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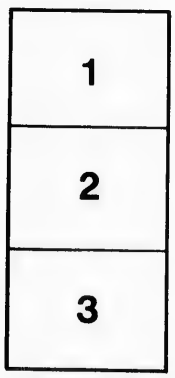

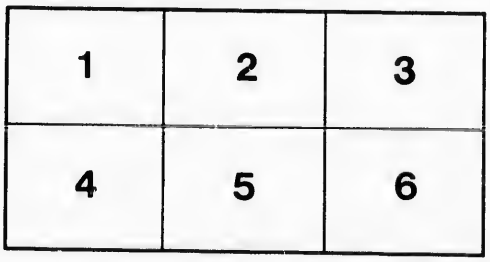

REPORT

ON

IMPROVEMENT IN THE WATER SUPPLY

OF THE

City of Halifax, N. S.,

BY

F. W. W DOANE M. Can. Soc. C. E.

CITY ENGINEER.

CITY ENGINEER'S OFFICE,
HALIFAX, N. S.,
FEB. 12TH, 1892.

Chairman Board of City Works:

SIR, on the 6th of July, 1891, a resolution was passed by your Honorable Board requesting me to make such surveys as were necessary for the purpose of determining the most favorable route for a duplicate main for the low service system.

In accordance with that resolution, after examining every possible route, I submitted a report dated September 5th, 1891, recommending the adoption of a line which, in my opinion, would be most favorable if the scheme for a new pipe should be carried out. The route was described as follows:—

"Starting at the north pipe house at Lower Chain Lake and following the present pipe to the brow of the hill on the west side of the Arm, the route of survey turns northwardly and running in a nearly direct line to Bayer's Road continues along the highway to McCollough Street. Thence the line proceeds along the lowest part of the depression across Windsor Street, and passing north of the Paint Factory crosses Kempt Road and Longard Street to Young Street. From Young Street the pipe may be laid down Gottingen Street or down Kaye Street to Campbell Road."

The report mentioned above was referred back to me for cost of right of way and such other information as I could obtain. I therefore beg to submit the following communication, and in doing so I may say that the delay has been caused by the difficulty in getting answers from property owners on the proposed line, some of whom are in England.

The first point to be considered is the necessity for improvement or increase in the water supply of the city. That there is need of improvement cannot be disputed. The question to be decided, however, is how that improvement is to be made. The object apparently would be to obtain the greatest degree of efficiency in the most economical manner. The system has never been perfect since its inception, and looking over the history of the works it is almost impossible to discover any year in which complaints were not made respecting its inefficiency.

The original works were constructed by a private company, organized in 1845, of which Jas. B. Uniacke was President. After some preliminary surveys, made by Mr. Charles F. Fairbanks, C. E., they obtained the services of John B. Jervis, a civil engineer well known in connection with the Croton Water Works in New York. He made a report on the 28th of August, 1845, which resulted in the laying of a twelve inch main from Lower Chain Lake to St. Andrew's Cross. Mr. Jervis considered a ten inch main ample for the estimated population of from 20,000 to 25,000, but in order to provide for future requirements he recommended a twelve inch pipe. He also proposed to construct a distributing reservoir at a point within the city known at that time as Windmill Hill, and described as about one thousand feet from St. Andrew's Cross. This important part of the scheme was never carried out, although subsequently advised by other engineers, including my predecessor. Water was first turned on from the Chain Lake in 1847.

In 1854 an additional main 15 inches in diameter was laid down to make the supply equal to the rapidly increasing demand. In 1855 Long Lake was drawn down 3 ft. 9 in. below the waste weir, leaving only 2 feet of water over the bottom of the conduit between Long Lake and Upper Chain Lake. This evidence of the limited storage capacity of the lakes and the necessity of a further increase in the supply roused the City

Council to action and a Water Committee, of which Henry E. Pugsley was Chairman, employed Jas. Laurie, C. E., to report on several proposed plans for improvement. In 1861 the works were purchased by the city and a Board of Commissioners of water supply was appointed of which John A. Bell, the present City Auditor, was Chairman. The first work carried out by the new Commissioners was the lifting of the old 12 inch main and the substitution of a new 24 inch pipe which was completed in 1861 or early in 1862. This pipe is the present low service main. The two mains were capable of supplying about 12 times as much as the demand estimated by Mr. Jervis, although the population had only increased 50 per cent.

The Long Lake water, however, did not control the highest portions of the city and in many places where the domestic supply was sufficient no pressure could be obtained for fire purposes. Accordingly in 1868 the High Service Works were constructed under the supervision of the Board of Commissioners of Water Supply and on the recommendation of Thomas C. Keefer, a hydraulic engineer of the highest standing.

In 1864 Long Lake fell to within 11 inches of the bottom of the conduit carrying the water to the Upper Chain Lake. Mr. Keefer reported in connection with the high service on the practicability and advisability of raising Long Lake dam, but it was not carried out until 1877, when the work was performed under the supervision of the City Engineer at a cost of $13,500. The raising of the lake and consequent increase in storage had become an absolute necessity. During the preceding summer Long Lake was so low that window washing, street watering and other similar uses of water were prohibited, and water takers had to be cautioned against waste. In 1886 the conduit between Long and Chain Lake was lowered and the storage capacity of our low service reservoir increased over 100,000,000 gallons.

Notwithstanding the fact that the supply considered sufficient at the inception of the works, has been multiplied by from 12 to 15, while the population has not even doubled, we are again compelled to consider the question of increase. The experience of Halifax is repeated in few cities and the consumption per capita at times has been exceeded by none. Taking the statistics of consumption for works all over the country we find on comparison that there is a great difference in the amount of water consumed in different places, and if from 30 to 50 gallons suffice in certain cities, the use of 90 or 100 gallons in others presupposes a considerable waste. For domestic and household uses 20 gallons per person per diem is a sufficient allowance; taking into account the water used for mechanical and manufacturing purposes, that necessary for street sprinkling, extinguishing fires, for use in stables, etc., 60 gallons per diem for each inhabitant is a liberal quantity in the case of the larger cities and manufacturing towns. In the case of the smaller, non-manufacturing towns 35 or 40 gallons should suffice.

The great waste which takes place in Halifax being acknowledged, the question arises how to prevent or at least diminish it. There should be no doubt in the mind of any citizen that a great waste does take place, for instead of 60 gallons per day being sufficient on an average, our daily consumption has at times reached four times that quantity. The cause of such an enormous consumption has been pointed out so often that the City Council has ceased to take any notice of it, if indeed it ever did. As a natural consequence of the complaints respecting waste being made to unheeding ears we are now compelled to face a possible expenditure of $150,000 to improve the service to say nothing of the thousands of dollars that have gone up in smoke in some parts of the city which better pressure might have saved. Nor will the expense stop on the completion of the proposed improvements, for if the consumption increases as in the past the quantity of water available will be exhausted and we will be asked to solve the problem of augmenting the supply.

If the question of expenditure were less important and th supply inexhaustible I would have no hesitation in recommending immediate increase on account of the difficulty in checking waste in our climate and the impolicy of restricting every legitimate use of water. A lavish waste of water seems to have begun soon after the first pipe was laid, and following the history of the works we find the water pressure rapidly decreasing and in some parts of the town where a few years ago, streams from the fire hydrants could be thrown over the top of buildings, the water now will not rise to the nozzles. In consequence the High Service had to be diverted to the low, thereby distroying the High Service System. All over the city stop-cocks have had to be partially or entirely closed in order to give a supply to houses which otherwise would have none. As the consumption increases from year to year the loss of head which was at first trivial must increase so that during fires and in times of greatest draught the water must fall away in houses receiving it on the second and third floor to the first floor and basement and from elevated houses altogether.

Not only will consumption of daily supply, when reached generally take place in the 12 hours of the day and therefore require a capacity double the average for the 24 hours, but at all times when fire occurs the demand requires the utmost efficiency throughout every part of the pipe. That the consumption of daily supply has been reached has been proved by the fact that at times the draught is so great that not only is there no pressure on Quinpool Road but the water does not fill the pipe. By the time those who are inclined to doubt the enormous consumption or waste have digested that statement they may, perhaps, be converted.

The most important result of the great waste is the greater risk from fire and consequent higher rate of premiums. Waste and therefore loss of pressure destroys the value of the fire

department. When a fire breaks out the first sound of the alarm calls the turnkeys, who have special instructions, and the Foreman of the Water Department under whose immediate direction the turnkeys are. I also attend as many alarms as possible myself. The first duty of the men is to concentrate the water as much as possible to the locality of the fire by, shutting it off from the other parts of the city, and in this way the pressure necessary can be obtained, although in the higher parts of the Low Service, where there was formerly a fair fire pressure, the High Service has to be utilized It is necessary to exercise the greatest caution in concentrating the whole available force of water so that the wrong valves may not be opened or closed and the district entirely deprived of water. There is also a danger of the same result from the bursting of a main caused by a valve being closed too hastily. If the waste were checked the normal pressure would be greatly augmented and the necessity for concentration would not exist. Moreover I shall be able to prove that if the waste were stopped the benefit obtained would be greater than that from any other improvement within our present means.

The principal causes of waste are bad plumbing, exposed pipes, taps and fixtures and hopper water closets. One strong proof that waste is caused by exposed pipes, taps and fixtures and bad plumbing lies in the fact that the consumption in winter is much greater and the pressure consequently much less than in summer. The consumption during the winter of 1874-5 became so great that the water had to be concentrated in districts during a certain portion of each day on the higher streets, in order to give a domestic and manufacturing supply. The weak pressure made it necessary to turn off the water from one district to supply another, and in some places the High Service had to be tapped to supply Low Service districts.

In 1879 the City Engineer reported that there were 4291 service pipes, the greater part of which were $\frac{1}{2}$ inch. In 1492

buildings supplied with water the pipes were laid in exposed and dangerous positions, so that the inmates were obliged to let the water run almost constantly through the winter In 1185 buildings the pipes or water fittings were in bad condition or in some way defective.

In 1889 there were 5215 service pipes with a total of 13966 taps. In 1890 there were over 800 exposed pipes and taps. About 3500 taps running at a rate of one gallon in a minute would consume almost the entire available supply. In some cases tested it was found that the waste from a single tap was $8\frac{1}{2}$ gallons in a minute. In view of this fact it is not surprising that the pressure is weak, and when to the waste from exposed taps is added that from hopper closets does any body wonder why the mains cannot supply the draught caused by the enormous useless discharge into the sewers. In 1879 there were 880 hopper closets; in 1889 there were 1400. In a report dated August 3rd, 1891, now on the order of the day in the City Council, I gave the result of some experiments made in Boston to determine the waste in hopper closets, and taking the result as an average in our own case showed that the waste in Halifax would be over 400,000,000 gallons in a year. It was also stated that we had been able to make a test for ourselves with 9 closets, and applying the average result to the whole number of hopper closets in the city, we were sending a useless stream into the harbor during the year, amounting to over 900,000,000 gallons, a quantity equal to the whole storage capacity of Long Lake.

In 1881 the heavy incrustation was taken off the inside of the High and Low Service Mains by mechanical scrapers, and the result was that the pressure was largely increased all over the city. At some hydrants the increase amounted to 28 pounds. This improvement lasted for a short time only and the old evil destroyed the benefit derived from the cleaning of the pipes. The effect of the increased pressure was that more water was

wasted, and the condition of the works will soon be about the same as in 1880. The following statement shows the pressure at some well known points before the cleaning operations were undertaken, after the first cleaning, and during the month of March, 1891

LOCALITY.	Lowest pressure in winter of 1880.	Lowest pressure in winter of 1881.	Pressure March 1891.
INTERSECTION OF	lbs.	lbs.	lbs.
Agricola Street and North Street	5	30	6
" " " Almon "	10	34	13
Almon Street and Kempt Road	8	34	12
Bilby " " Gottingen Street	15	40	23
Brunswick Street and Prince "	5	13	5
" " " Jacob "	12	27	21
" " " North "	0	12	32
Cogswell " " Gottingen Street	5	19	10
Dresden Row " Artillery Place	35	60	42
Duke Street and Barrington Street	23	39	33
Grafton " " Blowers "	0	15	6
" " " George "	4	20	11
Prince " " Argyle "	6	23	13
Quinpool Road and Robie "	24	52	31
Water Street " Fawson "	23	38	23
" " " North "	18	46	27
Moren's Wharf	33	50	33
Queen's "	36	55	47
Cronan's "	32	58	51
West's "	30	56	47

Under the present condition some parts of the city have no reason to complain and probably have always had a good supply for domestic and fire purposes. It is necessary that the same benefit should be extended to all parts of the city in order that the feeling of security, the advantages arising from reduced premiums for insurance, and the luxury of a full supply of pure water enjoyed by that part of the city where the most trade is carried on, the bulk of the merchandise stored and the most costly buildings erected, may be equally enjoyed by all.

The quantity of water available in the High Service system should be ample to supply c. half of the city (in population.) The City Works yield enough water to supply a population of 80,000 and if anything like economy were enforced the supply would suffice for a much larger number. With a source 200 feet above tide, making every allowance for loss of force from friction in pipes and constant draught for domestic supply, all points 150 feet above tide should be provided by the Low Service with sufficient means for extinguishing fires. Such, however, is not the case and in some places the High Service is let down to points 94 feet above tide. These extensions have destroyed the High Service and in any dry season it is liable to become exhausted.

Prevention of waste.

I would not give so much attention to waste concerning which the Council has already heard so much, if no remedy could be recommended. In some countries it has been found necessary to adopt very harsh measures in order to try and prevent unnecessary waste. Waste in cold climates depends on the regulations for prevention and the degree of stringency with which such regulations are enforced.

A step in the right direction has already been taken. House to house inspections are made during the winter and the water is turned off wherever exposed taps or pipes are discovered. We

are not yet in a position to prevent bad plumbing in houses, although we may be certain when it is being put in that it will cause waste. If the plumbing regulations submitted to the Council by the City Health Board become law we shall be able to control all new work.

The most important recommendation I could make for the prevention of waste is the abolition of all hopper water closets. The inmates of houses in which hopper closets are found allow a small stream to run day and night, with the idea that they are flushing out their drains or preventing the entrance of sewer gas. They could not be more mistaken, for the small stream does neither. A bucket of water would do more towards flushing the drain than the small stream would do in a week. It is impossible to flush a six inch drain with the amount of water usually found running for that alleged purpose. Neither does it prevent the entrance of noxious gases. In most cases the water is turned on by the tipping of the pan worked by a handle or lever. When closed the pan is filled with water and forms a water trap, effectually preventing the entrance of gases. Not satisfied with this condition, which is the safest, such unsanitary arrangements can be left in, the water taker generally props up the handle or lever so that a stream will run continuously. This operation opens the trap and provides an unobstructed canal up which sewer gas may pass into the house. The City Health Board have asked the Council to wipe them out of existence, but so far no action has been taken. They are the most unsanitary form of closet and every time the pan is tipped, if only for an instant, the door is open to disease. In my opinion these closets are responsible for the greater part of the disease which the city authorities have tried to stamp out, and while such facilities exist for communication from house to house through untrapped drains laid with criminal negligence, we cannot hope to see its extermination.

There is another effectual remedy for waste which should be

generally adopted in Halifax. The experience in other cities shows a great reduction in the consumption by the use of meters for detecting waste. Wherever they are used they play a most important part in reducing or keeping down the consumption of water and consequently the necessary size and corresponding cost of water works. There are a few in use in Halifax, but very few compared with the number of taps. Meters were first used in the city in 1876. The meter put on at the Halifax Hotel in that year reduced the daily consumption from 18,600 gallons to 6,700 gallons and at the International Hotel from 10,500 to 1,290 gallons. At present there is no meter on either of those houses.

In one instance coming under my own notice during the past summer a meter was put on where the average consumption was supposed to be about 10,000 or 12,000 gallons a month. During the first month a waste amounting to 1,400,000 gallons was detected As a result of the application of the meter that amount is saved to the city every month.

There is a good deal of opposition from consumers to the general adoption of meters, and I am sorry to have to add that their efforts to prevent the putting on of meters have in some cases been effectually assisted by members of the City Council. In an ordinary house where care is used to prevent waste the cost to the consumer should not be greater than under the present system of assessment, while those persons who will not exercise common care would have to pay in proportion to their consumption. There can be no question of the justice and propriety of measuring the water used for manufacturing purposes, or in hotels and large institutions. It is sometimes objected that the adoption of meters for private dwellings will cause an injurious economy in the use of water among the very class of the population where it is important that water should be used freely. This objection is obviated to a great extent, in some places,

where meters are employed by fixing a minimum tax—to be paid by all water takers—which shall cover a certain quantity, based on a reasonable estimate of domestic needs. Water used in excess of this quantity should be paid for by measurement, and special arrangements may be made for tenement houses. Cold weather waste can never be completely stopped until property owners are obliged to arrange their plumbing so that the water can be completely drawn from the pipes when liable to freeze. By the use of meters the waste will be reduced to the minimum amount required to prevent the pipes from freezing, and it would become a question to the water taker whether it was economy to waste water or remodel his fixtures.

Some consumers protest against the use of meters because they are unsanitary and in proof of their statetment say that they are not in use in other cities To show that such is not the case I will give a few figures taken from recent returns. Of 77 German cities with a population of 7,600,000 twenty-six per cent. sell water *exclusively* by meters. In the remainder meters have been generally adopted. Since 1878 Berlin has used meters exclusively in selling water. Manchester, New Hampshire, has a population of 44,126 and uses 1135 meters. Providence, Rhode Island, with 14,896 taps has 9286 meters. Halifax with 13,966 taps uses 44 meters. In the United States 43.1 per cent. of all the works have meters in use. Alleghany, with a consumption per capita of 238 gallons per diem, uses no meters. Atlanta, with 89.6 per cent. of taps metered, consumes 36 gallons, and Fall River, with a population of 74,398 and 74.6 per cent. of taps metered, consumes only 29 gallons per capita, or 2,157,542 gallons per diem. Halifax with one-half the population of Fall River has an estimated consumption of 6,500,000 gallons. No further comment is necessary.

All the remedies mentioned should be ordered by the City Council and faithfully applied. If the suggestions made were strictly carried out at once I have no hesitation in saying that when the pressure at the hydrants is taken in March, 1893, the result will show the works to be in as good condition as in 1882. If this course is not followed we must resort to the most expensive remedy additional supply.

Construction of Reservoir.

The most economical method of increasing the supply would be the construction of a reservoir in some central position within the city limits. It was a part of the original design for the works and has been repeatedly recommended by the City Engineer during the past three years. The advantages are generally, that while the effective head and consequently the discharge is diminished by the friction on the sides of the pipes and the various curves and bends in long mains, the reservoir collects near the centre of distribution a large quantity of water at nearly the full elevation of the source of supply, and by a system of stop cocks exert the force due to that elevation upon the service pipes and hydrants. In case of accident to the main or during cleaning operations the city is supplied for a time proportionate to the capacity of the reservoir, independent of the lakes. The water discharged into the reservoir during the night or while the consumption is lightest during the day, is fed out to the overworked main during the time of greatest consumption when the draught becomes too great for the capacity of the pipe. In some cities, however, the amount of water drawn from the distributing reservoir during the night often far exceeds the average used in the day time. Under the present condition of the service a similar occurrence would be noticed in Halifax. In winter, on the highest parts of the High and Low Service the pressure is at times 5 pounds less during the night than in the day time. Such being the case I would hesitate to recommend the adoption of a reservoir as a solution of the difficulty. While it might be very bene-

ficial in summer I fear it would be of little use in winter, when most needed. The main will not deliver as much water into the reservoir as it will directly into the distribution while its full capacity is exerted, because in the latter case it will always be discharging under a lower head. Now when at times during the day we find the draught so great that the main on Quinpool Road is not full, and we also find the pressure less at night than during the day where is the water coming from to fill our reservoir. It would not only be impossible to fill it, but during the coldest days not a drop of water would be discharged into it so long as the consumption is so large.

Duplicate Main.

While there is a possibility of the reservoir failing in its purpose it would be advisable to offer an alternative scheme for your consideration. Such a scheme has been outlined in the proposal to lay a duplicate main. The advantages of a duplicate main would be, in a measure, similar to those already mentioned in connection with the reservoir, while there would be no danger of failure except from limited supply. It will be readily acknowledged that the necessity for better fire protection is very urgent. Should a fire gain headway in some parts of the district supplied by the Low Service while a burst in the main is being repaired, or while the scraper is being run through the pipe, the result would be disastrous. In the latter case it might take three or four hours to get water to the scene of conflagration. When the water is turned off on the High Service it takes five hours from the time of turning on to reach the highest and most remote points in the city. The following statement taken from a table prepared for Alderman Pickering, Chairman of the Board of Firewards, shows the normal and concentrated pressure at five Low Service hydrants near recent fires:

LOCALITY.	Normal pressure.	Pressure concentrated on district.
INTERSECTION OF	lbs.	lbs.
Barrington and George Street.....	30	47
Spring Garden Road and Grafton Street.....	25	31
" " " " Pleasant "	21	35
Brunswick Street and Prince "	7	12
Water Street, opposite Taylor's Wharf.....	48	65

The pressure at the corner of Brunswick and Prince Streets is obtained by turning on the High Service. It can be still further increased by about 30 pounds, but concentration takes time. The pressure on this hydrant in 1881 was 13 pounds from the Low Service alone.

The supply of water available for the Low Service System is by no means inexhaustible, although the attention of the Council has not been called to the fact in former reports made on the subject of improvement. In wet seasons the quantity of water drawn from Long Lake could be doubled without exhausting the supply. In the dryest seasons our surplus is limited. Below is given the lowest point to which the water has been known to fall each year since 1881, the year in which the mains were first cleaned:

Month.	Year.	Level of Surface Below Waste Weir.	Rainfall for Year at Lakes.
October.....	1881	3 ft. $1\frac{1}{2}$ in.	48.65
September..	1882	2 " $4\frac{1}{2}$ "	56.089
January....	1883	3 " 4 "	46.201
October.....	1884	3 " $9\frac{3}{4}$ "	59.252
October.....	1885	4 " 5 "	47.995
November...	1886	2 " 3 "	46.60
August.....	1887	3 " 9 "	59.82
June.....	1888	1 " $3\frac{3}{4}$ "	68.525
November...	1889	5 " 11 "	46.81
August.....	1890	4 " $1\frac{1}{2}$ "	59.38
October.....	1891	3 " $6\frac{1}{2}$ "	57.12

It will be seen that the lowest level reached since 1881 was 5 feet 11 inches below the wast weir. Long Lake will yield the requisite quantity per diem till it is drawn down to 8 22 feet below the waste weir. The quantity of water remaining in Long Lake and available for city use was about 225,000,000 gallons. During the year 1889 the amount of water running over the waste weir was about 250,600,000 gallons. Assuming that this could be saved and added to the quantity remaining in Long Lake in November, 1889, we could have increased the consumption during the year by 475,600,000 gallons, which is only 1,300,000 gallons per diem.

The rainfall during 1889 was much below the average, being only 46.81 inches. Only twice since 1858 has it fallen below 46 inches. In 1860 the rainfall in the city was only 39.51 inches and in 1879 it was 40.76 at Chain Lakes. In reference to the latter case, however, the City Engineer says in his report for 1886-7, "There is reason to believe that sufficient care was not always exercised when making the observations." In the city during the same year it was reported as 47.7 inches,

If the rainfall in 1889 had been no greater than in 1860 the available supply from the Long Lake Water Shed would have been diminished 490,000,000 gallons, and the present 24 inch main would have drained the lake to the lowest possible level. If a duplicate pipe is laid and the consumption increased there would be a risk in very dry seasons of the city being entirely deprived of water. It is therefore an absolute necessity to reduce the consumption, no matter what other plan for improvement is adopted.

Taking 46 inches of rainfall as a basis on which to calculate the required diameter of pipe for the proposed new line and considering the loss of head as the pipe gets foul and the fact that the consumption of daily supply, if properly controlled, takes place in the 12 hours of day, it would be advisable to lay a pipe not less than 24 inches in diameter. If we consider the efficiency demanded when a fire occurs (more especially when the other main is turned off) nothing less than a 27 inch pipe will satisfy the reuqirements.

There is another question which should govern the decision respecting the size of the pipe. We should first ascertain by careful survey and estimate of cost whether when the question of additional supply again arises we shall be able to bring more water into the Long Lake Water Shed or look for increase from a separate service. In a short report made by Wm. Gossip, C. E., he suggested that it might be found cheaper to bring water from Governor's Lake than from Birch Cove or Pockwock Lakes. If there is any probability of water being brought from Governor's Lake the capacity of the new main should be proportioned to the future supply and consumption. Judging from a cursory inspection of Governor's Lake I am of the opinion that any increase in supply will not come from that locality.

From the limited information I have been able to obtain in the time at my disposal I can only give an approximate estimate of the cost of the proposed line of pipe. A portion, say one mile of main, should be of extra thickness on account of the heavy pressure it must sustain in crossing the hollow at the head of the North West Arm. The cost of laying a 24 inch main would be about $94,000 not including new distribution, land damages and changes required at the lakes. The cost of a 27 inch main would be about $104,000. The cost of right of way is estimated at $3,000 besides some concessions respecting water supply. Should a new line of pipe be laid, some alterations and additions will be necessary in the distribution. There will also be some alterations needed in the gate houses at Lower Chain Lakes. The intake pipe at the north gate house is too small, even for present use, and is not capable of supplying the Low Service when the south intake is shut off. The screen boxes would be too small and an additional chamber would have to be added in each gate house. The loss of head caused by the inefficiency of the gate house is very important. It may be found necessary to raise Long Lake one foot. In any case Nickerson's dam should be strengthened. The work should not be neglected until some improvement is made in the service, but should be carried out at once.

Earthen dams give very little warning before giving way and, while I do not wish to cause unnecessary alarm, I would recommend that the work required to make this dam reasonably safe be ordered at once. The lake was raised in 1877, but the dam was left in an unfinished condition. The whole lake face requires strengthening. In 1881, after a north-east gale, about 200 feet of the wall showed signs of movement towards the lake. There is a risk during every north-east storm that from the action of the waves the lake wall of the dam will slide northward or into the lake. Any accident to this structure occasioned by storm or freshet would be attended with such serious consequences, that

immediate measures should be taken to prevent such a calamity. The leaks, some of which have existed since 1848, show no apparent increase.

Diversion of Highway.

Another very necessary improvement in connection with the Low Service reservoirs is the diversion of the public highway. This work, like the completion of the dam, should be carried out in any case. The proximity of the road to the Chain Lakes is one great cause of the acknowledged impurities in the water in these lakes. During the spring thaws, when the entire accumulations of winter are being washed from the road into the lake, the discoloration of the water may be noticed at times extending over half way across.

Mill Owner's Claims.

I will also call attention to another great source of annoyance and loss to the city. We gain practically nothing by making the Chain Lakes part of the Low Service Works owing to the great quantity of water claimed by the mill owners for the natural flow through the Upper and Lower Chain Lake. Some definite agreement should be made with the mill owners along the brook and at the head of the Arm stating the quantity of water they should be entitled to receive. This matter should be settled before one dollar of expenditure is made which might lead to new difficulties. The purchase of the water-power would be a very expensive remedy, and in 1876 and following years it was recommended as a solution of the difficulty that the supply be taken direct from Long Lake by conduit or tunnel at an estimated cost of $45,000 In support of this project it was claimed that the whole head could be utilized, purer water could be obtained, the water would be entirely at our own disposal, the complaints of Mill owners would be avoided and the city freed from the danger and uncertainty of a suit at law.

All these benefits except freedom from mill owners claim, can be obtained more economically by raising Lower Chain Lake and in addition the loss of 190,000,000 gallons of storage would be avoided and the capacity of these Low Service Reservoirs would be increased to 350,000,000 gallons, a matter of the greatest importance considering the present condition of the works. The proposed conduit could not have been built in permanent material for the amount estimated. The design was for a wooden structure 6 feet high, the bottom of which was to be placed 11 feet below the ordinary surface level of the water. In order to prevent the wood from decaying it was intended to keep it always under water. If this intention had been carried out the available depth of storage would be five feet, minus the thickness of the wooden top of the conduit. The depth of storage under the present system to the top of the conduit between Long and Chain Lakes is a few inches more. At times it will be absolutely necessary in order to satisfy the demand to draw the lake down 3 feet lower. Such being the case it would not be advisable to construct such an expensive piece of work of perishable material. A comparison of the cost of building the conduit of permanent material with that of raising Lower Chain Lake, all the resultant benefits on both sides being considered, would probably lead to the adoption of the latter scheme. If carried out it would have the effect (besides that already mentioned) of increasing the head 7 feet, the pressure 3 pounds and the capacity of the main half a million gallons per diem, while the increase in storage would be 165,000,000 gallons.

The city owns nearly all the land around Long Lake, but there are one or two pieces yet to be acquired. The land owned by the city should be marked by proper boundaries. At present it is impossible to determine where any portion of it lies. I would strongly recommend that all land around Long Lake, Chain Lakes, Bayer's Lake, Ragged Lake and Spruce Hill Lakes, not already purchased, be acquired at once by the city and per-

manent bounds set up. Delay in this matter will cost the city thousands of dollars.

Increase in High Service.

Mr. Keefer suggested the creation of an intermediate service to relieve the High Service by constructing a reservoir in the valley of the Beaver-dam Brook. We cannot afford, however, to take any water from the Long Lake gathering grounds as the whole supply of Long Lake is required for those portions of the city commanded by it. The High Service cannot be increased from Spruce Hill Lakes as the present main will discharge all the water that can be obtained from that source. It would be practicable to bring the storage of Ragged Lake into the pipe leading from Spruce Hill Lakes and a 40 days supply of 1,500,000 gallons a day could be obtained during the dryest season, while the storage capacity, if the lake was raised 10 feet, would be over 400,000,000 gallons.

We have a few men employed at Spruce Hill Lakes cutting stone to complete the work of strengthening the dams. A portion of the work was done last fall, but the water came so near the top of the dam last month that we were obliged to insure the safety of of the structure by lowering the lake. When the work on the dams is finished we shall be able to store all the water that the Spruce Hill Lakes watershed will supply.

To recapitulate: the matters submitted for your consideration are:—

1. The necessity for improvement or increase in the supply.

2. Prevention or reduction of waste by the adoption of strict plumbing rules, house to house inspection, abolition of hopper and all other closets and urinals that are not self acting and the general use of meters.

3. The construction of a distributing reservoir or a duplicate Low Service Main.

4. Strengthening Nickerson's Dam.

5. Diverson of highway at Chain Lakes.

6. Final settlement of mill owner's claims.

7. Raising Lower Chain Lake.

8. Acquiring land around lakes and setting permanent bounds.

9. Increase in High Service by bringing Ragged Lake into the system.

Respectfully submitted,

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City Engineer.