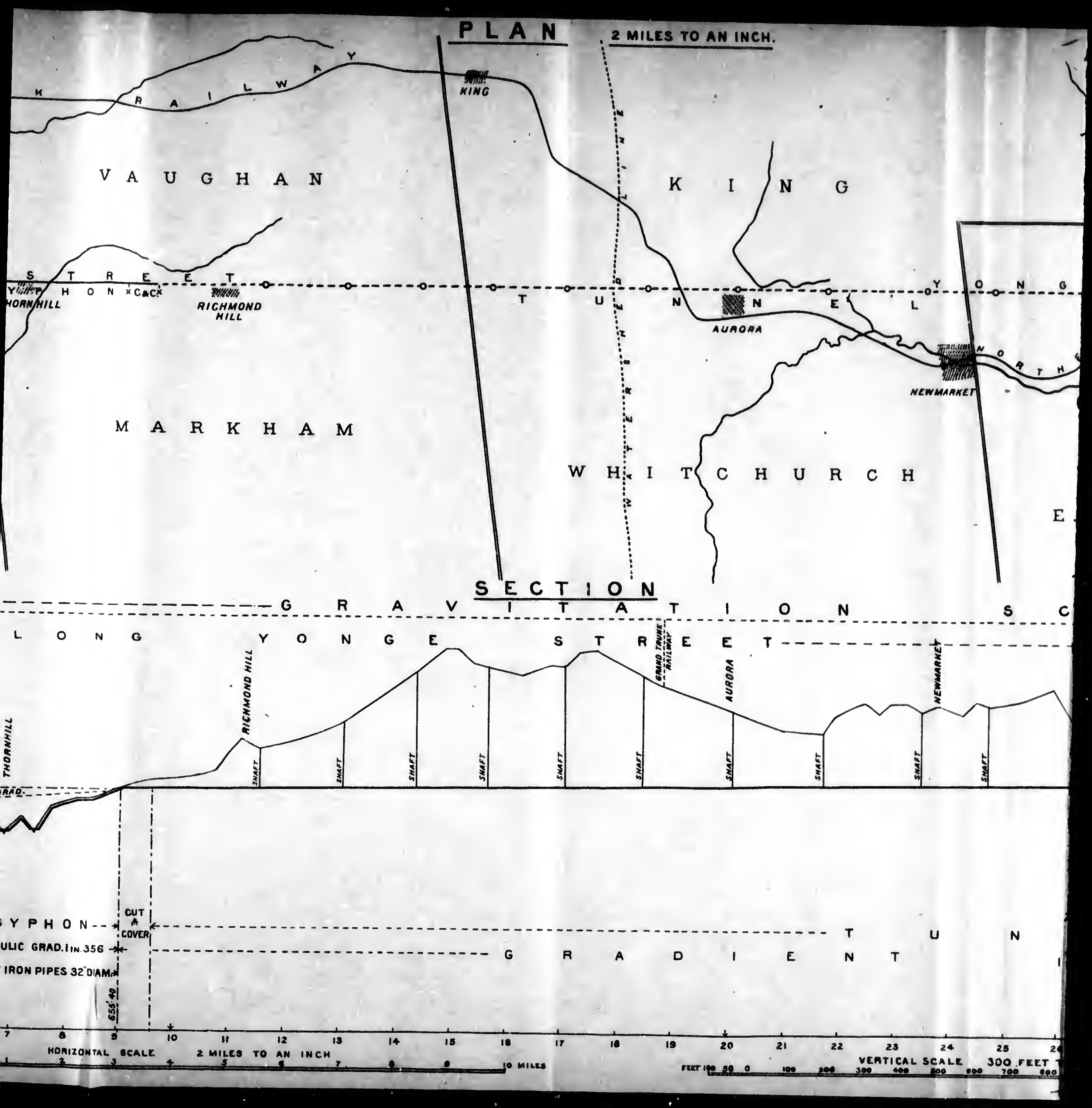
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RICHMOND HILL
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MARKHAM
WATERSHED LINE
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E
SECTION
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LONG YONGE STREET
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GRAND TRUNK RAILWAY
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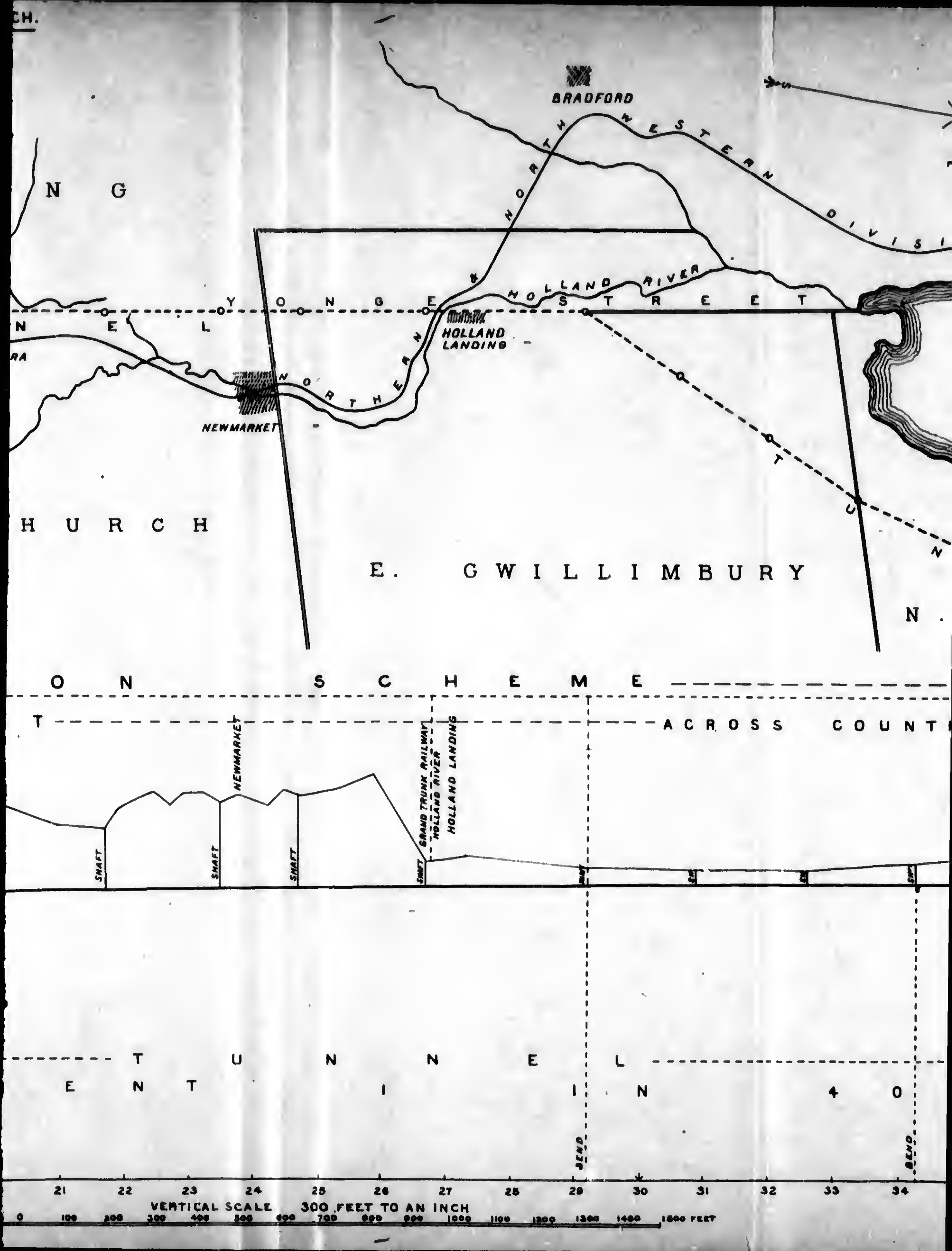

CH.
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O N S C H E M E
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NEWMARKET
GRAND TRUNK RAILWAY
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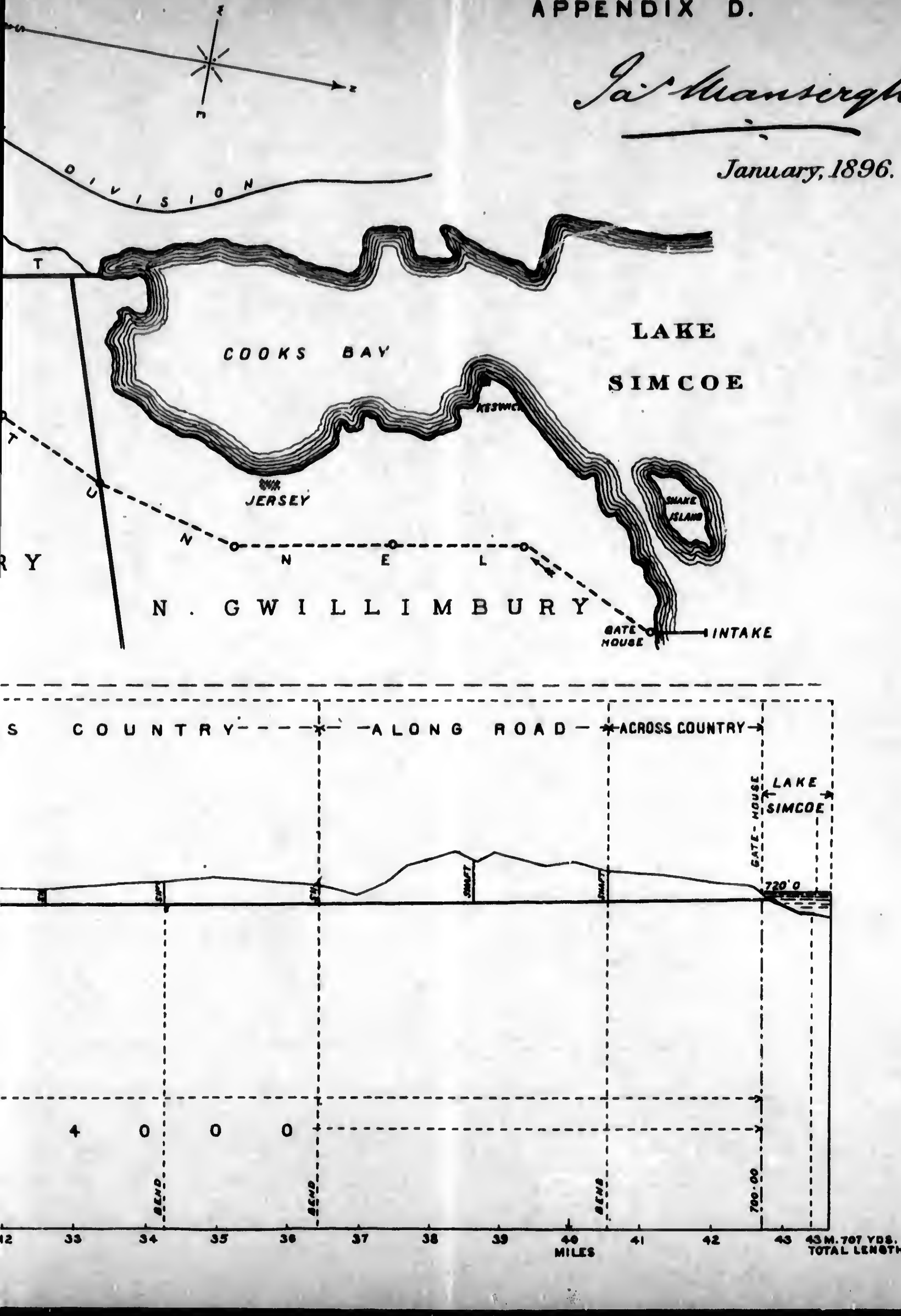
VERTICAL SCALE 300 FEET TO AN INCH
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 FEET

TORONTO WATERWORKS.

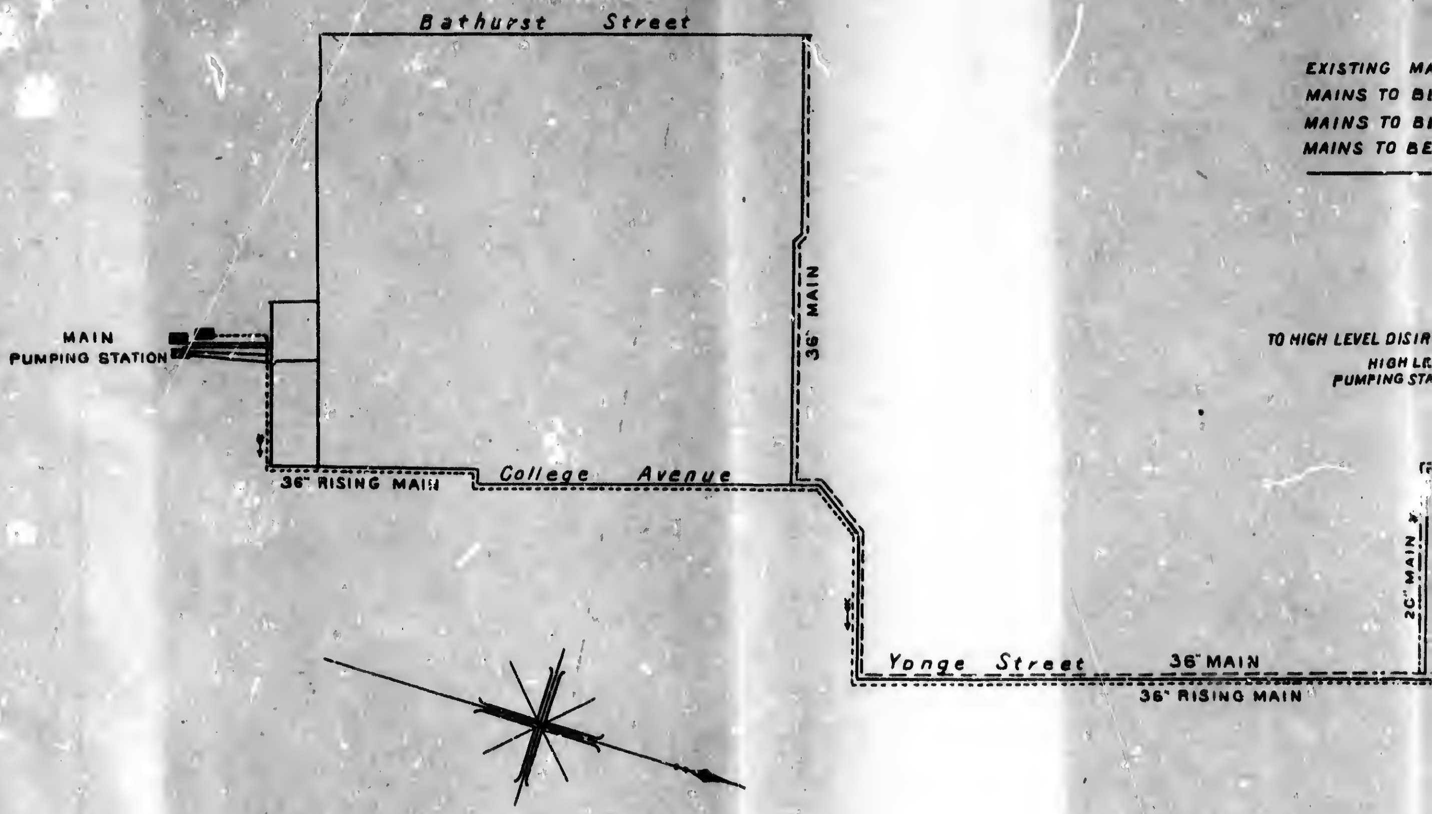
APPENDIX D.

Jas Mansergh

January, 1896.



SKETCH PLAN O



SCALE. 3 INCHE

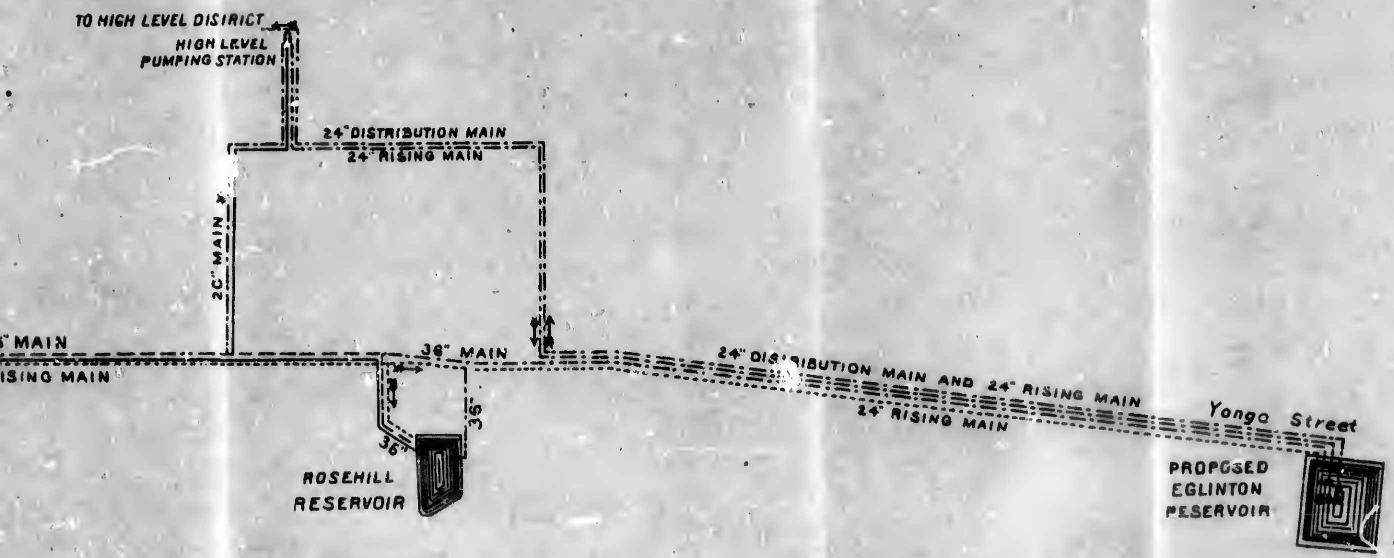
APPENDIX E

Ja. Mansergh

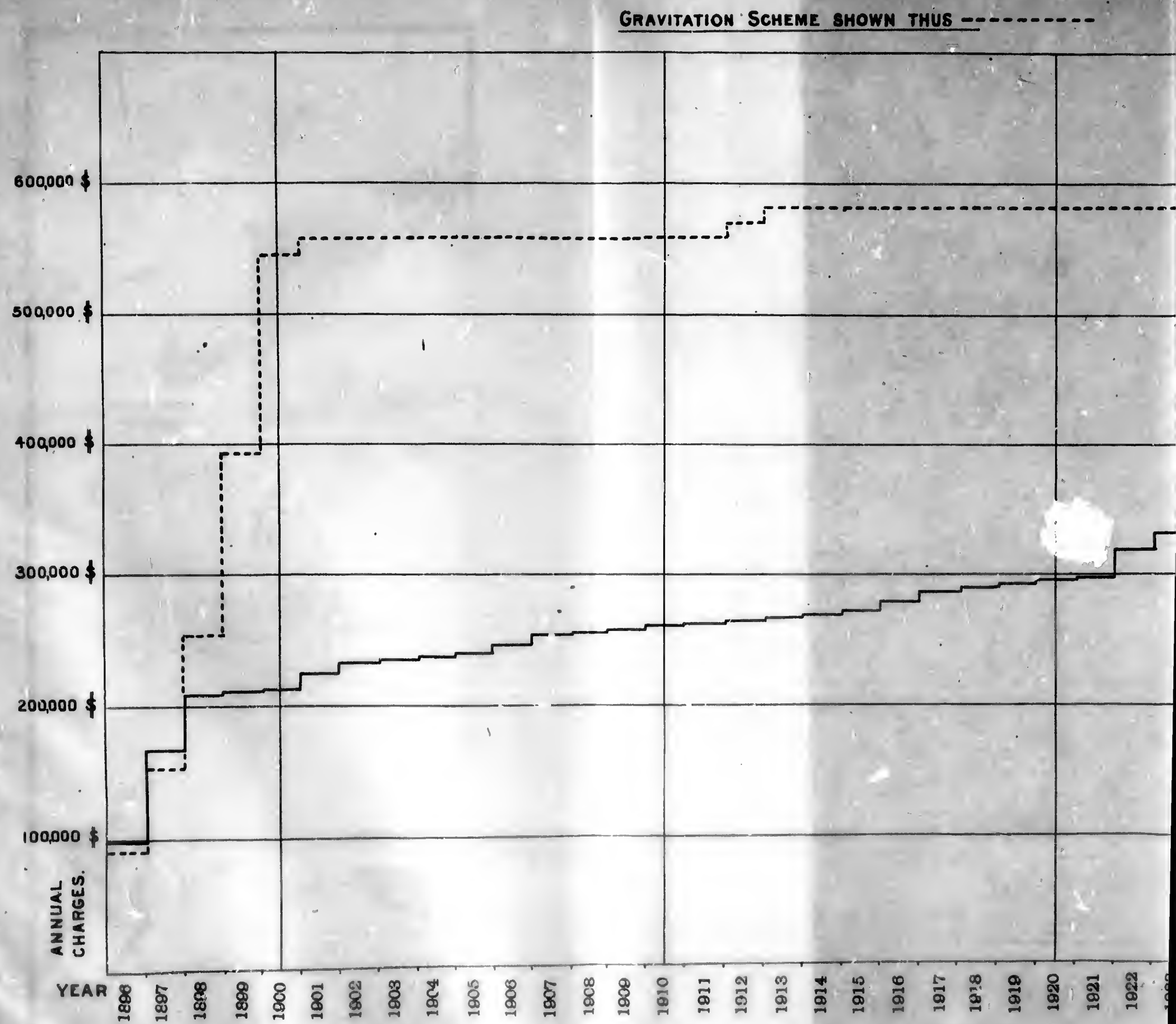
January 1896.

SKETCH PLAN OF MAINS IN CONNECTION WITH PUMPING SCHEME.

EXISTING MAINS	SHOWN THUS ————
MAINS TO BE LAID IN 1896	SHOWN THUS – – – –
MAINS TO BE LAID IN 1897	SHOWN THUS –·–·–·–
MAINS TO BE LAID WHEN NEW ENGINES ARE ERECTED	SHOWN THUS ········



SCALE. 3 INCHES TO A MILE.


GRAVITATION SCHEME SHOWN THUS
600,000 $
500,000 $
400,000 $
300,000 $
200,000 $
100,000 $
ANNUAL CHARGES.
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1901
1902
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1918
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1920
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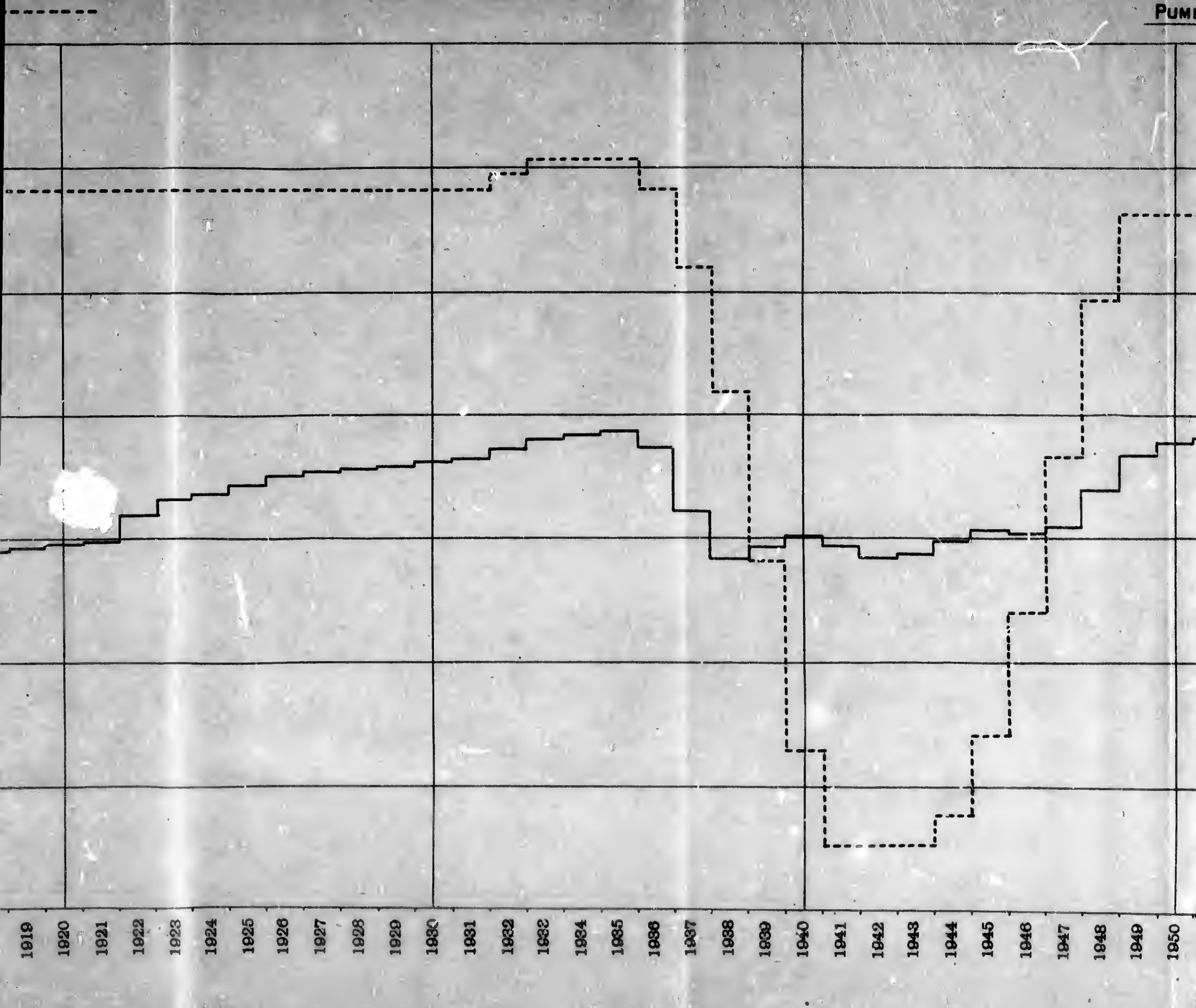
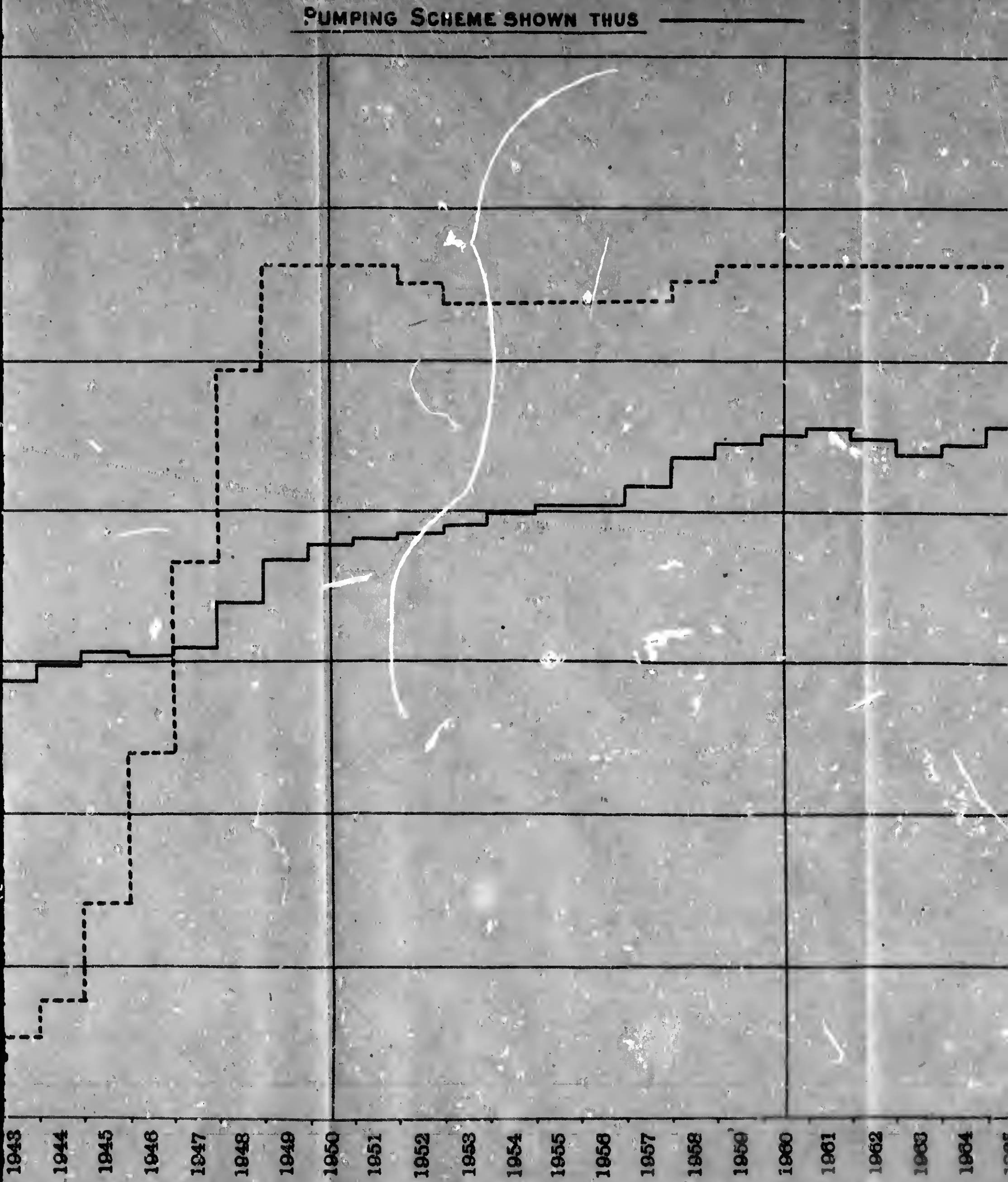
1922

DIAGRAM OF ANNUAL CHARGES.





PUMPING SCHEME SHOWN THUS
1943
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1945
1946
1947
1948
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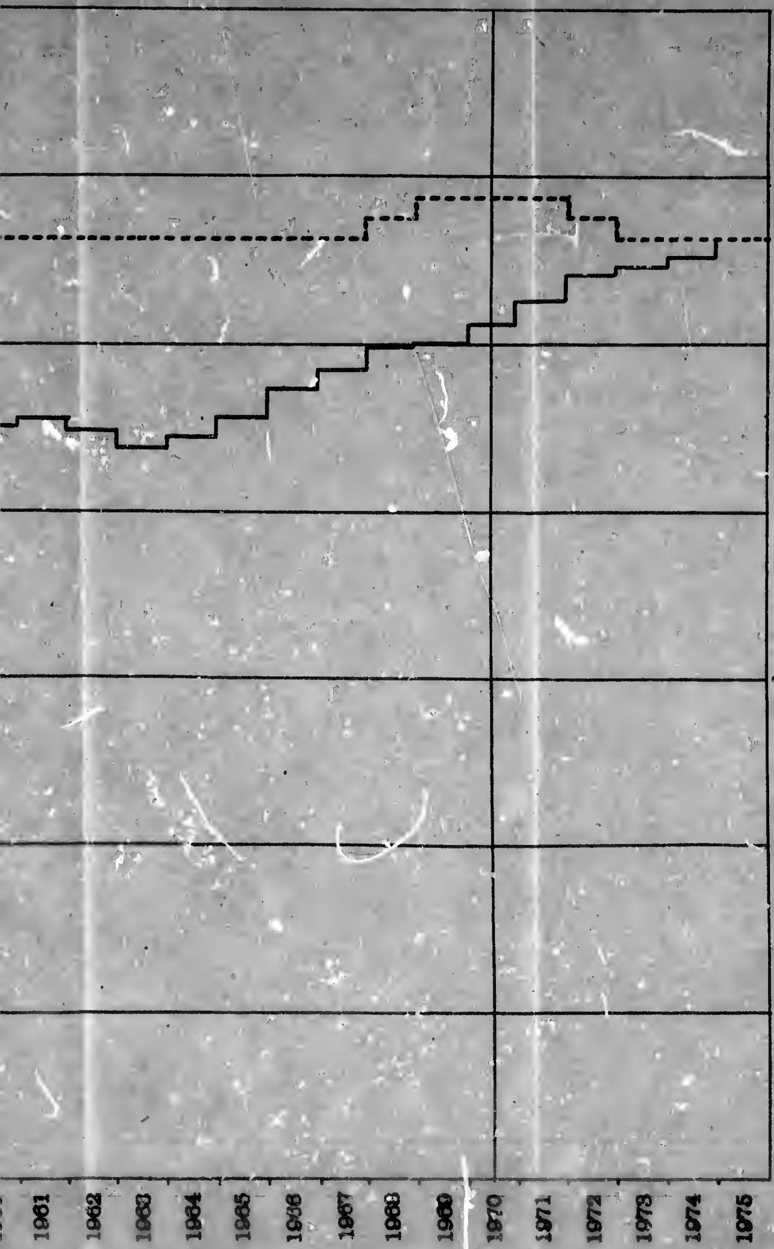
1960
1961
1962
1963
1964

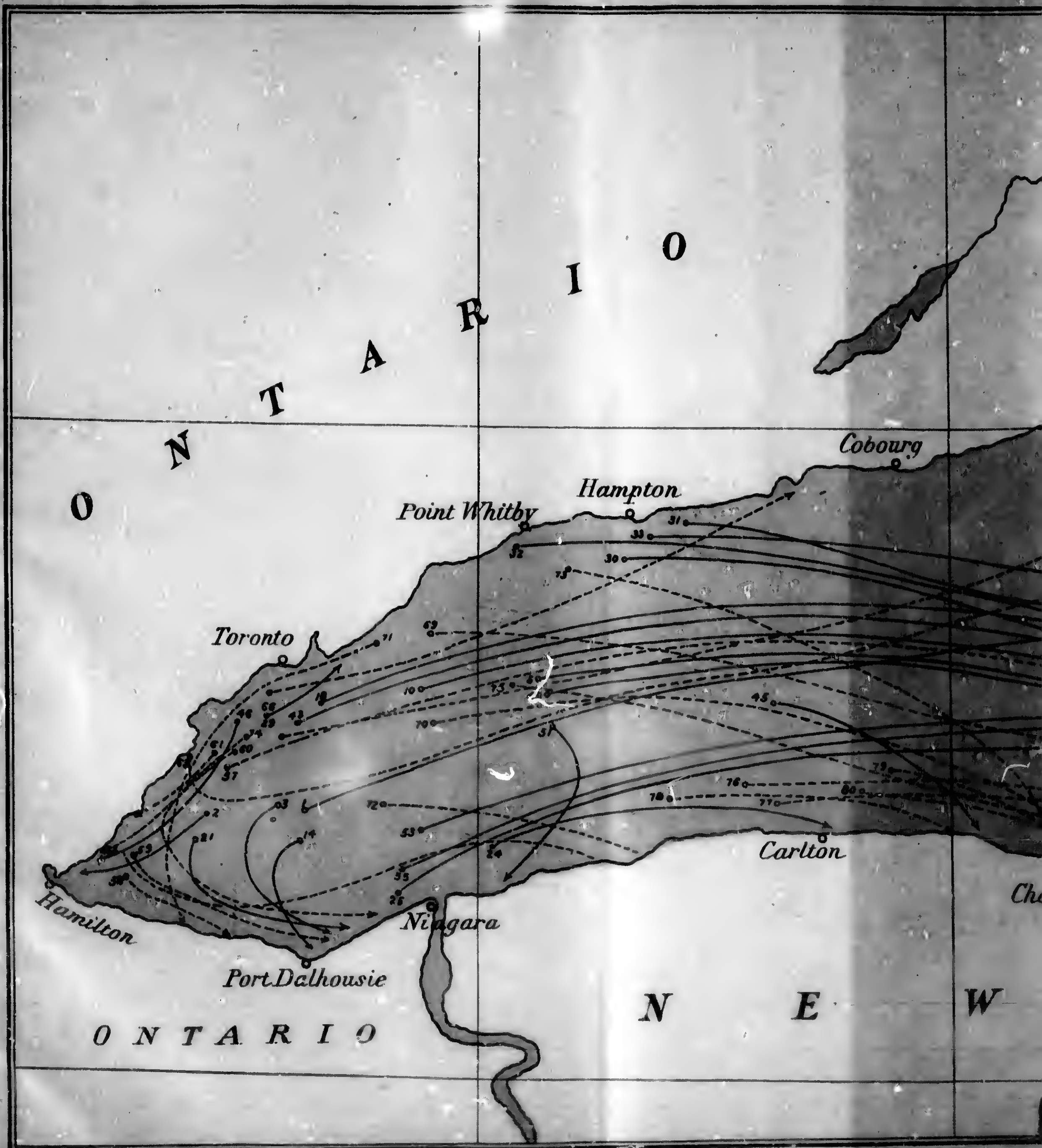
APPENDIX F.

January, 1896.



U.S. DEPARTMENT OF AGRICULTURE WEATHER BUREAU.

LAKE ON



APPENDIX G.

E ONTARIO.

BOTTLE PAPER COURSES OF 1892 & 1893.