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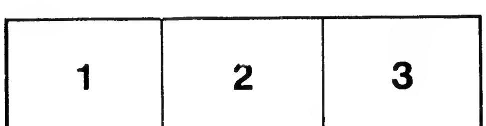

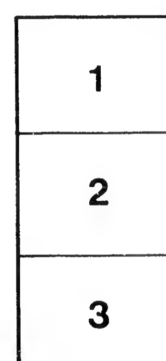

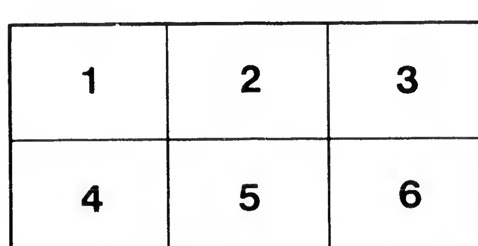

REPORT OF COMMITTEE

APPOINTED TO VISIT

LAKE SIMCOE

AND SURROUNDING COUNTRY

REGARDING

SUPPLY OF WATER BY GRAVITATION.

SUBMITTED AUGUST, 1891.

REPORT OF COMMITTEE APPOINTED TO VISIT LAKE SIMCOE AND SURROUNDING COUNTRY *RE* SUPPLY OF WATER BY GRAVITATION.

This Special Committee was appointed by the Council during the early part of the year to enquire into the question of a gravitation system of water supply. One of the first steps was to visit Lake Simcoe for the purpose of procuring samples of the water and analyzing its qualities, as well as to ascertain the extent and probable overflow of the lake.

The following members, viz., Aldermen Bailey. Foster, Phillips, and the Chairman (Ald. Hewitt), accompanied by the Medical Health Officer (Dr. Allen), W. C. Brough, C.E. (Water Works Department), W. Stuart, C.E., and J. W. Somers, Secretary of this Committee, proceeded to Lake Simcoe on June 19th, and now beg to submit their report as follows:

On our way we spent a few hours at Newmarket with Mayor Jackson and the members of the Council of this flourishing town, who very kindly showed us over their system of water supply, which is taken from several artesian wells recently sunk. The wells, reservoirs, engines and everything connected with the works reflect great credit on the enterprise and management of this thriving town. We took samples of the water, the analyses of which is given. We also visited and inspected the artesian wells which supply Barrie and Orillia, but no samples were taken, these waters having been previously analyzed by Professor Ellis.

We procured a tug at Barrie and spent two days in going over the lake taking samples, soundings, and gathering such information as we could as to the quality and quantity of the water. We were surprised at the extent of the lake. Our tug travelled at the rate of ten miles an hour, including stoppages to take samples of the water, and at this speed it took us nearly three hours to make the run from Barrie to Jackson's Point, while from Jackson's Point to the Narrows, at the northern end of the lake, is a run of three or four hours. From the centre of the lake land is invisible except, perhaps, one or two small islands.

We were thoroughly satisfied with the result of our visit, and cannot recommend in too strong terms the advisability of depending on Lake Simcoe as the main source of our water supply.

Unlimited Supply.

The area of the water-shed which supplies Lake Simcoe, and that of the lake itself, covers 1,400 square miles, or greater than the combined water-shed areas which supply Bombay, Boston, Dublin, Glasgow, Liverpool and New York. From calculations made on the rain fall over this water-shed it is found that the discharge from Lake Simcoe should be about 1,333,000,000 gallons per day. In order to test the accuracy of these figures the engineers who accompanied us on our recent visit made measurements of the capacity of the outlet to the lake and observations of the current at this point, from which data they estimated that 1,357,000,000 gallons per day pass through this outlet, which virtually confirms the former calculations and leaves no doubt that there is a superabundance of water for all time to come.

As the supply is clearly inexhaustable, the only point we need deal with is, How much will be sufficient to satisfy the requirements of the citizens in the near future? This is a difficult and weighty question, and can only be determined by first ascertaining the population for which the supply is required; but this is still more difficult to answer. Toronto has increased in population one hundred per cent. during the last ten years, but we can hardly suppose that this rate of increase will continue, as there are many contingencies to be considered.

Profiting by the example of other cities, which are supplied by gravitation, in constructing works of very much larger dimensions than their existing population would suggest, also seeing that very many cities, such as New York and Liverpool, have recently been obliged to construct new works, while others, as for instance, London and Birmingham, are now seeking other gathering grounds from which to augment their supply, we have determined, if possible, to provide for the wants of generations to come. At present we understand our daily consumption is about eighty gallons per head, and at this rate the supply we have fixed upon, viz., 120,000,000 gallons per day, will be sufficient for Toronto when her population reaches 1,500,000 souls.

Quality of Lake Simcoe Water.

We submit all the information, reports or extracts in our possession without comment, as to the superiority of one sample over another. Samples (F 1, 2, 3, 4) were all taken at the same place and at the same time, and although tested by different experts, the results are very similar, the variation being so small as to be well within the error of experiment.

Analysis of Water by Thomas Heys, Esq,

Toronto, June 30th, 1891.

Alderman Hewitt, Chairman of Gravitation Committee, City Hall:

Dear Sir,—In accordance with instructions received from you, I have made a careful analysis of the following samples of water, and beg to report as follows:

Sample marked "C" comes well within first-class water for drinking purposes, according to Muter's standard for organic impurity. The mineral standard is a little higher than Lake Ontario water.

Samples "A, E 2 and F 4" all come under second class water for drinking purposes, and are very closely alike in their general character. Sample marked "4" comes under a bad third class, and totally unfit for drinking purposes.

I remain, yours obediently,

Thomas Heys,

Consulting Chemist

Analysis of Water Marked "A."

	Parts per million.
Free ammonia	.060
Albuminoid ammonia	.134
Oxygen consumed in 15 minutes	.560
Oxygen consumed in 4 hours	1.500
Chlorine in chlorides	2.370
Total solids	145.000
Volatile matter	50.000
Odour	None
Appearance	Clear
Organic impurity—Muter's standard	36.

Contained a very slight sediment of vegetable spores and mineral matter.

Analysis of Water Marked "4."

	Parts per million.
Free ammonia	1.400
Albuminoid ammonia	.155
Oxygen consumed in 15 minutes	1.007
Oxygen consumed in 4 hours	2.000
Chlorine in chlorides	110.000
Total solids	415.000
Volatile matter	90.000
Odour	
Appearance	Very turbid, yellow colour
Organic impurity—Muter's standard	116.

Sediments, organic matter, animalculæ and mineral matter.

Analysis of Water Marked "E 2."

	Parts per million.
Free Ammonia	.034
Albuminoid ammonia	.146
Oxygen consumed in 15 minutes	.522
Oxygen consumed in 4 hours	1.442
Chlorine in chlorides	2.500
Total solids	156.000
Volatile matter	51.000
Odour	None
Appearance	Clear
Organic impurity—Muter's standard	35.5

Contained a slight sediment consisting of fresh water diatoms, vegetable spores and mineral particles.

Analysis of Water Marked "F 4."

	Parts per million.
Free ammonia	.060
Albuminoid ammonia	.145
Oxygen consumed in 15 minutes	.522
Oxygen consumed in 4 hours	1.346
Chlorine in chlorides	2.500
Total solids	115.000
Volatile matter	30.000
Odour	None
Appearance	Clear
Organic impurity—Muter's standard	35.5

Sediment traces.

Analysis of Water Marked "C."

	Parts per million.
Free ammonia	.016
Albuminoid ammonia	.024
Oxygen consumed in 15 minutes	.261
Oxygen consumed in 4 hours	.481
Chlorine in chlorides	1.400
Total solids	270.000
Volatile matter	50.000
Odour	None
Appearance	Clear
Organic impurity—Muter's standard	11.

Contained traces of vegetable conferæ, spores, animalculæ and mineral matter.

ANALYSIS OF WATER BY F. T. HARRISON, ESQ.

ONTARIO COLLEGE OF PHARMACY,
Toronto, July 4th, 1891.

Ald. Hewitt, Chairman Special Committee:

SIR,—I beg to submit the following report of the chemical analysis of the samples of water sent me by Mr. Brough, and which were collected on 19th June:

Sample.	Nitrogen as free ammonia and saline ammonia. Parts per 1,000,000.	Nitrogen as albuminoid. Parts per 1,000,000.	Nitrogen as nitrates and nitrites.	Chlorine as Chlorides. Parts per 1,000,000.	Oxygen absorbed in 15' at 80° F. Parts per 1,000,000.	Oxygen absorbed in 4 hrs. at 80° F. Parts per 1,000,000.	Phosphates.	Solids dried at 100° C. Parts per 1,000,000.	Loss on ignition. Parts per 1,000,000.	Phenomena on ignition.	Odor when heated to 100F
No. 1	.48	.082	Trace..	110.0	.447	.868	Heavy traces...	410	155	Darkened..	Nothing marked.
B....	Trace..	.123	"	1.0	.513	1.184	Very slight trace....	160	70	Blackened.	"
D....	"	.14	"	1.0	.473	1.144	"	150	70	Darkened..	"
E1...	"	.148	"	1.0	.473	1.158	"	160	70	"	"
F1...	"	.14	"	1.0	.473	1.144	"	150	70	"	"

It will be seen that sample No. 1 differs very materially from the rest, while samples B, D, E, and F, give very nearly the same results.

Mr. Brough requested that I give my opinion as to the value of these results. I may say that it is very difficult to form any just estimate of the value of palatable water without a knowledge of its source. Sample No. 1 will fully illustrate this point. By Muter's scale, this would be pronounced "undrinkable." By Tidy's as also by Wanklyn's scale it would rate second class, and were I to find this sample in a shallow well, I would have little hesitation in condemning it as unfit for use. The large amount of free ammonia, the somewhat excessive amount of albuminoids, large amounts of chlorides and presence of phosphates would indicate contamination of the water by urine as more than probable. It is, however, well known that waters from very deep wells contain large amounts of ammonia and the other constituents mentioned. Dr. Fox gives reports of waters from deep artesian wells renowned for their purity, as follows:

	Free ammonia.		Alb. ammonia.	
(*a*) Well 385 feet deep.........	.59	......	.04	Parts in 1,000,000
(*b*) " very deep.............	.41	......	.07	" "
(*c*) " 330 feet deep.........	.37	......	.06	" "

Wanklyn also gives the analysis of a pure deep spring water which he calls "first class," as follows:

Free ammonia, .80, albuminoid ammonia, .05, chlorine, .140 parts per 1,000,000.

I am sure this will fully show that a chemical analysis, apart from all other considerations, may not give a just estimate of the fitness of water for drinking purposes. This is due to the fact that the substances found, are for the most part looked on with suspicion rather to what they indicate than to any injurious effect which they themselves might produce.

Not having explicit information as to the conditions which might effect these waters, I can only offer a few general remarks.

No. 1 I have already referred to; the other samples I may speak of collectively, the results being so nearly alike.

They would be condemned by the scale offered by Dr. Muter; by Tidy's scale they would rank as second class; by Wanklyn's albuminoid ammonia scale as third class.

By all these standards the average of Toronto water, as also a sample analysed by myself, drawn from the tap at the College of Pharmacy this week, would rank as first class.

These standards are based on the amount of organic matter found. As chemical analysis cannot certainly determine between injurious organic matter and that which may be uninjurious, the only safe way is to condemn such as contain it in large amounts.

It would be absurd, however, to judge absolutely the fitness of our upland surface waters for drinking purposes by comparing them with the standards to which I have referred. The sources of our streams and small lakes lie in dense forests, hence the water is loaded with vegetable organic matter.

Prof. Nichols says: "Such an absolute standard is impracticable, and would exclude many waters known to be free from contamination, and to be perfectly well suited for domestic use."

Dr. Smart, another authority says: "The waters of the purest mountain stream in our unsettled west, where animal contamination is an impossibility, contain .014 parts of albuminoid ammonia per 100,000 (.115 of N per 1,000,000). At other times they may contain .02 to .025 or more (.16 to .20 of N per 1,000,000), and yet be regarded as comparatively innocent."

To apply these standards to such waters would give quite a wrong impression, and would condemn waters much safer than some which might be placed in first rank by them.

While I say it is impossible to give a just estimate of the value of water for drinking or domestic purposes without thoroughly investigating the source, I have no hesitation in saying that I believe samples B, D, E, and F, to contain vegetable organic matter rather than that of animal origin ...deed, the practical absence of free ammonia, of nitrates and nitrites, of phosphates, and the very small amount of chlorides, would indicate that the organic matter was entirely of vegetable origin, and to be entirely free from sewer or animal contamination.

I have the honor to be, sir,

Your obedient servant,

FRANKLIN T. HARRISON.

ANALYSIS OF WATER BY A. R. PYNE.

GERRARD STREET EAST, July 9th, 1891.

To Ald. Hewitt:

DEAR SIR,—I beg leave to submit the analysis of two samples of water marked F2 and F3 sent to me from Engineer Brough's office on the 8th inst., some days after collection of same:

	In parts per million.	
	F2	F3
Total solids	140.0000	180.0000
Volatile matter	56.0000	92 0000
Solids non-volatile	94.0000	88.0000
	Last quantities nearly alike.	
Chlorine or chlorides	5.2000	5.0000
Free ammonia	.0355	.0291
Album. "	.1595	.1350
Oxygen absorbed in 15 mins	.6980	.7150
" " 4 hrs	1,3610	1.3100
No nitrites.		
No phosphates.		
According to Muter's scale	.396	.368

In commenting on the above results I might say, that notwithstanding the fact that the organic impurity is sufficiently high to place both samples in second class waters according to Muter's scale, I am of the opinion that taking into consideration the small quantities of chlorides present coupled with the absence of phosphates, together with other indications, that the source of organic impurity is vastly of plant origin, and not of animal excreta. It is also a notable fact worthy of consideration, being a favorable indication, that there is no trace of nitrites in either water, and further I might add that though a high degree of organic impurity is something most objectionable, yet it is very much less so when it can be shown to be of plant origin than of animal excrement.

All of which is respectfully submitted.

A. R. PYNE,

Analyst.

MEMORANDUM REFERRING TO THE SAMPLES OF WATER PROCURED BY ALD. HEWITT'S SUB-COMMITTEE, *re* GRAVITATION WATER SUPPLY WHILE INSPECTING LAKE SIMCOE, JUNE 19TH, 20TH AND 21ST, 1891.

BOTTLE No. 1—Taken from the artesian well at Newmarket. This well is *150 feet deep.*

BOTTLE No. 4—Taken from the artesian well at Newmarket. This well is *250 feet deep.*

LAKE SIMCOE.

BOTTLE No. "A"—Taken from the lake about one mile out on the production of the 6th concession of North Gwillimbury; sample taken at a depth of 40 feet, time 11.30 a. m., June 20th; full depth of water at this point 48 feet. Wind east.

BOTTLE No. "B"—Taken at a depth of 20 feet, about 1200 feet from Mossington's Point, time 12 o'clock, noon. Full depth of water 24 feet.

BOTTLE No. "C"—Taken from the spring which is situated on the banks of the lake, midway between Mossington's Point and Jackson's Point.

BOTTLE No. "D"—Taken from the lake about 2000 feet out from Jackson's point, sample taken at 25 feet, full depth of water 30 feet. Time 12.35, p. m., June 20th, 1891.

BOTTLE No. "E"—Taken from the lake one mile from Jackson's Point—north half east. Full depth of water 50 feet, sample taken at 40 feet. Time 2.25 o'clock p. m. Wind north-east.

BOTTLE No. "E2"—Taken same as "E".

BOTTLES No. "F1", "F2", "F3" and "F4"—Taken three miles north by west of Georgina Island—sample taken at a depth of 30 feet. Full depth of water at this point 65 feet.

EXTRACTS FROM REPORT OF DR. ELLIS.

(See Water Works Report for 1886.)

David Walker, Chairman Water Works Committee, City Council:

I have the honor to submit the results of my analyses of the waters of the Ridge lakes, of Lake Simcoe, of Lake Ontario, and of the water supplied by the Toronto Water Works.

Organic Matter.

This is the constituent of a potable water, the determination of which is of by far the greatest importance, for it is upon the quantity and kind of organic matter present that the wholesomeness of the water depends. In this respect the kind of organic matter is far more important than the quantity, and many authorities hold that the injurious effects of unwholesome drinking water are produced by certain kinds of living organisms which are present in such water and absent in those waters which do not cause disease. Unfortunately, we can ascertain very little about the nature of the organic matter contained in a water. From chemical grounds, it is impossible to say whether the organic matter of a given sample of water will be harmless or noxious. We can say whether there is much or little organic matter present; but whether this organic matter is injurious or not we cannot say. Again, by means of the microscope and other examinations from a biological standpoint, we can ascertain the presence or absence of living organisms and their relative abundance; but in the present state of our knowledge it is impossible to state whether or not a given sample is or is not free from dangerous contamination.

We know, however, that waters which experience has shewn to have produced injurious effects upon those who have drunk them, almost always contain an amount of organic matter in excess of those waters which are constantly drunk without ill effects. And although it is quite true that waters which contain a large excess of organic matters are often taken without any apparent evil results to the health of those using them, still it is obvious that in such a case as this it is better to err upon the side of safety and condemn all waters in which the organic matter exceeds the standards of ordinary purity. In this connection it must not be forgotten that the disease-producing matter of polluted waters is in at least those cases which excite our gravest apprehensions, derived from the excreta of men and animals, and cannot be introduced into the water without the introduction of other matters perhaps harmless in themselves, but which will raise the quantity of organic matter present in the water.

We may then say in general terms that a water which contains much organic matter is unfit to drink, and on the other hand a water which is organically pure is not likely to cause disease in those using it.

It is, therefore, of the highest importance to determine as accurately as possible the amount of organic matter present in a water.

Conclusions.

In judging of the character of a public water supply, it is impossible to lay down any hard and fast lines. Each case must be judged on its own merits.

Several analysts have proposed standards of purity, but none of these have been generally accepted, since local circumstances differ very widely, and analytical results which would point to dangerous pollution in one case might be without any serious significance in another. Still these standards are useful in permitting us to compare one water with another at a glance, and it will be worth while to apply them to the waters under consideration.

The late Mr. Wigner, when Secretary of the Society of Public Analysts of Great Britain, proposed a very elaborate scheme for valuing a water, which, although not officially adopted, has been used to a considerable extent by the members of that body, and has met with general approval even from those who have objected to binding themselves to any rigid standards. It takes cognizance of all the determinations which I have described and attaches a value to each, the most impure waters having the highest value.

The samples examined, when valued by this scale, show the following results. Mr. Wigner's limit for a first-class water is 40:

Lake Ontario,	8 miles out	22
"	at Bell Buoy	20
"	off Scarboro Heights	21
"	off Parkdale	21
"	in Shore Crib	23
"	in Pumping Well	22

The differences between these figures are so small as to be within the error of experiment, and these waters may be considered as practically of the same degree of purity. They are first-class waters.

Mr. St. George's well	(first-class)	32
Lake Simcoe,	off Grape Island	66
"	off Roche's Point	68
"	off Snake Island	71
"	in Cook's Bay	75

These are not first-class. The water seems to become gradually purer during its passage through the lake.

The Ridge Lakes.

Bond Lake	90
McLeod's Lake	99
Musselman's Lake	105
German's Spring	186
St. George's Lake	189
Reesor's Lake	198
Bayle's Lake	218
Willcocks' Lake	241
Ferguson's Lake	361

The waters of Bond and McLeod's Lakes are used for drinking purposes. The others are, I believe, not used except for cattle.

Dr. Muter proposed a scale on a similar principle to Mr. Wigner, taking account only of the four determinations which bear on the organic impurity, namely, the free and albuminoid ammonia and the oxygen absorbed in 15 minutes and 4 hours respectively.

He divides the water into three classes, as follows:

First class up to	·25
Second class up to	·4
Undrinkable over	·4

The waters examined by this scale are as follows :

CLASS I.

Mr. St. George's well	·04
Lake Ontario, 8 miles out	·09
" at Bell Buoy	·09
" off Scarboro' Heights	·09
" off Parkdale	·09
" in Shore Crib	·10
" in Pumping Well	·09

CLASS II.

Lake Simcoe :

Off Grape Island	·31
Off Roche's Point	·34
Off Snake Island	·36
In Cook's Bay	·38

CLASS III.

The Ridge Lakes :

Bond Lake	·53
McLeod's Lake	·68
Musselman's Lake	·69
Gorman's Spring	1·39
Reesor's Lake	1·49
St. George's Lake	1·65
Bayle's Lake	1·66
Willcocks' Lake	2·19
Ferguson's Lake	2·71

All these last are classed among undrinkable waters by this scale.

Tidy has proposed a classification of potable waters, based on the amount of oxygen absorbed, as follows :

Class I.—Waters of great organic purity, oxygen absorbed not over ·1 in 100,000.
Class II.—Waters of medium purity, ·1 to ·3.
Class III.—Waters of doubtful purity, ·3 to ·4.
Class IV.—Impure waters, over 4.

Classified on this basis, these waters range themselves as follows :

CLASS I.

1. Mr. St. George's well.
2. Lake Ontario, at the Bell Buoy.
3. Lake Ontario, near Parkdale crib.
4. Lake Ontario, off Scarboro Heights.
5. Lake Ontario, Pumping Well.
6. Lake Ontario, Shore crib.
7. Lake Ontario, eight miles out.

Class II.

8. Lake Simcoe, off Grape Island.
9. Lake Simcoe, off Snake Island.
10. Lake Simcoe, in Cook's Bay.
11. Lake Simcoe, off Roche's Point.
12. Musselman's Lake.
13. Bond's Lake.
14. McLeod's Lake.
15. Gorman's Spring.
16. St. George's Lake.

Class III.

17. Reesor's Lake.
18. Bayle's Lake.
19. Willcock's Lake.

Class IV.

20. Ferguson's Lake.

It will be seen from this that, by Dr. Tidy's classification, Mr. St. George's well and the waters of Lake Ontario, both in the open lake and as supplied to the consumers, rank as waters of great organic purity; the waters of Lake Simcoe, and of Musselman's, Bond, McLeod's, and St. George Lakes, and Gorman's Spring, as waters of medium purity; the waters of Reesor's, Bayle's, and Willcock's Lakes as waters of doubtful purity; and the waters of Ferguson's Lake as impure.

Mr. Wanklyn, who is the inventor of the albuminoid ammonia process, classifies waters according to the amount of albuminoid ammonia obtained from them, as follows, in parts per 100,000:

Class 1.—Extraordinary purity, ·0 to ·005, albuminoid ammonia.
" 2.—Satisfactory purity, ·005 to ·010, "
" 3.—Dirty, over ·010, "

Over ·015 of *free* ammonia, according to Wanklyn, condemns a water.

By this criterion the waters rank as follows:

Class I.

Waters of Extraordinary Purity.

			alb. am
1.	Mr. St. George's well		0
2.	Lake Ontario, 8 miles out		·002
3.	"	at Bell Buoy	·002
4.	"	off Scarboro' Heights	·002
5.	"	at Parkdale Crib	·002
6.	"	in Shore Crib	·002
7.	"	in Pumping Well	·002

Class II.

Satisfactory Purity.

8. Lake Simcoe, off Grape Island	·010
9. Gorman's Spring	·010

Class III.

Dirty Water.

10. Lake Simcoe, off Roche's Point	·012
11. " off Snake Island	·014
12. " in Cook's Bay	·014
13. Bond Lake	·014
14. McLeod's Lake	·018
15. St. George's Lake	·020
16. Ferguson's Lake	·020
17. Mussleman's Lake	·022
18. Bayle's Lake	·024
19. Reesor's Lake	·028
20. Willcocks' Lake	·042

Comparing now these results:

1. We see that by all these four standards the water of Lake Ontario is water of extraordinary organic purity, and that the water as supplied by the Toronto Water Works does not differ in this respect from that of the open lake.

2. The water of Lake Simcoe is not nearly so pure as that of Lake Ontario, and can only be ranked as a second-class water.

3. The water of the Ridge lakes is very impure, and entirely unfit in its present condition for drinking purposes.

These standards are all of English origin and intended for English waters, and in applying them to Canada we must of course take into consideration local conditions. In England the gathering grounds of the streams and lakes are largely under cultivation Here most of our rivers rise in land which is altogether in a state of nature, and which in many cases consists largely of tracts of ground such as cedar swamps, in which decaying vegetable matter is present in immense quantity. It is probably owing in part at least to this circumstance that the water of our lakes and streams contains, under circumstances which put out of the question any possibility of excremental or sewage pollution, considerably more organic matter than those of Great Britain. (W. R. Nichol's "Water Supply," p. 98.)

This shows itself by an increase in the albuminoid ammonia and in the oxygen absorbed. It follows that the standards of Wanklyn and Tidy, which are based upon these determinations, must be applied with caution to American waters. Thus in 23 public water supplies of Great Britain and Ireland, in 2 only does the albuminoid ammonia exceed ·010 parts per 100,000; while in 42 American waters this figure is exceeded in 33. (C. F. Chandler's Report on water of Hudson River, 1886.)

The organic matter of these lakes, as well as Lake Simcoe, is of vegetable origin, and is due to decaying plants and leaves. No trace of excrementious or sewage pollution is to be detected in any of them, unless the high amount of ammonia in St. George's Lake is to be taken as indication of pollution from farm-yard sources. The same holds good for Lake Simcoe.

Now we must not lose sight of the fact that the greatest of all dangers—the spread of infectious disease by a water supply—is quite independent of this *comparatively* harmless vegetable matter. This poison, whether living organisms or not, may be—indeed generally is—absent from a dirty water, and may be present in one comparatively clean, although there is every reason to think that the presence ot organic matter in a water helps the development and spread of this poison, if indeed it is not absolutely essential to its existence. The water of the Ridge lakes is dirty water, and the water we are getting from Lake Ontario is clean water. But if any of the town sewage should get into the water supplied to us, even though it should be in a quantity so small as to leave the water, as determined by analysis, far better, apparently, than the water of the Ridge lakes, yet it would be infinitely more dangerous. It is, therefore, most essential to make sure that this is not the case.

My analysis given in the table is satisfactory so far as it goes. I cannot distinguish between the water of the pumping well and the lake water, except in permanent hardness. Why the pumping well should be harder than the lake water I am not prepared to say. It is very unsafe, however, in such a delicate matter, to draw conclusions from a single analysis, and I would suggest to your committee the great desirability of having monthly analysis made of the water for a sufficient time to enable one to draw a reasonably certain conclusion. It would be very desirable also that not only a chemical but also a biological examination should be made, systematically, of the water. Since the danger feared is by many believed to be caused by, and by all is allowed to be associated with, the presence of certain living forms; and since many new and refined methods have been devised and used recently for the examination of water in this respect, I would respectfully request that, if your Committee see fit to entrust me with any more researches on this important subject, that they would associate with me Professor Ramsay Wright, in order that we might carry on the chemical and biological examinations conjointly.

ANALYSIS OF LAKE SIMCOE WATER.

Parts per 100,000.

	Grape Island.	Snake Island.	Roache's Point.	Cook's Bay.	Asylum Spring, Orillia.
Appearance, seen through 2 foot tube	Clear, pale, greenish yellow.	Clear, pale, greenish yellow.	Clear, pale, greenish yellow.	Clear, pale, greenish yellow.	Clear, colourless.
Smell at 100 deg. Fah.	None.	None.	None.	None.	None.
Chlorine	.05	.05	.05	.05	.20
Phosphoric Acid	None.	None.	None.	None.	None.
Nitrogen in Nitrates	.0033	.0033	.0033	Very little.	.1676
Free Ammonia	.004	.004	.004	.008	.004
Albuminoid Ammonia.	.010	.014	.012	.014	None.
Oxygen absorbed in 15 minutes	.0576	.0548	.0588	.0656	None.
Oxygen absorbed in 4 hours	.1356	.1592	.1512	.1496	.0346
Hardness before boiling	7.95	11.05	11.5	11.35	15.79
Hardness after boiling.	2 82	2.99	3.9	2.73	1.27
Total solid matter	10.36	14.4	15.6	16.4	29.6

Microscopical Examination—A few diatoms.

EXTRACT FROM REPORT OF WILLIS CHIPMAN, C.E., ON PROPOSED SYSTEM OF WATER WORKS FOR THE TOWN OF BARRIE.

(Results are given in parts per million.)

	Rake's Bay.	Kempenfeldt Bay
Physical character	Clear.	Slightly turbid
Color	Nearly colorless	Nearly colorless
Dry solids at 100° C.	148	148
Ignited solids at 100° C.	88	84
Loss	60	64
Phenomena of ignition	Charred	Blackened
Hardness before boiling	106	92.9
" after "	30	19.5
Albuminoid ammonia	.1324	.1324
Free ammonia	.0329	.0165
Nitrates, etc.	.0906	.0658
Chlorine	2.0	2.0
Phosphates	None	None
Oxygen absorbed in 15 min.	0.6096	0.6096
" " 4 hrs.	1.3116	1.2716

Contains much vegetable matter.

The above analyses were made by Dr. Ellis, of Toronto.

Extracts from Report of Messrs. McAlpine and Tully.

(*See Water Works Report for* 1886.)

The water supply to Toronto was stated lately to be the purest in the world; if so, it is strange that this pure water cannot at all times be supplied to the citizens.

The Report of Professor Laut Carpenter, who was here in 1884 with the British Association, and who tested the water at various points in the Bay and Lake, states that the water at the bell buoy, outside the Island, the inlet of the water supply pipe, is "decidely the best sample of all. but did not compare well with pure water. This is without doubt contaminated to a certain extent;" also, (3) "That the water as drawn from the bell buoy is by no means free from contamination from sewage and other organic impurities." His conclusions are (4) "That this water becomes mixed in its passage from the bell buoy to the pumping house with the bad water in the Bay, probably from leaks in the pipes, and in the well at the lake end of the wharf at the pumping house."

"A town may go on for some time drinking contaminated water with apparent freedom from illness, but this water is the breeding ground for many germs and microbes, and experience has shown that the intestinal discharges of one typhoid fever patient into such water is sufficient to poison a large water supply, so rapidly do the germs multiply under favorable conditions."

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 The plans herewith presented contemplate the removal of all existing decayed or growing vegetable matter from the bed of the lakes to a depth of fifteen or twenty feet, and coveringall of the surfaces, when the beds of the lakes are liable to grow vegetation, with coarse gravel. These measures will remove almost or nearly all of the vegetable contamination to the water from these lakes. It is also proposed that the water from the lakes shall be conducted in open channels for considerable distances, and particularly down the channel of the upper part of the west branch of the River Don, where the fall is frequently considerable, which will produce much agitation. These exposures of the running water to atmospheric influence will doubtless oxydize the impurities of all kinds which may happen to enter the waters.

It is also intended to have automatic reversible filters in one of the lower reservoirs on each of the rivers, which will remove any possible remainder of the impurities. In many cases the cost of filtering is expensive, but in the present one the power required to force the water through the filter will be without cost, and the previous action of the subsidence in the large reservoirs and aeration in the open channels will leave but little, if any, for the filters to perform, and their expense will be comparatively small. The water from these sources thus treated will undoubtedly be equal to that from Lake Ontario, with less degree of hardness, Bond Lake being only six degrees, while Lake Ontario is ten. St. George's and Willcocks, however, are harder than Lake Ontario, according to the analyst's report. The water will be agreeably aerated by the rapids of the rivers and in passing through the filters.

These waters may be discharged through a fountain in the centre of the Rosehill reservoir, thereby ensuring aeration and further oxydation, an arrangement which has been successfully and ornamentally carried out at the lowest reservoir at the Rochester Water Works.

Water running through streams is self-purified. All the impure matter is oxydized by its contact with the atmosphere, and when it is collected into the reservoir, and becomes quiescent, the operation of purification goes on always. All the matter that it hitherto contained which is heavier than the water goes to the bottom, and that which is lighter than the water rises to the top, is exposed to the air, becomes volatilized, and is carried away by the wind.

Hence the best mode of purifying the water is a reservoir, and a natural lake, of which the engineer's reservoir is merely an imitation. Water from land used for agricultural purposes is not objectionable. In no part of the world has water from farming lands been found to be defiled. In fact, good earth is of itself a purifier of water, as instanced in earth closets.

As before mentioned, in addition to its purity, the water which can be supplied by gravitation to the City will be found suitable for domestic use on account of its softness as compared with the water at present supplied from Lake Ontario, a matter of the utmost importance to the citizens.

EXTRACT FROM REPORT OF WILLIS CHAPMAN, C.E., ON PROPOSED SYSTEM OF WATER WORKS FOR THE TOWN OF BARRIE.

Kempenfeldt Bay.

"The water at present is as good as could be desired for domestic purposes."

EXTRACT FROM REPORT OF MESSRS. HERING & GREY.

Lake Simcoe Water.

"From the analysis made by Dr. Ellis, we can assume that the water is also suitable in quality; if taken from a point sufficiently distant from the discharge of the marsh water at its southern end; although we must add that its taste is inferior to that of Lake Ontario, and that it is chemically less pure, containing a greater proportion of organic matter, which is probably of vegetable origin."

During our recent visit to Lake Simcoe we paid particular attention to the physical nature of the surrounding country. The low lying land along the west branch of the Holland River, made us feel that it would not be advisable to locate the intake anywhere in Cook's Bay. We therefore suggest Jackson's Point or somewhere in that vicinity as the most desirable place from which to take the supply. Here there is no indication of a marsh country, the shore of the lake being comparatively steep and the beach composed of boulders, course gravel and sand. We saw the samples taken ourselves and can vouch for them, the appearance of the water when drawn to the surface was perfectly clear without sediment or any minute particles being visible, while its taste was all that could be wished for.

Lake Simcoe Water as Compared with that of Lake Ontario.

As far as we are able to judge the chief difference between the quality of Lake Simcoe water and that of Lake Ontar o is the presence of much vegetable organic matter, which is not so prevalent in Lake Ontario. That this vegetable matter can be got rid of we have no doubt, by the process of filtration and aeration, although we hardly think it necessary, still if this be required we are confident that the quality of the water by the time it reaches Toronto will compare most favourably with any in the world.

On the other hand Lake Ontario water shows the presence of very much more animal organic impurities than can be found in Lake Simcoe, which impurities we consider are due to sewage pollution, the ill effects of which may be judged from the extract taken from Dr. Ellis' report.

In arriving at a comparison between the waters of Lake Simcoe and Lake Ontario, we find that of Lake Simcoe always rated as a second class water, while Lake Ontario is mostly pronounced first class. The natural inference would be that the water we get now is the better of the two, but we think not. We understand the impurities which cause Lake Simcoe to rank only as second-class are entirely due to vegetable organic matter, no animal pollution being found. On the other hand, Lake Ontario is frequently tainted with organic matter distinctly traced to animal or sewage contamination. We are told by Professor Ellis and others that this vegetable organic matter is comparatively harmless, and that the animal organic matter is infinitely more dangerous, even although the quantity present be so small as to have little or no effect on the sample taken for analysis. Again, all the experts state most emphatically that the standard used in judging the quality of such water as Lake Simcoe being an English one, is much too high when arriving at the true value of the water, and is not adapted to the true testing of such water as flows off such a country as the water-shed supplying this lake; it must therefore follow that chemical analysis places this water in a lower class than it deserves.

All the analyses of Lake Simcoe water differ only to the extent of a few points, in the degree of organic impurity, which according to Muter's scale is about 35 degrees, showing that the quality of water remains constant. On the other hand, that of Lake Ontario fluctuates, and analyses made this year of samples taken from the pumping well show a variation of from 15 degrees at its best stage to 67 degrees at its worst. The average would give 41 degrees of impurity, which would therefore make it rank lower than that of Lake Simcoe. Of course we do not say this is a fair average quality of our water all the year round, for fortunately, the periods when the water is really bad are comparatively of short duration. But water is necessary at all times; no matter whether it is good or bad we must use it every day. Under these circumstances we must prefer the water which retains its good character at all times to that which, while it is generally first class, does at certain periods drop into a low third class, and is pronounced undrinkable.

During stormy weather, Lake Ontario, like all other large sheets of water, becomes somewhat riley, and, owing to a system of direct pumping, not unfrequently does the water we draw from our taps have a very turbid appearance. Although this may or may not have an injurious effect, still it is certainly very objectionable; and it is clear that much of this suspended matter must lodge and accumulate at the bottom of the mains to become the breeding ground for microbes and disease-bearing germs. This is particularly applicable to "dead ends" and portions of the mains where, through lack of sufficient consumption, the water is allowed to become stagnant; consequently we find the quality of the water worse in some portions of the City than in others.

Under a gravitation system this evil will cease. Of course Lake Simcoe is also subject to storms, and doubtless its water does at times become more or less disturbed; this cannot be prevented, but the remedy is simple and inexpensive. At the upper end of the aqueduct wire strainers, and, if necessary, filtering beds can be established, and after the water has passed through these, it will have to travel through forty miles of conduit before reaching the reservoirs, so that any particules held in suspension would surely settle, naturally at the lowest portions of the pipes, where "blow-off" valves, etc., would be placed for cleaning purposes.

But even, if by any chance, some particules did find their way into the reservoir it would not matter. Here all the water is brought to rest and all sediment allowed to sink to the bottom, so that nothing but pure and absolutely clean water could at any time pass into the distributing mains.

REPORT OF WALTER C. BROUGH, C.E.

TORONTO, July 2nd, 1891.

To the Chairman and Members of the Gravitation Committee:

GENTLEMEN:—I beg to make the following report on the information gained in a preliminary investigation as to the advisability and possibility of the City of Toronto drawing its future water supply from Lake Simcoe.

On June 20th, 1891, samples of water were taken from various points at the south shore of the lake at different depths and distances out, and marked carefully as given hereafter, and which can therefore be compared with the results of analysis made by Professors Heys, Harrison and Dr. Pyne.

It will be observed by referring to a map that sample "A" was the nearest to Cook's Bay, and sample "E" the furthest westward on the south coast.

Samples "F1" and "F4" were taken out towards the centre of the lake, which would consequently locate the position in almost a direct line of the current between Cook's Bay and the outlet of the lake at the "Narrows."

Samples No. 1 and No. 4 were taken from two artesian wells at Newmarket on June 19th, 1891; the former being six inches in diameter and 180 feet deep, and I learn has been flowing for about four years; the latter is of the same diameter but 250 feet deep, and, I am informed, is greatly affected in color after a heavy rain storm, thereby proving it must have its origin at the surface of the earth.

No definite information could be gained as to the combined discharge of these wells, but the estimated flow is supposed to be 70,000 imperial gallons per twenty-four hours.

The shore of the lake, reaching from Roach's Point to Jackson's Point opposite where the samples were procured, is elevated several feet above the lake, is of gravel formation and free from marsh except at Black River where there is a narrow strip of marsh.

The bottom of the lake was of clean sand and gravel, which could be seen through the clearness of the water at a depth of from ten to fifteen feet.

The lake is fed by numerous rivulets and springs, which are reported to be within an average of a quarter of a mile apart round the entire shore of the lake.

The surface of the lake is close on to 300 square miles with a drainage area of 1,000 square miles.

The discharge from Lake Simcoe amounts, at a low estimate, to 1,400,000,000 imperial gallons per 24 hours, and flows through the only one visible outlet, being the "Narrows" between Lakes Simcoe and Couchiching. The flow from Couchiching and Simcoe combined amounts to over 2,000,000,000 imperial gallons per 24 hours.

The important points to be considered are:

1. Is the water in its natural state of a satisfactory quality, if not, what is the prevailing foreign matter in it, and can this matter be got rid of by filtration without adding too much to the cost of the works.

2. Is there a sufficient quantity for present and future use?

3. Would the expense necessary for conducting the water from Lake Simcoe to the City be too excessive?

The answer to the first and second portions of the first enquiry will be given by the analysis, and the third portion may be explained by stating that the plant for filtering 30,000,000 gallons per day would cost in the neighborhood of $150,000.

As to the second important point there is no doubt as to there being a sufficient quantity for all time to come, for although there was not sufficient time to take accurate gaugings, still from what measurements, etc., I could take I am convinced that the foregoing estimates, namely, 1,400,000,000 in the one case and 2,000,000,000 in the second, of discharge can be very considerably increased by making fuller investigations.

With reference to the third important consideration, it is impossible to answer with such limited information, but without presumption on my part and with due respect to Messrs. Hering and Gray's report on the same subject I think the work could be carried out to a much greater advantage and more reasonably on a line leading from near Jackson's Point or opposite where sample "C" was obtained to the southern side of the Oak Ridges in almost a direct southerly line from whence it would take a south-westerly direction following the most advantageous topography of the country until the desired point near the City was reached.

My reason for selecting this route is because without doubt the intake would be at the most favorable point for purity, because out of the line of current between Cook's Bay and the "narrows," and would, therefore, be principally fed from springs freer from vegetable contamination, and also that the country for about fourteen miles southward from the lake to the base of the ridges rises only about one foot per mile and that the ridges at this point, judging from the grades on the railways and from other information, are nearly two hundred feet lower than on the line of Yonge Street, and I should, therefore, imagine in consequence that the width of the ridges and necessary tunneling would be greatly reduced also.

I also consider that a vast reduction in the cost of construction might be obtained by greatly reducing the depth of the cutting from the lake to the ridges and lessening the length of tunneling in the following manner:

1. In reducing the depth of the cutting immediately at the lake, for although the intake might be at any desirable depth (as in the present system of water supply for the City) it does not necessarily follow that it is to maintain that depth, but instead of being twenty feet below water level of the lake it might rise at the shore to within about five feet (refer to profile in the Water Works Annual Report for 1883) for this depth would ensure a sufficient frictional head, even should the lake be lowered two feet by the bursting of dams, etc., or as at present desired by the inhabitants of the surrounding country.

Further, instead of having as steep a grade from the lake to the south of the Ridges, as shewn in the above-mentioned profile, I would advise to greatly lessen the fall, thereby lessening the cuttings and tunnellings, but in compensation therefore, would increase this portion of the conduit in proportion; or in other words, have this portion act more in the capacity of an arm of the lake, say eight feet instead of six feet, or similar proportion as might hereafter be judged consistent.

If it were considered necessary to filter a portion of the water for domestic purposes, then a filter with a capacity of 30,000,000 imperial gallons might be located at the discharge of this arm, or just at the south of the Ridges, allowing the filtered water to pass through one line of piping to the City, and the unfiltered to pass through a second line of pipes for manufacturing purposes, with valves so arranged that the filtered or unfiltered water would be controllable, and conducted through either line of pipes at will.

One point I might draw your attention to is that the waters of Simcoe and Couchiching might be made controllable from an engineering point of view, as to their lowering or heightening, by enlarging or closing their final outlet into the Severn River by blasting and removing the rock at the mouth thereof, or by the placing of gates, which could be done with comparatively little expense as the openings are narrow and of solid rock; therefore, although considerable water might be drawn to the City, it does not follow that the level of the lake should be changed.

Finally, I consider it advisable to further investigate this probable important source of water supply, and to obtain as accurate an estimate of the cost thereof as possible; and in the first place, in order to do so, I would suggest having flying levels taken across the Ridges on the concession lines (if such can be done at right angles to the Ridges), from the level of Lake Simcoe on the north to the same elevation on the south, taking the town lines and lots for the measurements of distances, and for a width of several miles, so as to ascertain without doubt the narrowest portion of the Ridges, which would be the location for a tunnel.

Then from the data thus gained a location line should be run from the intended intake across the tunnel line to the City; after which borings might be made at considerable distances apart at first on this line; but should these borings prove that the strata greatly varied, then intermediate borings would have to be made.

I have not taken artesian wells into consideration in this short report, but would say, as the borings to ascertain the geological formation of the country were being executed, the possibility of the artesian well system might also be tested.

All of which I respectfully submit.

WALTER C. BROUGH,
A. M. Can. Soc. C. E.

ENGINEER'S REPORT ON GRAVITATION.

The first report on the subject of obtaining water by gravitation was presented to the Council in 1857 by Mr. T. C. Keefer, C.E. He examined and reported on three different sources of supply, viz, the rivers Don and Humber, Bond Lake, and also Lake Simcoe. The fertility of the water-shed of the Don and Humber, he considers, will cause these rivers to be turbid, particularly during freshets, and is of opinion that Toronto can never depend on pure water at all times from this source.

Bond Lake and its surrounding water-shed he considers altogether too small to meet the requirements of this City.

Lake Simcoe, he says, "besides being over thirty miles distant, lies one hundred and fifty feet lower than the intervening ridges which separate it from Toronto, a fact which precludes all idea of obtaining a supply from that source, as its waters could only be abstracted by a cutting several miles in length."

In 1887 Mr. Kivas Tully, C.E, in conjunction with the late W. J. McAlpine, C. E., reported favorably on the project of collecting the waters of the Don and Rouge as well as those of the Ridge Lakes, and conveying them by gravitation in canals and steel pipes to the City. Their estimate for a daily supply of 36 million gallons was $1,535,450. An analysis of the water to be procured was then made by Professor Ellis, who reported unfavorably on the quality of the water, and this project was then dropped.

Two years later, or in 1889, Messrs. Hering & Grey, well known Hydraulic and Sanitary Engineers, were asked to report to the City Council, as to the best means of increasing the water supply and also disposal of sewage.

They condemned the project of bringing water from the Ridge Lakes, on account of its inferior quality.

These gentlemen also considered Lake Simcoe as a possible source of a gravity supply, and while they considered the water sufficiently pure and the scheme perfectly feasable they objected to it on account of its cost. The following is their estimate for a supply sufficient for a population of 500,000.

107,000 feet of brick conduit, 6 feet in diameter, at $25 50	$2,728,500 00
53,000 feet of tunnel, 6 feet in diameter, at $39	2,067,000 00
Two lines of 48-in. cast iron pipes, each 85,000 ft. long, at $11...	1,870,000 00
Crib at lake, connections at reservoir, overflows, etc	40,000 00
Total exclusive of land damage	$6,705,500 00
Add 15 % for contingencies, engineering and superintendence.	1,005,825 00
Sum total	$7,711,325 00

The total length of their proposed conduits was 46 miles, that of the tunnel being 10 miles.

Their final advice to the Council was to extend and continue the present pumping system, provided the sewage was carried to, and disposed of in the lake, opposite Victoria Park. Their estimate of this work was:

Extending present pumping system	$870,550 00
High Level service......	155,250 00
Sewage disposal	1,471,048 00
Sum total....................................	$2,496,848 00

In addition to which they estimate the annual expense for pumping sewage at $8,000. Their advice to the Council, that it would be more economical to extend the present pumping system than to attempt a gravitation method, is based solely on the fact that the first cost in the one case is less than the first cost in the other; but they have utterly ignored the question that there might be any difference in the future annual cost of maintenance, under both systems.

We regard the consideration of "maintenance" as the turning point of the problem now before us, and in the absence of any figures, or any discussion on this most important subject, we are compelled to reject the advice of these experts, and to regard their report as incomplete.

Towards the close of the year 1890, Messrs. McLennan, Stuart & Chapman, Civil Engineers, of this City, entirely at their own expense, made a preliminary survey, in order to estimate the cost of bringing water from Lake Simcoe, the result of which, together with plans and estimates, they voluntarily submitted to the sub-Committee on Gravitation.

The object which these gentlemen had in view was to ascertain the altitude of Lake Simcoe above Toronto, the length and height of the intervening ridges and to obtain levels and distances from which to form an estimate of cost; they therefore chose Yonge Street, being the shortest route between the two lakes, which route they surveyed and based their estimate on, but they do not desire to be considered as favoring this particular location, being decidedly of opinion that a more extended survey will reveal a line—possibly somewhat east of Yonge Street—on which the conduit can be constructed very much under the amount of their estimate.

The total length of the conduit, according to this survey, was 39 miles, 15 of which require tunnelling.

These gentlemen place much importance on the value of the water power which can be developed, and which they claim can easily be converted into electrical power and utilized throughout the City. Their estimate of cost, for a supply of 60,000,000 gallons per day is $4,632,204, exclusive of land damages, and for a supply of 120,000,000 gallons, $6,396,314, which includes land compensation. They estimate the value of the water power at $60,000 per year, under the smaller supply, and at $210,000 per year if the daily supply be increased to 120,000,000 gallons from which they conclude that it will be the most profitable to construct the conduit of the larger dimensions, viz.: 9 feet diameter in the tunnel section

All these reports are now in the custody of the Water Works Department and have been duly considered by us.

Impurity of the Present Supply Caused by Sewage Pollution, and also the Ever Incpeasing Annual Cost of Pumping, Demand a Gravition System.

Before the present system of water works was inaugurated the question of sewage disposal was a matter of little or no consequence. Trunk sewers, intercepting sewers, and such like were unnecessary and little thought of while the ordinary privy filled all the requirements of the average citizen.

With the advent of a waterworks system came also its necessary consort, a sewage system, and to this alone we must attribute all the impurities which now taint the once pure waters of Lake Ontario. For a time the quantity of sewage was so small, compared to the area of water in the bay, that even the bay water was good enough for drinking purposes; but with the rapid increase in population and modern sanitary conveniences and industries of all kinds there has been a corresponding increase in the amount of sewage and filth, so that the bay water is no longer drinkable, and in fact there seems to be no doubt that the water of the lake itself is now becoming polluted, and its quality gradually becoming deteriorated year by year. Recent tests and analysis made at the bell buoy or mouth of the intake of the water works system (and there have been many such tests) all go to show that we can place little or no dependence on the water being pure and remaining pure at all times. One week we find it rating a high first-class water, and possibly next week it is pronounced as undrinkable. There must be some cause for this. Is the whole of Lake Ontario becoming tainted by the large amount of sewage matter which drains into it from Chicago and all the other large cities on the Great Lakes? or, is Toronto alone to blame for the cause of this pollution? Possibly it is, and the fluctuation in the quality of the water tends to show that the direction of the wind has some effect on the lake currents, and therefore on the carrying of sewage outside the Island.

The building of a trunk sewer and the carrying of all sewage matter eight or ten miles east or west of the City, would no doubt help to keep the quality of the water pure—at least for a time—but just for how long it is impossible to say.

The cost of pumping has now become an enormous tax on the City Treasury; ten years ago $39,632 was sufficient to pump all the water we required, while in 1889 it increased to $88,087 or more than double, and that this increase must continue to expand seems only natural so long as we persist in forcing water up hill.

By the introduction of the gravity system of water works we surmount both these difficulties. When our water supply comes from Lake Simcoe it matters not to us whether Lake Ontario be tainted with sewage or not; and when the ridge has once been pierced and Lake Simcoe water commences to flow into our homes all further expense will be at an end and pumping can be dispensed with once and for ever.

Problem of Sewage Disposal Solved by the Introduction of a Gravitation System of Water Works.

The question as to the best means of disposal of sewage has long been a weighty and serious matter before the members of the City Council. At present all our sewers discharge into the Bay or harbor immediately in front of the City. The intake pipe of the Water Works system also passes through this Bay, which has now become completely polluted with sewage, so that any leakage in the intake pipe at once taints the purity of our water supply, while the effects of a break or failure in this pipe would doubtless prove fatal to many. Besides this there is ample proof that bay water does, at certain periods, find its way outside the Island, from whence our water supply is drawn This is particularly noticeable under strong, changeable winds.

Water supply and sewage disposal are so closely connected that they must be considered together.

Several reports on this subject have already been submitted to the City Council. In 1886 Mr. Sproatt (late City Engineer) recommended a system of intercepting and trunk sewers, discharging opposite Victoria park, at a cost of $1,418,355, with an annual charge of $43,455 for pumping.

Later, in 1889, Messrs. Hering & Grey practically corroborated Mr. Sproatt's project, their estimate of the work being $1,471,048, the annual charge for pumping being $8,000.

Several devices for treating the sewage matter, mechanically, chemically, and also for using it as a fertilizer, have also been put forth, but have not found much favor.

All these reports point out the advisability of removing the outlet of our sewers as far distant as possible from the intake of the Water Works system, demonstrating the impossibility of pouring filth into one side of a basin and drawing pure drinking water from the other.

We agree with these reports and would go still further, believing that if our water comes from Lake Simcoe, it never can become contaminated with sewage, and if we draw our supply from that source, there can be no necessity in spending nearly $2,000,000 on extending an elaborate system of trunk sewers ten miles away from the City. We therefore claim that this $2,000,000, which appears to be absolutely indispensible under the pumping system, should be placed as a credit towards defraying the first cost of the gravitation system. True, it is neither pleasant or conducive to public health that the Bay should remain polluted to its present extent, but we claim that the increased and abundant supply of Lake Simcoe water we propose to bring, will permit of our sewers being flushed daily, or hourly, if advisable, causing a rush of water which will carry all filth far out into the lake, leaving the sewers clean and pure at all times. The new steel conduit, and also the wooden one, being no longer required, could be converted at a slight cost, so as to convey sewage, but this matter we do not intend to deal with at present, but simply report that water by gravitation from Lake Simcoe completely removes any difficulty connected with the sewage problem.

Gravitation Water Works Elsewhere.

New York receives its supply from the Croton river by gravitation. In 1885 the old conduit become unable to supply all the water required, and a new one of larger proportions was commenced. In order to collect the waters of the Croton watershed it was necessary to build a retaining dam across the river, which was only done at an enormous cost.

Boston draws its supply from three different sources, the Mystic River, Sudbury River, and Lake Cochituate, having three different conduits, 1¼, 15 and 16 miles in length, respectively. The water runs by gravitation to the main reservoir, from whence it is delivered partly by gravitation and partly by pumping, according as the various altitudes of the City will permit.

Much expense was incurred in building dams on the watersheds for the purpose of impounding and storing a sufficient supply.

Liverpool has of late years completed what is known as the Vyrnwy system of water works. Great difficulty was experienced in procuring a sufficient supply. No lake of sufficient capacity was obtainable, so that the forming of an artificial lake was necessary. Property had to be acquired, and what was once the thriving village of Llanwddyn, with its churches and schools, now lies at the bottom of this artificial lake. The dam itself was 1,172 feet long and 161 feet high, while the total cost of forming this lake was $3,354,930. The aqueduct is 78 miles in length, and includes several tunnels and numerous viaducts.

Glasgow secures her water supply from Loch Katrine, where impounding dams first had to be built. Thirteen miles of the conduit, which is thirty-four miles long, required to be tunnelled, the material being chiefly rock, of a very hard nature. About thirty masonry and iron viaducts were necessary. The quality of the water was excellent, and the work said to be the best of its kind in the world.

Dublin is supplied from the River Vartry, the waters of which are impounded by a large and costly dam, which forms a reservoir or storage pond. The conduit, which is 25 miles long, is principally cast iron pipes, although it was necessary to tunnel through 2½ miles of solid rock.

One of the most recent gravity systems of water works is that of Bombay India. This work was commenced five years ago, and is now almost completed. The work consists of what is known as the Tansa dam, 8,430 feet long and 135 feet high, and built at a very great cost. It forms an artificial reservoir of eight square miles. The conduit is 53½ miles long, and includes almost every description of engineering work. It crosses mountains and valleys and jungles, and is composed of 13 tunnels, aggregating four miles, all through hard trap rock, 24½ miles masonry conduit, and 25 miles of cast iron pipe, while to carry the latter over the numerous valleys, three large bridges and 22 viaducts were necessary.

These are a few of the largest and most important gravitation water works systems in the world, and an important point which cannot be overlooked is that in every instance it was first necessary to go to enormous expense in building dams and forming artificial lakes or reservoirs from which to draw the supply. Lake Simcoe offers to Toronto a natural and everlasting reservoir which cannot be surpassed in the world, while dams are not needed. The great advantage which Toronto possesses over all cities as regards the source of supply is at once apparent.

The following table shows the comparison of our proposed system with those of other cities:

	Water Shed area	Available daily supply.	Length of Conduit.	Length of Tunnel.	Time in constructing.	Daily capacity of conduit.	Total cost of Conduit.	Cost per mile of Conduit.
	sq. m.	gallons.	miles	miles	years	gallons.	$	$
Bombay	..	......	53½	4	5	31,000,000	5,000,000	93,458
Boston (Mystic Works)			1½	..	2	....	129,714	86,476
" (Sudbury Works)	120	73,000,000	16	1¾	2½	....	1,186,254	74,141
" (Lake Cochituate Works)			15	¾	2	....	....	......
Dublin	22	262,000,000	25	2½	..	20,000,000	1,746,840	69,875
Glasgow	40	100,000,000	31	13	2½	50,000,000	3,857,740	113,463
Liverpool (Vyrnwy works)	35	....	68	4½	..	40,000,000	4,651,215	68,400
New York	363	250,000,000	33	23	2½	320,000,000	13,358,367	404,799
Toronto	1,400	1,333,000,000	39	15	2½	120,000,000	5,846,381	149,907

It is seen that the estimate of the Toronto project is greater than the actual cost of any of these works except New York, and there the capacity of the conduit was nearly three times greater than that proposed from Lake Simcoe.

It is therefore reasonable to suppose that this estimate is too high, but we come to the conclusion that it is better at first to over-estimate rather than under-estimate the probable cost, and are confident that when detail surveys are made and closer estimates prepared that the cost per mile will compare favorably with that of any of these cities named; as we know we will have no engineering difficulties to contend with, such as we read of in all these other works.

Cost of Pumping in the Past, and Probable Cost in the Future, Compared with Cost of Gravitation, if Total Cost be Spread over Sixty Years.

In 1878 the water works system, which for the preceding five years had been supervised by a Board of Water Commissioners, then came under the control of the City Engineer and Manager. In 1885 he was relieved of these duties by Mr. Wm. Hamilton, the present Superintendent.

From the report of these officials the following figures are taken, which give the actual cost of "pumping and maintenance of engines." These figures are substantially the same as those to be found in the official annual reports with the exception of a slight charge for insurance on pumping plant, and also the cost of pumping at the High Level Station, it being necessary to make these additions when arriving at the comparison.

Cost of Pumping and Maintenance of Engines, including Insurance and High Level Station.

	Total Cost.	Quinquennial Average.	Quinquennial Increase.
	$ c.	$ c.	$ c.
Year ending Dec. 31st, 1878	25,246 50	27,730 47	
" " 1879	30,214 43		
" " 1880	39,632 75	51,499 60	23,769 13
" " 1881	43,295 72		
" " 1882	43,769 63		
" " 1883	59,809 65		
" " 1884	70,990 24		
" " 1885	68,512 91	76,868 71	25,369 11
" " 1886	68,329 15		
" " 1887	79,905 96		
" " 1888	79,508 34		
" " 1889	88,087 19		

On looking at the annual expense as above, it is plain that there is no proportionate annual rate of increase, some years being less than the previous ones, while in many cases there is an increase of over $10,000.00. We have therefore found the average yearly expense for each period of five years, since 1880, and from that found the quinquennial rate of increase. This increase, we assume, will continue to expand in the same proportion for the next sixty years, and commencing with the actual cost for the year 1889, we estimate that the cost of pumping and maintenance of engines will be as follows :

Five Years.		Quinquennial Increase.	Yearly Expense.	Expense for the Five Years
From	To			
		$ c.	$ c.	$ c.
1890	1894	27,076 00	115,163 00	575,815 00
1895	1899	28,898 00	144,061 00	720,305 00
1900	1904	30,842 00	174,903 00	874,515 00
1905	1909	32,917 00	207,820 00	1,039,100 00
1910	1914	35,132 00	242,952 00	1,214,760 00
1915	1919	37,496 00	280.448 00	1,402,240 00
1920	1924	40,019 00	320,467 00	1,602,335 00
1925	1929	42,712 09	363,179 00	1,815,895 00
1930	1934	45,586 00	408,765 00	2,043,825 00
1935	1939	48,653 00	457,418 00	2,287,090 00
1940	1944	51,926 00	509,344 00	2,546,720 00
1945	1949	55,419 00	564,763 00	2,823,815 00
	Total cost of pumping for next 60 years.			$18,946,415 00

In addition to the cost of pumping the sum of $150,334.73 has been paid for engines and repairs during the last five years and charged to capital account. As, however, there was no outlay on capital account during the previous five years, this amount may be taken as the expenditure for new engines and repairs for 10 years.

Assuming that each ten years will only involve the same amount of expenditure for engines, and also assuming that the engines now in use, and those to be purchased in future will last for the whole sixty years, there would be a further outlay for pumping plant of $902,008, making a total outlay of $19,848,-423 as follows :

Cost of pumping and maintenance of engines..........................		$18,946,415 00
New engines and repairs..		902,008 00
Total for sixty years.		$19,848,423 00

COMPARISON.

Cost of pumping for sixty years as above		$19,848,423 00
The cost of gravitation is estimated at $6,400,000. The interest and sinking fund to redeem this debt in sixty years, either by instalments or the investment of a sinking fund at 3½ per cent. would be $256,567.23 per annum, which in sixty years would give a total of	$15,394,033 80	
It is estimated that water power can be secured which would yield the City a yearly income of $210,000, which in sixty years would amount to at the total of	12,600,000 00	
Making the net cost of gravitation water works...		2,794,033 80
A saving to the City of...		$17,054,380 20

in 60 years, in addition to acquiring the works without further payments, and securing the income of $210,000 in addition to the ordinary water rates, besides saving the enormous outlay that would then be necessary for pumping, which outlay would be a continually increasing quantity.

VALUE AS A WATER POWER.

Water power has long and universally been considered as the cheapest of all motives, that we need not dwell on its importance in the manufacturing and mechanical world.

The fact of 120,000,000 gallons of water per day falling a distance of 470 feet at once conveys the impression of immense power. Engineers informs us that that this force is equal to 4,775 actual horse power. This valuable water power might be utilized directly by the erection of mills and factories outside the City, but we do not recommend the booming and enhancing in value of outside property at the expense of the City of Toronto. Of late years electricity has made enormous progress in the mechanical field, and its real value and importance as a motor are now becoming more generally understood. It has been demonstrated that the initiative force of water and steam can now be converted into electric power and conveyed many miles by electric cable to where it is desired to be employed.

That electricity can be more economically generated by water than by steam power is generally admitted; still to prove this assertion we would draw your attention to the last report of the Directors of the Giant's Causeway and Portrush Electric Tramway, an Irish enterprise, the longest and possibly most complete of its kind in the universe. Here the electrical force is generated by water power, situated some distance from the tramway. Unfortunately for the company the amount of water power available is not sufficient during the season of heavy traffic, so that steam locomotives are often used. The report of the company's engineer shows that the cost of electrical power when generated by water power was only about one-fifth that of steam when used directly by the locomotive.

In order to utilize the water power at our disposal it is proposed to erect power houses, fitted up with the most improved pattern of Turbine water wheels and to convey their force to dynamos, which would generate the electrical power, this power to be conveyed to the City through an electric cable, and would be capable of being made use of anywhere and everywhere within the City.

Of the original 4,775 horse power derived from the Turbines some allowances must be made for loss in conversion into electric power and also for loss due to leakage in passing through the cable; but after making these deductions there is still a force equal to 3,500 actual horse power left at our disposal, or sufficient for street railway and street lighting purposes for many years to come. The value of this power has been placed at $60 per horse power per annum, which, we think, is a low estimate, considering the prices usually paid for other motive power in this City, and also that electricity differs from all other motors, in that it can be employed for twenty-four hours a day instead of ten or twelve, at scarcely any increase in cost.

One of the principal points for developing this water power will be at the crossing of the River Don, into which stream it is proposed to pass all the water not required in the City at present, so that the sewers be not overtaxed. The effect of this will be to effectually increase the current in the Don, which will be sufficient to thoroughly scour it out and remove all the filth and pollution which now make that river so objectionable as regards public health.

Benefits of Gravitation.

Some of the great benefits to be derived from a gravity system of water works may be briefly alluded to as follows:

(1) Enormous saving in cost over the present pumping system, as shown by the foregoing statement.

(2) An everlasting supply of pure water, which, from the favorable location of Lake Simcoe, can never become tainted with sewage or any other organic impurities, but must always remain pure and wholesome.

(3) Abundance of water with which to flush our sewers.

(4) Abundance of water with which to flush the Don River.

(5) Abundance of water with which to blow out the mains throughout the City, so that dead ends and dirty water, due to local causes, will become a thing of the past.

(6) The formation of a new reservoir, at least 100 feet higher than the present one on Rose Hill, will give us an equal fire pressure all over the City, and will enable us to supply the northern suburbs which are now without water.

(7) Under such a constant water supply, with an increased fire pressure, insurance rates will surely be lowered.

(8) Lake Simcoe ice has long been noted for its pure quality, and has always commanded the highest price in the market. The superabundance of water at our disposal, will permit of artificial ponds being constructed and filled with water, from whence our future ice supply can be harvested; this will also be a source of revenue to the Water Works Department, and will ensure a quality of ice which cannot be excelled in purity.

(9) Construction of a trunk sewer unnecessary for many years to come.

(10) Large annual revenue from water power.

Final Conclusions.

Your Committee respectfully contend that now for the first time they have the honor of submitting to this Council the important question of a gravitation water supply for this City in its true light. We have visited Lake Simcoe ourselves, and ascertained two most important and primary facts. First, that the water is pure beyond all question of doubt; and next, that the available supply is practically inexhaustable. We therefore recommend that for the future our water should be drawn from Lake Simcoe.

We have examined into the project of obtaining a supply from the waters of the Don and Rouge and Ridge lakes, as proposed by Messrs. McAlpine and Tully, and while the scheme looks advisable on account of its comparatively low cost, still we cannot endorse it, from the fact that the water was found to be of an inferior quality.

We have examined into the prospect of obtaining a supply from artesian wells and have visited those now in operation at Orillia, Barrie and Newmarket, but they themselves do not prove the extent of the underground stream, or whether it would be sufficient to meet our requirements; besides, even if it was, there would be no advantage in experimenting on wells sunk in the valley of Lake Simcoe, when as good, if not better water, can be procured from the lake itself, at possibly a lower cost, and where the adequacy of the supply is fully established. If these wells had been found on the south side of the Oak Ridges, their value would have been of more importance, at least to us, but we have no evidence before us of any continual flowing wells having been found this side of the height of land. Nor do we know of any city having so large a population as Toronto being supplied altogether from artesian wells.

As to the actual cost of bringing water from Lake Simcoe, we regret that the information before us is so meagre. Mr. Keefer reported the undertaking as not practicable on account of the intervening ridges, but we must bear in mind that this report was made over thirty years ago, and that engineering difficulties which in those days were supposed to be unsurmountable are now easily overcome, as for instance, the Sarnia Tunnel under the St. Clair River, which has recently been most successfully completed. Messrs. Hering & Grey devote the bulk of their report to the advisability of extending the present pumping system and also to sewage disposal, very little information being given on the subject of gravitation Their estimate seems only to be based on one line, and there is nothing to show that they examined the country closely, so as to find a shorter and cheaper location on which to construct their condu t.

McLennan, Stuart & Chapman admit that their survey was only "preliminary," and their estimate only approximate, no borings having been taken; and also distinctly say that they are of opinion that a cheaper location can easily be found than the one surveyed by them.

This is all the information we have on the question of cost, and we think it entirely inadequate. We would therefore ask for an appropriation of not less $12,000, to be spent in finding the most suitable and most economical location for the conduit, preparing plans and estimates of quantities, and also in borings to test the nature of the excavation, and having everything advanced to the stage when we can ask contractors to tender for the work. If this appropriation be granted, your Committee will endeavor to have all surveys, plans and estimates prepared with as little delay as possible, so that the great question of whether we shall or shall not have a gravitation system of Water Works may be submitted to the citizens as early as possible.

Your Committee feel that their labor and investigation into the matter has been fully recompensed by the result. We feel that the same has fulfilled the expectations of the most ardent advocate of gravitation; but, lest it should appear to some that we have not placed this subject before you in as strong a position as we might have done, we beg to say that our endeavour has been simply to ascertain the truth, and, in doing so, to dwell only on established facts. We, therefore, submit this report without color, without any superfluous gilding, which is sometimes drawn from imagination, and ask you to give it your grave and earnest consideration, and court the fullest investigation of the facts herein stated.

In advocating a new system of water works we do not wish to be understood as in any way reflecting discredit to our present system, or to those connected with it; such is not our object, for we are convinced that the Toronto Water Works, under its present management, holds a high position among the many similar systems of the world; but we object to the system of pumping, no matter how well organized, as being obsolete and too expensive, as well as the fact that the expense is everlasting and ever increasing.

Gravitation Water Works, where practicable, have (in the older world) invariably been introduced and have always been found to pay for themselves ten times over. No city that we know of is so favorably situated (topographically) as Toronto, for obtaining a water supply by gravitation, and why this grand project which lies so easily within our reach should any longer be delayed we do not understand.

We recognize that the chief feature of a water supply is to procure the purest quality of water possible; impure water must instantly be condemned, no matter how economically it can be obtained. We have, therefore, investigated fully the question of purity or impurity of Lake Simcoe water and have devoted considerable space to the discussion of the subject, not that we have any doubt ourselves as to the quality of the water, but because it has been found by analysis to rank only as second to that of Lake Ontario, and might at first sight appear inferior. This is due to the unfortunate fact that the standard employed is an English one and quite inapplicable to such water as Lake Simcoe. It is certain that our present supply is often tainted with sewage—analysis clearly shows this—while Lake Simcoe is perfectly free from any contamination, and even in its present state analyzes better than 33 out of 42 samples of water which is used for drinking purposes by the largest cities on the American continent; while a small amount of money spent in filtration and areation will doubtless remove the only objectionable substance, the vegetable organic matter, and leave us a water which cannot be surpassed in the world.

The quality of Lake Simcoe water is entirely independent from the growth of this City, and the corresponding increase in the volume of sewage filth which must be emptied into Lake Ontario. The very high altitude of Lake Simcoe, *i.e.*, 120 feet above Lake Superior, forbids of it ever becoming contaminated with sewage— the greatest of all evils—so that its waters cannot degenerate in quality. But it is not merely on account of the purity of the water, nor on account of obtaining an abundant and everlasting supply, that we recommend this gravitation system, but chiefly on the final disposal of the great and urgent problems—water supply and sewage disposal—at one stroke and for ever, and also that by doing so we effect an enormous saving, in point of cost, over the present pumping system. This saving, we have shown, will amount to over $17,000,000 in the next sixty years. At the expiration of that time all the indebtedness will have been paid off, and the City will be in receipt of a handsome yearly revenue, besides having acquired an asset far more valuable than any it now possesses. The rising generation will point with pride to a water works system which will be a credit to any City in the world and will not be slow in showing their approval of the energy, wisdom and forethought of the promoters of this grand project. The present system may possibly be satisfactory for a few years. No doubt it is as efficient and economical as any of its kind, but in just what state it would be in, if continued for sixty years, we leave you to judge. If a change in our system is deemed expedient and advisable, surely the present is an opportune time to effect it. The pumping power—since the recent completion of the new conduit—is amply sufficient, and with care should last until the gravitation system can be introduced. We, therefore, would urge upon this Council the desirability of taking speedy action; not that we advise undue haste. Let the question be well considered and freely discussed, and, if recommended, then let us use all our energy and all our ability to bring this grand undertaking to an early and satisfactory conclusion.