CITY OF HALIFAX,

PROVINCE OF NOVA SCOTIA.

REPORT

UPON

INCREASED WATER SUPPLY

AND

IMPROVEMENTS

IN THE

EXISTING WATER WORKS SYSTEM

OF

HALIFAX, N. S.

BY

WILLIS CHIPMAN, C. E., Toronto.

TORONTO, Ont., February 11th, 1907.

To the Mayor and Council of the City of Halifax:

GENTLEMEN:—As the full Report is necessarily a somewhat lengthy document, I propose to give at the outset a summary of the conditions now existing, the conclusions at which I have arrived from a study of the problem, and my recommendations.

The City of Halifax has to-day the largest per capita consumption, the lowest pressure, and the weakest fire supply of any Canadian City with which I am acquainted, and considering that a large precentage of the buildings are of wood, your preservation from a disastrous conflagration has been nothing less than miraculous.

I sincerely hope that the pumping station recommended may be completed before your are scourged by a fire that may destroy property the value of which might be many times the cost of the improvements proposed.

This may be the most fitting place in which to thank your City Engineer and his staff for the cordial manner in which they assisted me when in Halifax, and for their trouble in compiling data for this Report.

Thanking you for your patience I beg to remain,

Very respectfully yours,

WILLIS CHIPMAN,

Civil and Sanitary Engineer.

PREFACE.

SUMMARY OF CONDITIONS AND CONCLUSIONS.

1. Long Lake and Chain Lakes may be depended upon to yield 10,000,000 gallons per day to the Low Service District, during an ordinary dry season.

By raising the waste weirs another foot an additional supply of 1,000,000 gallons per day might be impounded for the summer months.

2. The two large conduits from Chain Lakes when clean can convey 10,000,000 gallons per day by gravity to the Low Service District, with the lakes at their lowest stages.

An additional supply may be drawn from the lakes through either of the conduits for short periods for fire service.

3. The Spruce Hill Lake watershed yields 2000,000 gallons per day in an average year, and may possibly for a dry year, but the storage capacity cannot be increased.

4. The conduit from Spruce Hill Lake to the High Service District is now taxed to its full capacity, the flow frequently exceeding a rate of 2,500,000 gallons per 24 hours.

5. The daily consumption during the entire year has not yet been determined, but the maximum exceeds 11,500,000 gallons, or over 300 gallons per consumer, the most extravagent consumption on record, and more than double what should be used.

6. Owing to the enormous waste of water, proper fire protection cannot now be given to the business portions of the City in the Low Service District, or to the High Service residental district. The City is practically without fire protection.

7. The supply would be ample for all the requirements of the City, if efficient means were taken to curtail waste.

8. Of the 11,000,000 gallons of water conveyed to the City, about 3,000,000 gallons represents legitimate consumption; 4,000,000 gallons, leakage from mains and services; 2,000,000 gallons, leakage

from plumbing fixtures; 2,000,000 gallons careless waste by householders.

9. The leakage from the mains and services may be considered as not immediately controllable, due largely to the fact that in the oldest parts of the system, and the lowest parts of the City, the mains are jointed with wooden staves. As the old mains are replaced by new pipes this leakage will decrease.

10. Defective plumbing is responsible for a large precentage of the uncontrollable waste. For fifty years after the construction of the original water works system the plumbing in the City was not regulated by By-law. The Plumbing By-law passed in 1896 should be revised, brought up to date, and made retroactive.

11. In gravity systems with flat rate tariffs, the citizens are as a rule, careless and extravagant in the use of water, but this waste can be stopped.

12. By adopting meters the consumption may by reduced at the rate of about 500 gallons per day for each meter set, ultimately reducing the daily consumption from 11,000,000 gallons per day to 8,000,000 gallons.

13. By metering the domestic services, there will remain an ample supply for the fire service, but additional large mains should be laid to convey about 4,000 gallons per minute to the warehouse and business districts in the low service areas.

14. In the high service district, the consumption may be reduced to a maximum of 1,500,000 gallons per day by meters, which will leave about 1,000 gallons per minute for fire supply in the lower parts of the district or five fire streams.

15. By erecting a water tower on Shaffroths or Hungry Hill. the pressure in the High Service District may be equalized. This reservoir is desirable, but not essential.

16. By the installation of a pumping plant on the 27 inch conduit line, the normal flow into either the low service district or the high service district may be increased as desired for fire supply, but steam fire engines must be relied upon to give the necessary pressure as at present.

17. An independent high pressure sea water system for fire protection would be too expensive and would not improve the pressure or the supply outside of the area served.

18. The necessary improvements and additions recommended, will involve an expenditure of not less than $225,000, nor more than $350,000.

19. The additional annual charges will be between $30,000 and $40,000.

20. By adopting a meter rate for all consumers not exceeding the rate now charged for the largest users of water the annual revenue will be sufficiently increased to meet the annual charges due to the improvements recommeded.

21. In Halifax it is either meters, or an additional supply from Birch Cove Lakes, with many additional large distributing mains.

WILLIS CHIPMAN,
Civil and Sanitary Engineer.

Toronto, Ontario,
February 11th, 1907.

RECOMMENDATIONS.

1. Set meters upon all water services, commencing the work in the lowest parts of the City.

2. Revise the Plumbing By-laws now in force and make the same retroactive.

3. Replace some of the smaller pipes now laid by large fire supply mains more particularly in the business districts.

4. Instal pumping machinery of large capacity for fire protection on the line of the 27 inch conduit near Kempt Road.

5. Erect a Water Tower on Hungry Hill to equalize the domestic pressure in the High Level District.

WILLIS CHIPMAN,
Civil and Sanitary Engineer.

Toronto, Ontario, February 11th, 1907.

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CITY OF HALIFAX,

PROVINCE OF NOVA SCOTIA.

Report Upon Increased Water Supply and Improvements in the Existing Water Works System.

BY

WILLIS CHIPMAN, C. E.

TORONTO, February 11th, 1907.

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

GENTLEMEN:—In February, 1905, I received your instructions to examine the Water Works System of the City of Halifax, and make recommendations towards the betterment of the same. The snowfall in March was so exceptionaly heavy that my first visit was deferred by request until the last week in April.

INSPECTION.

The civic elections were being held on the day of my arrival, April 26th, 1905. During the following days I inspeoted the existing sources of water supply, and several lakes that had been suggested as possible sources for supplementing it, including Pockwock Lake.

From May 1st to May 6th inclusive I was engaged in collecting data, examining plans, testing pressures, etc.

After consultation with the Mayor and the City Engineer, it was considered advisable to delay my report until meters had been placed upon the three main conduits that supply the City, plans and profiles prepared of these conduits, and also a general plan made showing the lakes and streams within a reasonable distance of the City.

I afterwards requested that the elevation to Birch Cove Lakes be determined.

Three Venturi meters, each with recording apparatus were ordered in August, 1905, one 14 inch, one 24 inch, and one 26 inch. The 14 inch meter has been in successful operation since February, 1906, but the two larger meters were not set until November, 1906.

In June 1906 I again visited Halifax, on which occasion I inspected Birch Cove Lake, also the "divide," between Pockwock Lake and Tomahawk Lake to determine the possibility of diverting the water of the former lake into that of the latter.

Historical.

A brief historical sketch of the Halifax Water Works System may be of some value for reference.

In the year 1846, Jas. B. Uniacke, Esq., and others organized a company, and an agreement was entered into for supplying the City with water from Long Lake. In the same year construction commenced, and the original works were completed in the following year. A dam was constructed at the south end of Long Lake and a conduit constructed to Chain Lakes. Another dam was built at the outlet of lower Chain Lake and a 12 inch cast iron main laid to the City. The capacity of the main was assumed to be 700,000 gallons per day. In 1854 an additional 15 inch main was laid, increasing the supply to 2,000,000 gallons per day.

In 1860 when the population of Halifax did not exceed 30,000, Jas. Laurie, C. E. was engaged to report upon different proposed schemes for increasing the supply. As a result of his investigations, he recommended that a conduit be laid to Ragged Lake for a high service gravity system.

In 1861 the works were purchased by the City, and in the following year the 12 inch conduit was replaced by the 24 inch main now in use.

In the years 1863, 1865 and 1866, several reports were received from various Engineers, and certain surveys were made, as a result of which it was decided to adopt Spruce Hill Lake for the high service supply instead of Ragged Lake.

In 1868 the high service works were added, the 15 inch main being disconnected from Chain Lake and extended westerly to within one mile of Spruce Hill Lake as a 15 inch pipe, the remaining portion being a 20 inch pipe.

For nine years the supply was ample and satisfactory. In 1877 the Long Lake dam was raised several feet, thus increasing the storage.

The first scraping of conduits was done in the year 1881 upon the advice of Mr. E. H. Keating, then your City Engineer. This increased the pressure but not permanently.

In 1886 the dam at the foot of the Lower Chain Lake was repaired and altered the dam between the two Chain Lakes repaired, and the conduit connecting Long Lake with Upper Chain Lake lowered. Nothing further was done until 1892, when the dam at Long Lake was raised two feet to its present elevation, but the waste weir was not changed.

In the year 1893, the twenty seven inch cast iron conduit pipe was laid to Chain Lakes from the northerly part of the City, and in the next year the dam at Chain Lakes was rebuilt.

Chain Lakes and Long Lake.

The two Chain Lakes, Upper and Lower, originally discharged easterly through a small stream into the head of the North West Arm, west of the City, the flow being sufficient to operate a small mill at the Arm, Long Lake, which lies a mile south from Chain Lakes, discharged southerly. When these lakes were decided upon as the source of water supply, a dam was built at the south end of Long Lake, and the flow diverted through a conduit 1400 feet in length to Upper Chain Lake. A dam was also built at the outlet of Lower Chain Lake, and another between the Upper and Lower Chain Lakes.

The dam at the foot of Long Lake was raised in 1877, in 1892, and in 1905. In 1886 the conduit from Long Lake was rebuilt, and the Chain Lake dam raised, flooding the dam at the outlet of the Upper Lake.

In 1894 the Chain Lake dam was rebuilt, the elevation of the waste weir now being 206 feet above sea level.

By an agreement with the mill owners at the Arm, a certain minimum quantity of water is diverted from the lakes for the mill.

The watershed and water areas of these lakes are as follows :—

	Watershed acres.	Water acres.	Land area.
Long Lake	3,551	458	3,093
Chain Lakes	873	90	783
Totals	4,424	548	3,876

These lakes will store about 700 millions of gallons of water, allowing the water to be drawn down five feet, or 1,000 millions if drawn down nine feet.

Assuming the lakes full to the elevation of the crest of the waste weirs, the available storage would yield an average of nearly three millions of gallons per day to the City for the entire year, or four million gallons per day for nine months. For three or four months of every year, water is wasting at the weirs, the yield exceeding the demand.

Spruce Hill Lake.

The high level service from Spruce Hill Lake was introduced in 1868. The waste weir at this lake is at elevation 363.34 above the sea, and the watershed contains 1,009 acres, of which 224 acres represent water surface.

Since the construction of the dam and embankments at the outlet end of this lake, it seldom overflows. The lake will store about 60 millions at waste weir level for one foot in depth, and probably 45 millions at a depth of six feet below the waste weir. The total available storage may be taken as 300 million gallons, which would give an average of 800,000 gallons per day for a year.

Precipitation and Yield.

The rainfall and melted snow together make up the precipitation. Observations have been recorded year by year, at the Halifax Meterological Observatory since 1869, and at the Lakes by the Water Works Department since 1879.

The average precipitation at Halifax from 1869 to 1904 inclusive was 58.3 inches varying from 45.80 inches in 1894 to 69.86 inches in 1896. At the lakes it was slightly greater.

In 1860 a rainfall of 39.51 inches was reported, but it is doubtful if this record be correct, although the scarcity of water that year lead to the purchase of the Water Works from the company by the City in the following year.

The determination of the percentage of the precipitation that runs off from a given watershed is a complicated problem, depending upon the character of the watershed, its slope, the proportion wooded, the water areas, the distribution of the precipitation throughout the months of the year, etc. Rarely is it possible to store the entire runoff, owning to great variations in the precipitation and to the great increases in flow due to thaws, which may suddenly convert accumulated snow to water.

Fortunately careful observations have been taken for years by your Water Works Department, of the elevations of the water in Long Lake and Spruce Hill Lake, and the surplus overflow has also been estimated.

In 1905 the precipitation amounted to 51 inches. In this year Long Lake was overflowing during April and May, and on November 1st it had been drawn down to the lowest limit, or nine feet below the waste weir.

In five months the City had therefore consumed about 1,000 million gallons stored, also that part of the rainfall not evaporated or absorbed during this period.

Assuming that one third of the rainfall during this period on the land surface was impounded, this would give a depth of about six inches on 3,875 acres, or 500 millions of gallons. Adding this to the storage gives a total of 1,500 millions in five months.

The evaparation from the water areas of the Lakes would probably exceed the rainfall during these months.

It is now known that nearly ten millions of gallons per day, or approximately 1,500 millions were conveyed from the Lakes to the City during these five months.

In 1905 the Spruce Hill Lake was lowered six feet in six months, during which period the rainfall was 18½ inches.

Assuming that one third of the rainfall was impounded, or say six inches of the rainfall, this would yield 120 millions on 885 acres of land. Adding this to the quantity stored, gives a total of 420 millions of gallons.

During this period about 2¼ millions of gallons were conveyed to the high level district daily, which gives 410 millions for six months, a close agreement.

It follows from the above that the runoff during the summer months of a dry year from one thousand acres of wild land in the vicinity of Halifax, amounts to over 2,000,000 gallons per day.

Conduits.

From 1847 to 1855 the City was supplied by one 12 inch main from Chain Lakes.

About 1855 a second conduit was laid 15 inches in diameter alongside the 12 inch, both being used until 1862, when the original 12 inch was replaced by the existing 24 inch pipe.

In 1868 the fifteen inch was utilized for the high service by continuing it to Spruce Hill Lake.

In 1894 the new 27 inch conduit was laid to improve the low service.

During low water in Long Lake the 24 inch conduit when clean, should deliver about 5,400,000 gallons per day at St. Andrew's Cross.

Deposits and incrustations within the pipe, however, materially reduce this, and it would not be safe to estimate upon more than 5,000,000 gallons as its capacity.

The new 27 inch conduit if clean should also deliver 5, 400,000 gallons at Kempt Road and Young Street during low water, but as this pipe has not been cleaned since it was laid, its capacity is now only about 5,000,000 gallons. Cleaning will increase this to something between the two amounts.

The 15 inch pipe at low water, should, when clean, deliver 2,000,000 gallons per day at a sufficient elevation to reach the attic floors in residences on Willow Park Hill, but frequently during recent years, these buildings have been without water, due to excessive consumption, or to the fact that the conduit was not clean.

Under the most favorable conditions this conduit would convey 3,600,000 gallons per day, or 2,500 gallons per minute to steam fire engines drawing from fire hydrants on Quinpool Road or vicinity, but this draught would leave nothing for domestic supply.

The combined capacity of the three conduits at low water may be taken as 12,000,000 gallons per day, or 8,333 gallons per minute.

With the Lakes standing at the elevations of the waste weirs, the carrying capacity of each conduit would be slightly increased.

Syphonage over the higher points of the conduit lines within the City, may also cause a temporary increase in the discharge of the conduits.

It is a remarkable fact that discharges of the 24 inch and the 27 inch conduits are now practically identical.

QUALITY OF WATER.

In October 1905 samples of water taken from Long Lake, Spruce Hill Lake, and from two taps in the City, were analyzed by Prof. E. MacKay of Dalhousie College, Halifax, the results being as follows :—

SAMPLE OF WATER TAKEN FROM LONG LAKE, OCT. 6TH, 1905.

Constituent.	Parts per Million.	Remarks.
Free Ammonia	.01	
Albuminoid Ammonia	.222	Very high.
Chlorine	10.5	High.
Nitrogen as Nitrate	.425	
Nitrogen as Nitrite		
Required Oxygen	9.870	Very high.
Hardness	12.8	Low.
Total Solids	118.2	

SAMPLE OF WATER TAKEN FROM F. W. W. DOANE'S RESIDENCE.

Free Ammonia	.014	
Albuminoid Ammonia	.224	Very high.
Chlorine	10.9	High.
Nitrogen as Nitrate	.40	
Nitrogen as Nitrite		
Required Oxygen	9.80	Very high.
Hardness	13.4	Low.
Total Solids	123.8	

SAMPLE OF WATER TAKEN FROM SPRUCE HILL LAKE, OCT. 6TH, 1905.

Free Ammonia	.026	
Albuminoid Ammonia	.120	High.
Chlorine	8.0	High.
Nitrogen as Nitrate	.30	
Nitrogen as Nitrite		
Required Oxygen	9.68	Very high.
Hardness	14.1	Low.
Total Solids	103.2	

SAMPLE OF WATER TAKEN AT DALHOUSIE COLLEGE, OCT. 10TH, 1905.

Free Ammonia	.020	
Albuminoid Ammonia	.124	High.
Chlorine	7.8	High.
Nitrogen as Nitrate	.300	
Nitrogen as Nitrite		
Required Oxygen	9.60	Very high.
Hardness	14.1	Low.
Total Solids	107.9	

Mr. Doane's residence is supplied from Long Lake, and Dalhousie College from Spruce Hill Lake.

Prof. MacKay reported as follows:—

"The quality of the water which had passed through the City mains was found to be essentially the same as that taken directly from the lakes.

All samples had a somewhat yellowish tint due to disolved vegetable matter. Of the total dissolved solids more than 70 per cent was found to be of vegetable origin. The amount of vegetable matter is relatively large, and to this is due the high values found for Ammonia.

Our analyses showed all samples to be wholly free from indications of essentially injurions constituents or contamination."

From a sanitary standpoint, bacteriological examinations of the water, would have been of more value than chemical analyses.

Algea and allied organisms exist in all upland waters, and if in too large numbers or quantities, their death and decay may impart to the water, unpleasant tastes and odors, and may cause diarrhoeal diseases.

Your Assistant City Engineer Mr. H. W. Johnston, has compiled such data as are available respecting this matter.

Previous to 1876 the Spruce Hill supply was frequently offensive but in that year the water was lowered, and the Lake cleaned out, the stumps, logs, brush etc., being removed. Long Lake was cleared of timber, marshland, etc., in 1877 when the dam at outlet was raised.

From 1878 to 1883 inclusive, a fresh water sponge caused trouble at Chain Lakes. It was cleared out in 1883, since which time it has not given trouble.

The common microscopic plant known as Trichormus flos aqua, has occasionally imparted a bright green color to the water.

In 1885 a peculiar gelatinous growth appeared that choked the screens at the inlets to the conduits.

Frequent microscopic examinations should be made of your water supply as delivered at the taps in the City, to guard against sudden pollution from decaying organisms chiefly vegetable. This organic matter becomes proper food for various bacteria, and as a further precaution, bacteriological examinations should also be made and results recorded.

There is no possibility of the City's water supply becoming contaminated by sewage and as the watersheds are almost entirely rocky wildland with few swamps, there is no probability of farm drainage polluting the supply.

The chance of local pollution at the screen chambers, or in the vicinity of the inlets to the conduits, may be remote, but the gatekeepers should be ever watchful.

The Halifax and South Western Railway follows the north shore of Chain Lakes from the outlet for a distance of about one half a mile west. There is more danger from section men and from navvies working on the road, than from passenger and freight trains.

On the whole, the quality of the Halifax water supply is excellent one of the purest and best in Canada, but occasionally it becomes surcharged with minute vegetable organisms that impart to the water an offensive taste and a slight odor. By studying the conditions favorable to their development, and the exercise of proper precautions, this source of objection may be almost entirely eliminated.

The Halifax water has a decided amber tint, not so dark as the Ottawa and other Laurentian Rivers, nor as transparent as the St. Lawrence. It is remarkably soft and therefore rapidly attacks unprotected iron, forming incrustations and tubercular nodules within cast iron pipes, if they be not perfectly covered with a tar or asphalt coating.

Scraping Mains.

In 1880 a 12 inch mechanical scraper for removing incrustations from the interior of water mains, was imported from Scotland, and in the following year the 15 inch and the 24 inch conduits were scraped, with the result that the average pressure was increased by nearly 20 pounds at the fire hydrants, but the higher pressure increased the leakage, and the incrustations commenced again immediately.

For several years past, the 15 inch conduit has been scraped in May, September and November, and the 24 inch in November.

From 1881 to 1904 about 223 miles of pipes have been scraped at a cost of only $8.00 per mile. Before being scraped for the first time, twelve inch mains were found reduced to a diameter of ten inches, and four inch mains to two inches.

A chemical analysis of the materials removed from the mains by scraping, gave the following results:—

"We have made a careful analysis of the sample of powder received from you, and report as follows:—

Oxide of Iron (Ferric Oxide)..............	75.50%
Oxide of Iron (Ferrous Oxide)............	0.90%
Oxide of Alumina (A1203)...............	2.48%
Rock matter....................................	1.92%
Lime (Ca0).......................................	0.48%
Magnesia (Mg0)................................	0.63%
Sulphuric Anhydride (S03)..................	0.23%
Moisture at 212 deg. Fahr.	7.32%
Organic Matter by ignition.................	10.38%
Difference	0.16%
	100.00%

We do not think that the above could represent the mineral matter contained in a water "Unless it was drained from a Hematite Iron deposit" and that the oxide of iron must have originated from the corrosion of iron pipes."

Yours truly,

THOS. HEYS & SON.

CHARLES H. HEYS

Mgr.

EXISTING SYSTEM.

The greater part of the city, including the commercial and manufacturing districts, is supplied by gravity through two large conduits, 24 inch and 27 inch in diameter, from Chain Lakes and

Long Lake, which now stand at the same elevation, 207 feet above tide. This is the low service system.

The higher portions of the city, principally residential, are supplied by the 15 inch main from Spruce Hill Lake, this lake having an elevation of 363 feet above the sea.

On the low service system there are 19,000 consumers, and on the high service 16,500 or thereabouts, a total of 35,500 out of a total population of 42,000.

THE PIPEAGE WAS AS FOLLOWS IN APRIL, 1905:

Diameter.	Conduits.	Distribution.	Totals.
27 inches	14,560 feet		14,560 feet
24 "	13,200 "	7,324 feet	20,524 "
20 "	6,712 "		6,712 "
15 "	29,488 "	14,748 "	44,236 "
12 "	....	37,201 "	37,201 "
9 "	....	43,127 "	43,127 "
8 "	....	415 "	415 "
6 "	....	136,296 "	136,296 "
4 "	....	33,272 "	33,272 "
3 "	....	30,653 "	30,653 "
Less than 3 in.	....	898 "	898 "
Totals	63,960 feet	303,934 feet	367,894 feet

I have assumed that the 15 inch and 24 inch conduits end at St. Andrew's Cross, and the 27 inch conduit at Gottingen Street. This gives a total of nearly 70 miles of piping.

There were set on the system at the date above given 424 fire hydrants and 598 gate valves on mains over three inches in diameter

SERVICES.

When the works were taken over by the City in 1861, the population was about 30,000, of whom it was estimated that 19,000 were water takers consuming 1,500,000 gallons per day through 1,000 service pipes. Practically all of the service pipes were of cast iron three fourths of an inch in diameter.

In 1862 about six and one half miles of these cast iron services were replaced by lead pipes, the standard being half inch.

At the present time there are about 7,000 services laid, of which about 300 are "dead," leaving 6,700 in use for 35,400 consumers, or 5.28 persons per service.

The total population of the City is now given as 41,400 but is probably 42,000 of whom 6,000 are not supplied from the Water Works System. Service pipes are being laid at the rate of about 100 per year during the last two years.

The growth of the distribution system from 1895 to 1905 has been as follows:

Sizes Mains.	1895.	1899.	1902.	1905.
24 in. and 20 in......	7,324	7,324	7,324	7,324
15 in. and 12 in......	51,531	51,949	51,949	51,949
9 in. and 8 in........	30,183	42,816	43,542	43,542
6 in..................	95,705	122,568	131,559	136,296
4 in..................	14,484	19,415	20,540	33,272
3 in. and less........	46,342	47,341	45,623	31,551
Total feet............	245,569	291,413	300,537	303,934

The yearly extensions before 1899 were greater than since.

There has been practically no increase in the large mains, 24 in., 20 in., 15 in. and 12 in.. since 1893. The nine inch was extended 40 per cent. between 1895 and 1899, but very little since that date. The greatest increases are in the four inch and six inch. During the last few years three miles of pipe of a diameter of three inches and less has been replaced by larger sizes.

The high service district covers an area but slightly less than the low service district. The total length of mains and population served in each district is approximately as follows:—

District.	Miles.	Fire Hydrants.	No. Service Pipes.	Pop. served.
Low................	34	250	3,600	19,000
High...............	23	175	3,100	16,400
Totals.............	57	425	6,700	35,400

Previous to the year 1890, all the pipes three inches and four inches in diameter were laid with leaded joints, and all pipes larger than four inches with wooden stave joints.

In 1890 turned and bored joints were adopted for all mains four inches and greater in diameter.

METERS SET.

In the year 1895 there were installed 147 meters, which number has been increased year by year, until there were 493 set in 1905.

The following schedules give the number of each size of meter set in each year from 1895 to 1905 inclusive.

SIZES OF METERS.

Year.	6	4	3	2	1½	1¼	1	¾	½	Totals
1895...	1	12	18	4	1	3	9	30	69	147
1896...	2	12	17	5	2	2	13	41	99	193
1897...	2	14	18	7	2	3	13	40	181	280
1898...	2	13	16	8	2	2	14	43	132	282
1899...	3	9	21	7	4	2	17	42	193	298
1900...	3	8	21	6	5	2	20	39	191	295
1901...	3	7	19	7	4	2	20	42	207	311
1902...	4	9	20	10	4	4	21	42	206	320
1903...	4	9	16	16	2	5	21	37	217	327
1904...	4	9	16	17	5	4	20	44	229	348
1905...	4	9	16	17	5	4	26	65	347	493

In 1904 the 348 meters, set, were of the following kinds:—Siemen, 244; Trident, 98; Beck, 1; Crown, 2; Empire, 1; Neptune, 1; Indicator 1.

It will be observed that in the year 1897 eighty six meters were set, and in 1905 one hundred and forty five, both dry years; but the large number set in 1897 was chiefly due to the fact that in the years 1896 and 1897 a greater number of services was laid than in any preceeding or succeeding two years.

The Schedule following gives the number of services laid each year since 1894, the quantity of water metered, and the amount collected for the same.

Year.	Number of Services laid during year.	Total Services laid.	Meters in use.	Total gallons metered per year	Total amt. received per year for metered water.	Average rate per 1,000 gallons in cents.
1894...		5,505				
1895...	159	5,664	147	87,663,412	$ 9,942	8.8
1896...	251	5,915	193	128,946,398	10,893	11.8
1897...	211	6,223	280	114,947,792	11,070	10.4
1898...	182	6,407	282	116,652,791	11,482	10.2
1899...	176	6,583	298	183,572,099	14,197	12.9
1900...	56	6,639	295	126,735,312	12,372	9.1
1901...	57	6,728	311	143,264,344	16,150	11.2
1902...	76	6,804	320	113,982,605	12,297	10.7
1903...	68	6,872	327	147,438,344	13,620	9.2
1904...	67	6,939	348	183,882,212	14,893	8.0
1905...	112	7,051	493	166,155,462	16,647	10.0

About 351 of these services may be assumed to be "dead" or not in use, leaving 6,700 revenue producers.

Twenty seven of the metered services consume from 1,000,000 to 36,000,000 gallons per year, the average being 4,900,000 gallons per year, or 13,400 gallons per day.

The following is a list of those consuming over one million gallons per year ;—

Owner.	Class of Premises.	Consumption.	Amount.
I. C. Railway	Round House	11,071,200	$ 840.34
Dominion Cotton Co.	Factory	3,683,000	384.07
H. G. Bauld	Laundry	1,817,800	146.00
Sisters of Good Shepherd	"	4,462,250	429.61
Dominion Government.	Immigration Sheds.	3,186 000	349.52
Wm. Cunard	Wharf	1,388,000	203.42
A. Keith & Son	Brewery	3,893,000	399.30
"	"	1,326,281	136.62
Dominion Government	Custom House	1,079,000	159.53
John P. May	Brewery	1,375,000	187.12
Furness, Withy & Co.	Wharf	1,126,700	206.83
Halifax Electric Tram Co	Company	12,078,000	925.85
Intercolonial Railway	Station	2,971,000	252.10
William Wilson	Hotel	1,119,000	163.31
Max Ungar	Laundry	3,087,500	316.75
Dominion Government	Boiler House	15,705,843	1,175.93
Halifax Electric Tram Co.	Gas Works	8,850,000	673.75
School for the Blind		1,517,000	112.19
Acadia Sugar Refining Co.	Refinery	36,205,220	2,722.89
Dominion Government.	Marine & Fisheries.	2,365.000	290.65
Plant S. S. Co	Wharf	3,310,000	363.42
Halifax Club		1,210,000	174.57
Convent Sacred Heart		1,032,000	82.24
Max Ungar	Laundry	2,672.000	277.20
Commercial Cable Co	Wharf	2,432,000	300.65
Intercolonial Railway	Freight Shed	2,207,390	172.55
Dominion Government	Armoury	1,090,000	165.16
Totals		132,260,184	$11,611.57

A large number of smaller consumers increases the total amount of metered water to 166,155,462 gallons, and the total revenue from meters to $16.647.

Although seven per cent. of the total number of services are metered, including all the large consumers of water, only four per cent. of the water that flows into the city through the three conduits is accounted for by the meters.

Consumption.

Statements have appeared from time to time in the City Engineer's Annual Reports as to the enormous consumption of water by the citizens. These statements were the results of calculations based upon gauge readings and upon assumptions that were probably reasonably correct, but there were sufficient indefiniteness in the results to detract seriously from their value.

Upon my first visit I recommended that a Venturi meter be set upon each of the conduit pipes to determine the exact flow.

The fifteen inch meter has been in service since February 15th, 1906, and the two larger meters since November 28th, 1906. The exact amount of water consumed can now be stated with certainty.

Before the Venturi meters were set it had been estimated that the two large conduits delivered daily about 8,000,000 gallons per day to the low service district, and the small conduit about 2,000,000 gallons daily to the high service district, or a total of 10,000,000 gallons per 24 hours.

The recording registers of the three Venturi meters have proven that the actual consumption is 10 per cent. greater than the above estimate.

On the 15 inch conduit the flow has varied from 2,000,000 to 2,500,000 gallons since the latter part of February last, the average being 2,200,000 gallons.

The population of the City is now about 42,000 people, but from a census taken of the water takers, 35,400 only are supplied. This gives a daily consumption of 310 gallons per water consumer.

In the low service district the population served is about 19,000, the average consumption being 8,800,000 gallons per day, or 462 gallons per consumer, over ten barrels per day for each man, woman and child.

In the high level district the consumption averages 132 gallons per day per consumer.

The daily discharge of each of the two larger conduits during the first week in December, 1906, was found to be 4,500,000 for the 24 inch and 4,750,000 for the 27 inch, at which time the 15 inch discharged 2,300,000 gallons per day, or five per cent. more than the average.

Deducting five per cent. from the recorded flow in the two large conduits gives the average as 4,300,000 gallons and 4,500,000 respectively. The total daily average consumption is therefore 11,000,000 gallons, or 262 gallons per capita, or 310 gallons for each consumer.

The maximum domestic supply during extreme hot, dry weather, or extreme cold weather, probably exceeds 14,000,000 gallons per 24 hours, or say 10,000 gallons per minute, of which quantity—

The 15 inch probably discharges 2,000 gallons per minute.
The 24 " " " 3,750 " "
The 27 " " " 4,250 " "

WASTE.

The excessive waste of City water has been so exhaustively dealt with by your City Engineer that there is little new that can be said upon the subject.

Instead of getting on comfortably with 4,000,000 gallons per day you are consuming about three times that quantity, two thirds of which is probably wasted.

The quantity of water absolutely necessary to properly supply the City has been variously estimated. Recent statistics show that in the large manufacturing cities of the Northern United States the maximum consumption should not exceed 100 gallons per capita per day computed as follows:—30 gallons for domestic uses, 30 gallons for manufacturing purposes, 10 gallons for public uses, and 30 gallons unaccounted for, that is, leakage.

In Halifax practically all of the large consumers are metered, but the average water metered is less than 450,000 gallons, or 11 gallons per capita per day.

If Halifax were an average City the daily coumption would be about 4,000,000 gallons per day, possibly attaining a maximum of 6,000,000.

The following Schedule giving the daily consumption of water in some of the Cities of the Northern United States with populations from 35,000 to 60,000 is worthy of study.

City.	Population	Per-capita gals.	Percentage taps metered.	Domestic Pressure.	Gravity or Pumping.
Akron, O.	46,733	137	7	80	Pump.
Brocton, Mass	50,000	36	96	30 to 70	"
Davenport, Ia	37,768	100	43	75	"
Duluth, Minn	57,397	85	41	120	Grav.
Elmira, N Y	37,106	125	10	25	P. & G.
Erie, Pa	56,363	168	2	60	Pump.
Ft. Wayne, Ind	48,031	84	27	35	"
Fitchburg, Mass	34,378	90	48	40 to 170	Grav.
Harrisburg, Pa	52,951	135	66	40 to 80	Pump.
Haverhill, Mass	38,987	111	..	40	Grav.
Holyoke, Mass	50,831	100	½	25 to 100	"
Lincoln, Neb	44,158	36	100	40	Pump.
McKeesport, Pa	38,274	90	25	45	"
Portland, Me	52,656	110	..	30 to 80	Grav.
Saginaw, Mich	45,543	200	8½	55	Pump.
South Bend, Ind	40,327	81	12	60	"
Springfield, Ill	36,211	108	12	35	"
Terre Haute, Ind.	54,008	77	19	50 to 60	"
Waterbury, Conn.	56,521	130	22	100	Grav.
York, Pa	36,438	70	3	75	Pump.
Average	45,734	103	28%		

In five Canadian cities the consumption is as follows:

London	42,000	85	2⅜%	40 to 90	Pump.
Hamilton	57,500	91	1½%	40 to 100	"
Ottawa	65,000	184	⅜%	100	"
St. John	40,700	110	..	20 to 60	Grav.
Halifax	42,000	262	7%	10 to 50	"

The proportion of the services metered and the consumption varies greatly. At one end of the scale stand Saginaw and Erie, examples of extravagance and waste, and at the other end of the scale are Brockton and Lincoln with a consumption of less than 40 gallons per capita for all purposes.

At Portland, Maine, Holyke, Mass,, Fitchburg, Mass., and Duluth, Min., the Water Works Systems and conditions are more similar to Halifax than in the other places mentioned, yet the average consumption per capita in these places is only 100 gallons per day with a higher domestic pressure.

The consumption in Halifax may be accounted for as follows :—

	High service.	Low Service	Entire City
Domestic uses...................	50 gals.	75 gals.	65 gals.
Manufacturing purposes.....	5 "	15 "	10 "
Municipal and Public........	5 "	15 "	10 "
Leakage and waste	70 "	365 "	225 "
Total per Consumer...	130 gals.	460 gals.	310 gals.

The leakage and waste in the high level district is double what it should be, but in the low level district the loss is twelve times the average.

Cause of Waste.

The cast iron pipes in the original Distribution System, and in the 15 inch conduit were uncoated, and the joints were made with sections of wooden staves driven concentrically between the hub and spigot.

The 24 inch conduit laid in 1862 was of cast iron, coated but the joints were of wood. About 1884 lead jointing was adopted in extensions to the distribution, but this method was superceded by turned and bored joints in 1891.

The 27 inch conduit laid in 1893 is of cast iron, with turned and bored joints.

Probably 50 per cent of the distributing mains in the low level district are jointed with wood. This no doubt accounts for a large porportion of the leakage.

Until 1896 the plumbing in the City was not regulated by by-law, the result being that cheap, unsanitary fixtures were generally installed, often in exposed places.

An enormous quantity of water can be wasted through defective plumbing and from fixtures unprotected from frost.

Since 1896 there has been an improvement in new work, but all old work should be thoroughly inspected, tested, and condemned if not up to the modern standards. The most effective way of accomplishing the desired results would be to place the responsibility of waste on the owner of the premises, each to be charged for his own carelessness in respect to waste or to leakage from cheap plumbing.

It is not fair to charge the careful householder who instals first class plumbing, and uses about 50 gallons per capita per day, for the water wasted by his neighbor whose plumbing is defective, yet that is what your are doing in Halifax.

The leakage from mains and services in an ordinary Water Works system should not exceed 20,000 gallons for each mile of main, or say 1,500,000 gallons per day in 75 miles of pipes. In Halifax however, the leakage from this cause is probably between 3,000,000 and 4,000,000 gallons.

An increase in pressure would increase the leakage and waste but this might serve to discover many lakes that could then be reparied.

Many of the older cities in Canada acquired by purchase a leaky water distribution system from a private company, but in most of these places the old leaky mains were afterward taken up and replaced by larger ones with standard leaded and caulked joints. In Toronto, cement lined pipes were largely used in the original system; in Kingston, uncoated pipes; in Sherbrooke, a sulphur compond was used for joints; at Moncton, wood jointed pipe; and in some places pipes made from logs were laid. In Halifax many miles of old leaky pipes have been replaced by new mains, but there yet remains too large a precentage of old pipe.

WASTE PREVENTION.

The waste of water in the City of Halifax is an evil of such long standing that only drastic measures, backed by public opinion, will effect a cure.

There is only one way to stop this waste; that is by metering the services, and thus demonstrate to every consumer the exact quantity of water he is using.

During the last ten years a great change has taken place in public opinion respecting meters.

It has been erroneously assumed that meters restricted the use of water, and in this way fostered unsanitary conditions. This has been proven by actual experience in many places within the last few years to be incorrect.

The first cost of installing meters is a comparatively large amount, but the owners of property are becoming convinced that it costs less in the long run to instal meters than to enlarge the entire water works system.

As a general rule the per capita consumption in the unmetered cities in Canada and the United States is fully double the consumption in metered cities. In a gravity system this means double the outlay for collecting and conserving the water, and double the expenditure for conduits and mains.

This matter has been presented to you so often by your City Engineer that it may have ceased to interest you, but unless meters be generally adopted it will be necessary to secure an additional supply of water. Nothing more can be drawn safely from Chain Lakes, Long Lake and Spruce Hill Lake. The limit has been reached—in fact they have supplied, and are now supplying more than the designing engineers estimated upon.

Frequent house to house inspections may serve to locate wastage, but the benefits of this system are not permanent in a City where inferior plumbing and carelessness of consumers have been the rule for half a century.

Comparative statistics demonstrating the efficacy of metering might be tedious, but some recent examples of what has been done to restrict waste in a few American cities are worthy of consideration.

At Atlantic City meters were decided upon in 1895, and within two years 71 per cent of the services were metered decreasing the consumption by more than fifty per cent.

At Milwaukee and at Cleveland where the supply is only limited by the sizes of the mains and the capacity of the pumping machinery, they decided that it would be more economical to meter the services than to duplicate mains and pumps.

In 1901 only six per cent of the services in Cleveland were metered, the per capita consumption than being 169 gallons per day.

In 1904 with 49 per cent of the services metered, the consumption had been reduced to 137 gallons, a saving of 32 gallons per capita.

The Superintendent is of opinion that with all services metered an additional 41 gallons per capita may be saved. At the end of 1904 over 30,000 meters had been set in Cleveland.

At Milwaukee the consumption of 113 gallons per capita in 1887 dropped to 102 in the following year, by the setting of 1800 additional meters. In 1904 with 80 per cent of the services metered, the consumption was 89 gallons per capita.

Richmond, Virginia, is another example worth studying. In 1885 the population was 70,000, and the consumption 24,000,000 gallons per 24 hours. This would be at the rate of 12,000,000 U. S. gallons per day for a City of 35,000, about the same as the consumption to-day at Halifax. This is over 340 gallons per capita.

In 1897 the Superintendent reported that nearly 500 houses were without water in the second stories during the day, and in 1899, after adopting meters, he wrote as follows :—

"It was mains or meters. Additional mains carried with them additional pumps ; the estimated cost was $270,000. From the beginning I was convinced that the meter system was a necessity for a City like ours, and from the first had urged its adoption. It is the same old story of opposition and postponement. Finally, after years of pleading, complaint became so loud that something had to be done. In the spring of 1897 the City Council appropriated $15,000 for the purchase of meters, and I was empowered to place them where I deemed best. I commenced setting the meters in June of this year, and placed them, irrespective of the size or condition of the premises, on the lowest plane. Nearly all the taps in this section supplied small dwelling houses, having two fixtures, a hydrant and a closet. The average consumption at each tap per month was nearly 30,000 gallons, and in a few instances reached as high as 140,000 gallons per month. This great waste was at once checked by the meter, or rather the bill, and at the end of the year the pressure at the high points had increased 40 per cent. Another appropriation of $5,000 for meters was made in 1898. They were set in the low district. At the end of the year the pressure had increased 100 per cent. at the high points. All complaint for want of water had ceased, and we had the same pressure at these points that would have been obtained by expending $270,000, which would have entailed an annual expense of $17,000. Prior to placing the meters our water power pumps were insufficient to keep up the supply, and we were often compelled to run the steam pump, which increased the cost of pumping $2,500 per annum. This pump has not been used for the past eighteen months. It will be seen, therefore, that the saving per annum amounts to $19,500, nearly equal to the entire outlay for meters. The per capita consumption for last year, 1898, was 99 gallons per day, a reduction of 41 per cent. from that of 1890, and the quantity of water used now is 27 per cent. less than in 1890, while the population has increased 20 per cent. Another advantage from the meters : In the past, during freezing weather, it was the general custom to leave fixtures running and wasting to prevent frozen pipes, the result was little or no pressure, reservoirs rapidly emptying, in the face of the fact that all the pumps were worked to their full capacity. Recently we have experienced the severest weather known in my section of the country, the thermometer for days being at or below zero."

In 1904, with 41 per cent. of the services metered, the consumption per capita at Richmond was 129 gallons.

Yonkers, N. Y., with a population of 60,000, and all services metered, consumed 94 gallons per capita in 1904. This represented 60 per cent. of the water pumped, the balance being unaccounted for, that is, 40 per cent. was lost through leakage in the mains and services and in the slip of pumps.

Many other examples might be cited of the efficiency and permanence of the results of general metering. At Atlanta, Ga., the consumption was reduced 60 per cent. in four years ; at Harrisburg, Pa., 32 per cent. in six years ; at Lowell, Mass., 39 per cent. in three years; at Madison, Wis., 60 per cent. in thirteen years; at Hartford, Conn., 36 per cent. in five years.

There can be no reasonable doubt that by metering the services in the City of Halifax that the consumption would be reduced to 3,000,000 gallons per day, as registered by the meters on services.

The uncontrollable waste from mains and services in their existing state would, however, probably amount to 4,000,000 galls., making a total of 7,000,000 gallons per day, as registered by the three large Venturi meters on the conduits at Chain Lakes.

After metering the services the mains that are responsible for the large leakage can be located and the pipes uncovered and rejointed if necessary. Any large leakage can be determined by pitometer or by tapping the main on each side of a gate valve by an inch pipe, setting a meter on the by-pass and noting the flow, with the gate valves on main and on all services closed. Tests of this character are definite, but can only be made at night. The capacity of an ordinary inch disc meter is 30 to 50 gallons per minute, sufficient to measure the leakage from two or three miles of properly jointed pipes.

Types of Meters.

There are five types of meters differing in principle of action as follows:—

(1) Disc meters, in which an oscillating disc usually of hard rubber, moves the recording mechanism.

To this class belong the Hersey, Pittsburg, Niagara, Trident, Nash, and Keystone.

Meters of this class are simple, cheap and reasonably accurate.

(2) Rotary Disc Type—of which the Crown, Union, Empire, Columbia, Hersey, and Lambert are examples.

These meters are probably more durable than these of the disc type, more expensive, and probably more liable to stoppage.

(3) Reciprocating Piston Type—built on the principle of a steam piston, designed for extreme accuracy. The Worthington Duplex is an example.

(4) Current Type—made on the principle of a water wheel, suitable for large discharges, of which, the Torrent, Gem, Eureka, Trident-Crest., and Standard are examples.

(5) Venturi Type—for large discharges which depend upon the principle that with water passing through a contracted pipe or throat the velocity increases and the pressure is reduced, the difference in pressure indicating the velocity of flow, and therefore the quantity being discharged.

This meter is adapted for low velocities in large pipes. It is not accurate for small flows, and the registering appaiatus is complicated and expensive.

The disc and rotary types are in general use in the United States and Canada on domestic services. They may be depended upon to register within two per cent. of the correct quantity passing through the service pipe with a trifling loss of pressure, they are easily repaired, readily tested, durable, and can now be delivered at reasonable prices.

In Halifax all the largest consumers of water are now supplied through meters, leaving about 6,200 live services unmetered. Disc and rotary meters would prove quite satisfactory for these services, of which fully 4,500 would be five-eights inch meters, the remaining 1,700 being of larger sizes, which we may assume would be as follows:—1,000 three-quarter inch; 300 one inch; 200 one and one-half inch; and 200 two inch.

Objections to Meters.

Many plausible objections have been urged against meters, those having the greatest weight being as follows:—

(1) Meters would restrict the use of water, and thus affect the health of the citizens.

(2) The revenue from water takers would be materially reduced.

(3) The first cost and maintenance would be excessive.

It has been proven beyond question that meters do not in any way restrict the lavish use of water, neither have meters any effect upon the health rate. Whether the revenue be affected or not depends upon the tariff adopted.

The item "Meter Rental" is distasteful to consumers, and should be avoided, but a minimum annual fixed charge should be made on each service, sufficient to meet the interest and sinking fund on the first cost, and to cover the operating and maintenance charges.

The fixed charges on the cost of a water works system must be met in some way, as well as the expenses for operation and maintenance.

That the City at large should be assessed for a large proportion of the annual outlay is reasonable, but the parties using the water, the actual consumers, should also pay for the water used, and meter rates may be so adjusted that the revenue from consumers will equal that received from flat rates. At the present time the unmetered consumers in Halifax are paying less than one and one-half cents per 1,000 gallons for water they consume, while the metered consumers are charged over nine cents per 1,000 gallons.

With a meter on every service this unfair inequality in rates would disappear.

The original cast of installing a general meter system has deterred many cities and towns from adopting the system but frequently this cost has been grossly exaggerated.

It may be safely stated that the average cost of installing meters in Halifax would not exeed $16.00 per service.

The life of meters has been variously estimated. It has been demonstrated however, during late years that twenty years is too low rather than to high.

Maintenance of Meters.

The annual charges for meters would be made up of the following items, interest on first cost, depreciation, repairs and renewals, inspections, reading meters and bookkeeping. The interest and depreciation may be taken as nine per cent.

The remaining items may be bulked together, and statistics show that about $1.00 per annum per service will be sufficient.

The average annual expenditure will therefore amount to about $2.50 per meter.

Fire Protection.

The volume of water required to cope with a serious fire in the business district of Halifax has been prescribed by the Fire Underwriters as 3,200 imperial gallons per minute, or sufficient to supply sixteen standard fire streams concentrated upon one block or square, this supply to be over and above that required for domestic consumption. The pipe system must also be of sufficient capacity to convey the water to the hydrants.

In Halifax the line of demarcation between the high service district and the low service district follows closely a contour line 120 feet above the sea.

The pressure at the fire hydrants in the lower district varies from 10 pounds to 60 pounds. Along Lower Water Street the average pressure is about 42 pounds, and along Upper Water Street about 8 pounds higher. These pressures are sufficient to extinguish an incipient fire in a low building.

To give a proper pressure steam fire engines are employed, the supply being drawn from the fire hydrants. Boston, New York, Montreal, Toronto and nearly all the larger cities rely almost entirely upon steam fire engines for fire protection.

To lessen the waste in the lower parts of the low service district certain gate valves on the mains are now kept closed, or partially closed. Upon a fire alarm being given it is the duty of the Water Works Department to open one or more of these valves in the vicinity of the fire. This is certainly a most undesirable state of affairs, even if the water supply were ample.

If all the valves were open, the water mains in the business portions of the City are now too small to convey the proper supply, in fact they are useless, except for domestic purposes.

The following mains in the heart of the business districts might be removed without impairing the fire protection:—

Argyle,—Blowers to Jacob.
Granville,—Salter to Buckingham.
Hollis,—South to Salter, and from Sackville to Buckingham.
Bedford Row,—Sackville to Duke.

In the important congested business districts, the mains on the cross streets are now depended upon for fire supply, all fed from one fifteen inch main on Grafton Street, which is taxed to its full capacity at times to convey the domestic supply. These cross mains should be fed from both directions, or from two additional larger mains laid on streets parallel with Grafton.

Along Lockman Street and Upper Water Street, fire protection is given by hydrants supplied with water from pipes laid on cross streets fed from the 12 inch main on Brunswick; all these cross pipes being 6 inches in diameter, except one 12 inch on

Cornwallis. It is doubtful if ten fire streams could be concentrated on the I. C. R. Station, or on premises north or south, with every pipe and valve open.

If the daily consumption of water in the low level district were reduced to what might be considered as a reasonable quantity, the sizes of the mains in the existing system would not be sufficient to fulfil up-to-date fire requirements.

The fire pressure in the high service district varies from 4 to 40 pounds at the hydrants, depending upon the elevation.

With the exception of Gottingen Street and Agricola Street, this district is chiefly residential, but it contains a number of important public institutions such as schools, asylums, hospitals, colleges, barracks, exhibition buildings, etc.

If the flow in the 15 inch main were available for fire service on Quinpool Road, possibly ten standard fire streams might be supplied, but as the entire flow is now taken by the domestic consumers, it follows that proper fire protection cannot be given at any point in the district, except along Gottingen Street, where a supply may be drawn from the 24 inch low service main, and possibly at some other points where large low service mains are available. It may be broadly stated, however, that although the conduit is now taxed to its full capacity, there is no water for fire protection in the higher parts of the district.

At Dalhousie College it is doubtful if more than two standard streams could now be drawn from the hydrants by steamers, and at the Exhibition grounds the supply would be less.

It is evident that some large mains should be laid in this district and an adequate supply of water provided at all times for fire protection.

The new distribution mains required, should be laid from the proposed source of additional fire supply to those points where the supply is now inadequate. The route for the mains as shown on plan, may be modified or changed, if desired, provided 4,000 gallons per minute in addition to the domestic demand be conveyed to any point in the low service district between Smith Street and the Refinery, and 2,000 gallons per minute in addition to the domestic demand to any point in the high service district.

The 15 inch on Grafton may be of sufficient size to give fire protection to the congested business districts, but you should not depend on one main. Another main should be laid on some parallel street, taking up the old leaky main now in use.

The cross mains on Duke and Proctors Lane, should be replaced with larger pipes, also the pipes on Gerrish east of Gottingen, North, east of Brunswick, and Russell east of Gottingen. South from Park to Pleasant should be relaid with a large main.

If the mains on Hollis and Lockman Streets be replaced by larger pipes, some of the cross mains mentioned may be omitted, and a better service given.

In the high service district 12 inch mains should be laid on Almon Street, Oxford Street, and South Street, also a 14 inch or 16 inch on Robie Street from Young Street to South Street.

If the mains on Hollis, Beford, Granville, Argyle and Lockman are jointed with wood, they should be removed and replaced by larger pipes.

It may be of interest to compare the number of fire hydrants in Halifax with the number in other Canadian cities :

PLACE.	Population.	Distribution.	Fire Hydrants.	Static pressure at hydrants.
London....................	42,000	81 miles	497	40 to 90
Hamilton....	57,500	106 "	952	40 to 100
Ottawa......................	15,000	105 "	867	100
St. John...........	39,000	55 "	350	20 to 60
Halifax	42,000	58 "	424	10 to 50

The hydrant pressures at Halifax are so extremely low that upon a fire alarm coming in from the congested districts certain valves are opened and others closed by the Water Department, thus concentrating the flow. This dual control of the valves is most undesirable, and tests made by the Fire Underwriters also show that by concentration the supply is inadequate.

The accompanying skeleton plans of the distribution systems in the business districts of Toronto, Hamiliton, London and Ottawa may be of interest. Toronto is now adding a high pressure fire system in part of the area shown. At London, where the fire supply is but little better than at Halifax, improvements that may cost half a million dollars are now under consideration.

HIGH PESSURE SERVICE.

Many of the larger cities in the United States and Canada have installed, or are now installing, high pressure water systems, for protecting the congested business districts, the mains being designed for high pressure given by powerful pumping machinery, the entire system being independent from the domestic supply system, and only operated during fires.

In some places the pumping machinery is placed on fire boats, from which heavy fire streams may be thrown, or the water forced into a pipe system on shore.

The pressure carried varies from 200 lbs. to 300 lbs. to the square inch, the hydrants are provided with three, four or five nozzles, and in some places fitted for three inch fire hose. Steam fire engines may be dispensed with in the district thus served.

Sea water has some slight advantages over fresh water for extinguishing fires. The volume would be limited only by the capacity of the pumps, and the domestic supply would not be affected.

The pumping machinery for a high pressure system may be operated by steam, gas or electricity. The last mentioned would be the cheapest in first cost, but possibly not as reliable as steam or gas. There would be but little choice between the two latter, but gas engines may be started in much less time than steam engines. Machinery to pump against a water pressure of 300 lbs. would be much more expensive than machinery for 100 lbs. pressure, and would require three times the power.

The installation of a high pressure system in Halifax, taking sea water from the harbor, would, however, be an expensive undertaking, owing to the great length and narrow width of the territory to be protected, and the great difference in elevations. The adoption of this system would mean the duplication of mains on many streets, the cost of which might better be expended in taking up the existing leaky pipes and relaying with larger mains.

Again, if only a part of the business district were included in the system the fire service in the remaining portions of the low district and in the entire high service district would not be improved except indirectly.

You now have an ample supply of fresh water available for fire protection throughout the entire City at a less cost than a high pressure sea water system.

Pumping Station.

By installing a pumping station on the line of any one of the three conduits, the supply of water flowing into the City, or the pressure, or both might be materially increased as desired for fire service, or to improve the domestic service in some districts.

As the 24 inch and 15 inch conduits are provided with wood joints except at and near the Dutch Village Road it would not be prudent to increase the pressure in these pipes, but this objection does not apply to the 27 inch main, which should stand any reasonable working pressure up to 120 pounds to the square inch.

The best location for this pumping station would appear to be on the City property east of Kempt Road, along which there is now laid a railway siding.

By means of properly arranged by-pass pipes and valves, water could be drawn from Chain Lakes through the 27 inch main, and forced under increased pressure into the low service system, or into the high service system. For such a variable service, turbine pumps would be specially suitable.

This pumping station would ensure a full fire supply in either district at any time, and would in addition permit water being taken from the low service main to improve the pressure in the high service district if desired.

The 27 inch conduit is of sufficient capacity to supply about 2,000 gallons per minute in addition to the quantity now flowing through it. When the waste is checked, the 24 inch conduit alone will supply the domestic demand, and the 27 inch can easily supply 6,000 gallons per minute to the pumping station or sufficient for thirty fire streams.

The maximum power required would not exceed 300 H. P., perferably subdivided into two or three independent units.

The source of power may be steam, gas or electricity, the final additions depending upon reliability rather than first cost or operating expenses.

Gas engines operated by City gas or producer gas, may be started almost instantly, and the operating expenses would be less than steam or electric power.

If gas from the mains of the gas company were used, the first cost of the plant would not exceed the cost of a steam plant. A producer gas plant would be more expensive but you would then be independent of the Gas Company.