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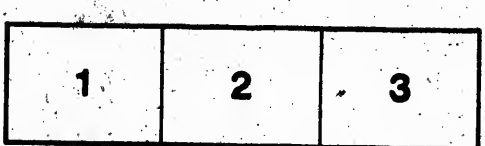
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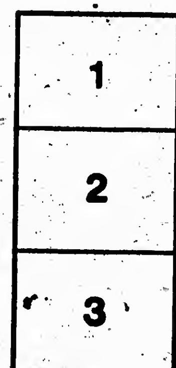
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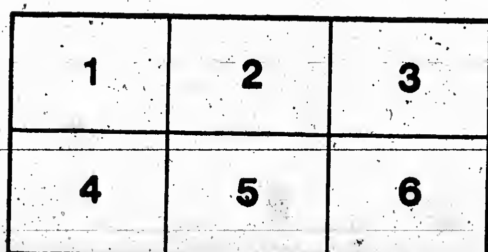
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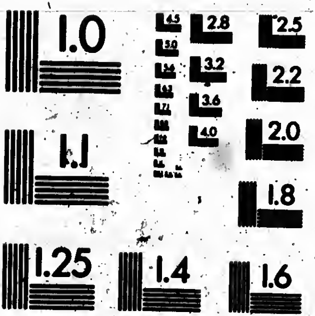

# REPORT

ON THE

# HALIFAX WATER WORKS,

BY JAMES LAURIE, C. E.

1860.

## OFFICE OF CITY CLERK,

HALIFAX, 15TH NOVR., 1860.

The following Report of Mr. LAURIE, relative to a more abundant supply of Water, is published for the information of citizens.

By order of the City Council,

JOHN L. CRAGG, City Clerk.

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NEW YORK, May 15th, 1860.

SIR,—I have now the honor to submit the following Reports on the several plans proposed for increasing the Water Supply of the City of Halifax.

Very respectfully,
I am, Sir,
Your most obedient servant,
JAMES LAURIE, C. E.

HENRY E. PUGSLEY, Esq.
Chairman of Water Committee, &c.

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### REPORT:

In 1846, James B. Uniacke, Esqr., and a few other public spirited gentlemen succeeded in organizing a company for the purpose of introducing Water into the City of Halifax by means of Iron pipes from Long Lake. Previous to this the city was dependent on wells and cisterns for water, both for domestic use and for extinguishing fires. The well water was hard and of indifferent quality, particularly in the lower portion of the city, where it had become contaminated by infiltration from the drainage above.

The preliminary surveys were made by Charles F. Fairbanks, C. E.; and John B. Jervis, Esq., of New York, was afterwards consulted. The plan recommended was to construct a dam across the outlet of Long Lake, to connect its waters by means of a canal with the Chain Lakes, and to lay a twelve inch pipe from the outlet of the latter to a Reservoir, on Camp Hill, in the city of Halifax. The reservoir proposed had a capacity of five million gallons.

The elevation of Long Lake, corrected to the datum of city levels, is [illegible] 2-10 feet above medium low tide. The length of the mains to St. Andrew's Cross, at the northern end of Camp Hill, is 2 56-100 miles. Mr. Jervis' estimate of cost, exclusive of land damages, and distribution within the city, was $120,000. This plan with the exception of the reservoir was carried out in 1846 and 1847, the water being first introduced in the latter year.

Mr. Jervis estimated that without allowing for increase of population there would in the course of five years, be 1500 water tenants consuming each 200 gallons, or in the aggregate 300,000 gallons per day. Including the supply required for the shipping, troops, manufactories, extinguishing fires &c. he estimated that 300,000 gallons more would be usefully consumed. The twelve inch main he estimated as capable of delivering 700,000 gallons per day. The completion of the works gave general satisfaction for a number of years, but as the number of water takers, and the consumption increased, complaints were made of the insufficiency of the supply; and in 1854 an additional main of 15 inches diameter was laid down.

The distribution is made through two 12 inch pipes; one passing to the north of

Citadel Hill, following Cogswell Street to opposite the North Barracks, 2800 feet in length, where it is reduced to 9 inches, and leads into Barrack and Jacob Streets, 835 feet. The other runs through the common to Spring Garden Road, 3400 feet in length, where it connects with three six-inch pipes. The remainder of the distribution is made through 6 and 3 inch pipes, of which there are 13,740 feet of 6 inch, and 62510 feet of 3 inch. The whole length of the pipeage including the mains from Chain Lakes, is 110,700 feet or 21 miles, nearly. The present distributing pipes are found barely sufficient to supply water for domestic purposes, and are totally inadequate for affording sufficient quantity for extinguishing fires. The ordinary draught through them is so great that no reliable effective head is to be obtained. If at the commencement of a fire there should be some head at a fire-plug, as soon as it has been in operation for a short time it not only loses its force but affects all others in the vicinity.

The present mains by the ordinary rules of calculation are capable of delivering at St. Andrews' Cross about two million of gallons in twenty-four hours; but the distribution being made through two 12-inch pipes, the amount passing into the city at any one time probably does not exceed the rate of one and a half million gallons per day. The mains have now a capacity equal to supplying an additional 9-inch distribution pipe.

By the present plan the sizes of the pipes are reduced too suddenly, so that sufficient water does not get down to the lower parts of the city. The most effective head is in the upper streets, Albermarle, and Grafton, where from their vicinity to the mains and a six inch distributing pipe, a head is maintained although the ground is elevated 100 feet above tide, while lower down with an increased actual head, the force of the water is almost entirely lost.

The entire works, like many others commenced about the same period, were planned on too limited a scale to be permanently available for fire purposes by the use of the hydrants and fire hose only. The quantity of water required, or at least used, for ordinary purposes, when introduced into houses, was much under-estimated. This has been found to be the case almost everywhere. In Boston, New York, and Philadelphia, when water was first introduced an effective head was obtained, but this as the consumption increased was lost, or so materially reduced as not to be available. The same has been the result in Halifax, and the defect is becoming more sensible every day. To remedy it various plans have been suggested.

Mr. E. J. Longard proposes to bring water from the Birch Cove Lakes, which have an elevation of 239 feet above tide, or 37 feet higher than Long Lake—to a reservoir on Shaffroth's Hill; and from this reservoir he proposes to conduct the water, by three mains of 15 inches diameter to different sections of the city, and to be used for fire and city purposes only.

The greater elevation of the Birch Cove Lakes is the principal advantage claimed for this plan. Much of this advantage however would be lost in overcoming the friction in the pipes on the greater distance the water has to be brought. By the present main from Chain Lakes to St Andrew's Cross, the distance is 2½ miles, and the loss of head to overcome the friction in the fifteen inch pipe when taxed to its estimated capacity is ten feet per mile, or 25 feet in all; which deducted from 200 feet, the ordinary level of the water in the First Chain Lake—leaves 175 feet effective head. If the same average descent per mile be given to the pipe from Birch Cove Lakes so that it will deliver the same quantity of water at St. Andrew's Cross—the distance being 5½ miles—the loss of head will be 55 feet, and calling the elevation of the Lakes when raised by a dam, 242 feet, will leave 187 feet as the effective head, or only 12 feet more than from the Chain Lakes. But this is not Mr. Longard's plan. He proposes to deliver the water in a reservoir on Shaffroth's Hill. In this case by laying the pipe with a descent of three feet per mile, it will discharge about one half the quantity it would at ten feet, which however would still be sufficient to maintain a head, in a large reservoir, for fire purposes. The loss of head on the four miles from the Lakes to the reservoir would be 12 feet; and from the reservoir to St. Andrew's Cross, assuming that the discharge should be equal to supplying ten jets, each throwing one hundred gallons per minute, the loss would be 18 feet when the reservoir is full; but it would be proper to allow of its being drawn down 8 feet—making 38 feet loss in all, which would leave 204 feet at the effective head at St. Andrew's Cross—being 29 feet higher than by the present pipes from the Chain Lakes. Should the size of the main however from Chain Lakes be increased to 24 inches, as is proposed, there would be a gain of 8 or 9 feet of effective head on that line—making the ultimate differences between the two sources about twenty feet.

The objections to Mr. Longard's plan are several:

1st. It will not deliver the water sufficiently high to be effective for fire purposes in the upper parts of the city—the only portion on which sufficient head cannot be obtained from Long Lake.

2nd. It will necessitate the laying down of an independent system of pipes through every district brought within its influence.

3rd. To prevent the water from freezing in the winter time, a continual draught through the pipes would have to be provided for unless they were laid much deeper under the surface than those of the present works, and to do so at all points both with the mains, and the distribution pipes in crossing and running parallel with sewers, &c., would be exceedingly expensive.

4th. As the pipes of the system would only be brought into active use on the occurrence of fires, there would be liability of their being out of order.

And 5th. The cost would be very considerable, as the mains and distribution pipes for fire purposes must be of large size.

Alderman Pugsley proposes to lay a system of pipes expressly for fire purposes, to get effective head by pumping up water by steam power,—(to be always kept in readiness on an alarm of fire being given)—into a stand-pipe, one hundred or more feet in height.

The water he originally proposed to take from one of the two 12-inch pipes entering the city. This however would only afford a sufficient quantity for supplying *five jets*, throwing one hundred gallons per minute, and would cut off the water from the district supplied by it. To render the plan effective without interfering with the ordinary supply, a new pipe would have to be laid from the Lake to St. Andrews' Cross, or to wherever the steam power is applied. A pipe eighteen inches diameter on the line of the present mains will discharge sufficient water, after allowing one-third for leakage and waste at the fire-plugs, to supply ten jets throwing one hundred gallons per minute each.

That effective head could be obtained by this plan there is no doubt, but there are some practical objections to it of a serious nature. There would be more or less delay in getting the steam up and pressure on the pipes after an alarm was given, and the fire meanwhile might get under such headway as to be difficult to get under. One bucket of water at the commencement of a fire is worth thousands of gallons after it has got under way. It is true Alderman Pugsley's scheme provides for a telegraph to the Engine House, and contemplates always keeping steam in the boilers, but, unavoidable delays would occur in communicating with the telegraph station and in getting the Engine in motion.

The water would leak or drain out of the pipes, and if once empty it would be necessary to open the several blow-offs to let the air escape before they could be filled again. To fill the present pipes from the Lakes requires from two to two and a half hours with the blowcocks open, and if they were not opened it would probably require a whole day. On the other hand if the pipes were kept full during the cold of winter, without a continuous current passing through them, the water would be liable to freeze. The only safe plan would be to provide for such leakage and current by continuous pumping—but this again would add largely to the expense of maintenance.

A preferable plan in my opinion would be to pump into a reservoir on Shaffroth's Hill; the reservoir being of sufficient capacity to hold water to supply waste and leakage and furnish all that could be required in cases of fire for 48 hours. The expenses attending the working of the engine would be less in pumping into a reservoir than in keeping the same engine always ready to pump into a stand-pipe. In the first case, by pumping only during the day one sett of hands would be sufficient and there would always be water in the reservoir and pipes to draw from. In the second case, two setts of hands would be required—one for the night and one for the day time.

An estimate for pumping into a reservoir on Shaffroth's Hill, will be presented, having reference to supplying the upper parts of the city, and which could also be used to give additional head in cases of fire.

Other plans have been suggested, having reference to increasing the general supply for domestic use as well as for extinguishing fires, but before discussing them it will be proper to determine the quantity of water that will be required, or advisable to introduce, keeping in view an increase of population and extension of the city.

It has ever been found that where places are poorly supplied with water and each individual family are put to labour or expense in procuring it, the quantity consumed is comparatively small, but where the supply is abundant and the convenience of having it in the houses exist—the consumption, and more especially the waste, is largely increased.

In France where much of the water used is procured from public hydrants and fountains, five gallons per day have been deemed a sufficient daily supply for one person. In Edinburgh under the old service where cisterns were necessary, twelve gallons were found sufficient, while under the new and enlarged works, 25 to 30 gallons are used. In London the present consumption is estimated at 35 gallons for each individual.

In the States, where aqueducts have been introduced into cities, and the supply of water is abundant the consumption has doubled or trebled over the quantities formerly consumed or estimated. Boston when indifferently supplied was estimated at 28½ gallons per head of the population, and since the Cochituate works were completed the actual consumption has gone up to 75 gallons per head. New York consumes at the rate of 50 gallons per head being all that the works will at present furnish. Philadelphia has always presented a moderate consumption, 35 to 40 gallons per head, although water is there more freely used, for useful purposes, than in any other city of the union. This is perhaps mainly due to their having to a large extent a surface drainage where water running to waste can readily be traced to its source. The danger also of the water freezing in the pipes is less than in more northern cities.

Boston and New York, like Halifax, have an underground severage where it is difficult to discover and remedy the evil of waste.

The present population of Halifax is generally computed at 30,000. In any expenditure for water werks however, which are meant to be of a permanent character provision should be made for an increase, and I will assume that the supply ought to be equal to furnishing a population of 60,000.

As to the consumption per head—were no water works in operation a lower figure could be adopted than the results of the present works indicate as necessary. In Halifax like other places where there is an abundant supply, there is extravagant waste, especially during the winter, when almost every tap, hydrant and fire-plug is allowed to run both day and night. Probably more than one half of the water brought into the city during the winter is wasted in this way; and has given rise to the impression that there must be underground leaks from the pipes. It would be possible for such leaks to exist without showing on the surface as the pipes are laid to a considerable extent in rock trenches; but I do not think it is necessary to speculate or search for other reasons for the great consumption than the admitted fact of allowing the taps to run. This has become so much the custom and practice, and to some extent perhaps is necessary to prevent the water from freezing in the pipes, in a climate where almost every winter there are several days with the thermometer 5 or 10 degrees below zero, that any attempt by rules or regulations to prevent it will not be effectual. All that can be done is to reduce it by demonstrating to the water takers that a very small stream indeed is sufficient to prevent the water from freezing, and I may here mention that an experiment was made last winter by Mr. Muir the superintendent of the works, on the hydrant in Blowers Street between Barrington and Granville. In this hydrant a hole was drilled at the bottom of the standpipe, about the size of a common-darning needle, and allowed to run during the winter. No trouble was experienced; while several others where much larger streams were ordinarily allowed to run to waste, got frozen up. I have no doubt that, by attaching a small but sufficient waste to all hydrants and taps and, allowing none other to be used would effect a great saving of water.

In other cities the waste is an annual topic of complaint, but so far no effectual means have been discovered of preventing it.

We have seen that the quantity passing into the city is equal to 1½ millions of gallons daily, and as there are only about 900 water tenants on the books of the Water Company, the consumption averages 1600 gallons per tenant; but as the Barracks, Navy Yard, and City, count as single tenants, and a large population is supplied from the free hydrants, I suppose the following may approximate to the population actually using the water—

| | |
|---|---|
| 892 water tenants, allowing 8 individuals to a family, - - | 7,136 |
| 36 free hydrants, supplying ten families each, - - | 2,880 |
| Barracks and Navy Yard, - - | 3,000 |
| Steam Engines, Ferry boats, and Shipping, equal to - - | 4,000 |
| City use, watering streets, waste from Fire plugs, &c. - - | 2,500 |
| | 19,516 |

Say 20,000, consuming 1½ million gallons daily is equal to 75 gallons per head of the population using the water; and, as the tendency everywhere is to an increased consumption I will assume that the sources of supply, and the capacity of the pipes should be equal to furnishing a population of 60,000 with 83 1-3 gallons per head, or 5 million gallons daily. The actual consumption will fall short of this, as the quantity is based on the maximum discharge through the pipes, while during the night, so long as there is no distributing reservoir, they will not be taxed to their full capacity.

The several plans proposed will be discussed in the following order—

1st—From Long Lake.
2nd—From Birch Cove Lakes.
3rd—Distribution.
4th—High Service, from Ragged Lake.
5th— Do from Long Lake,—pumping by steam power.

*1st—From Long Lake.*

In proposing to increase the supply it becomes important to enquire whether the present sources are sufficient to furnish the additional quantity. Long Lake is about two miles in length, by 1500 feet in average width, and contains 350 acres. The two Chain Lakes contain about 55 acres. Mr. Hosterman, the owner of the mills on the stream running from the Chain Lakes, is entitled to the natural flow of water from them, so that Long Lake constitutes the available reservoir for storage.

The drainage area or water-shed, which forms an important element in determining the quantity of water that can be collected has never been determined as to Long Lake. Did we know this, we know from analagous cases that about four-tenths of the whole fall, or say 15 inches could be safely calculated upon, the balance going off by evaporation and leakage; but not having this data we can arrive at approximate results by other means.

A record has been kept for two and a half years of the height of water in Long Lake, a copy of which is given in the appendix to this report; from which it appears, by calculation, that the water running to waste during that period was at least equal to 2500 million gallons per annum, equal to a supply of five million gallons per day for 500 days. The rain fall during the period the observations were made is believed to have been about an average. Could this water be stored there would be no question of the sufficiency of the supply.

The lake can be drawn down 5½ feet. In this depth it would furnish about 500 million gallons, or 100 days supply, assuming that the streams entering the lake would for the time make good the loss by evaporation, but this during the period of the record appears not to have been entirely the case. In 1857 the water was lowered Oct. 16th to 17 inches below the waste wier; in 1858 October 1st 24 inches; and in 1859 September 23rd 12 inches. The greatest reduction in any one week of the several years was as follows:

Week ending Sept. 11th, 1857, 5 inches,
" " July 30th, 1858, 5½ "
" " Aug. 19th, 1859, 5 "

Five inches in one week is equivalent to 5½ million gallons per day, while the whole quantity taken into the city did not probably exceed 1½ million gallons daily. How much during these weeks may have been allowed to run to waste from the outlet of Chain Lakes I have not the means of determining.

In 1855, I am informed, that Long Lake was drawn down 3 feet 9 inches. This is represented as having been a remarkably dry season, and it is also claimed that much water was allowed to run to waste through the Chain Lakes. Should like circumstances occur again it is evident that with the increased consumption contemplated the present storage capacity of the Lake will not be sufficient.

By the original plan of the canal connecting the Lakes, it was intended to be so made as to be able to draw the water down seven feet, but during the construction, from difficulties encountered by the contractor, the plan was departed from, and the bottom of the wooden trunk which conveys the water to the Chain Lakes is only 5 feet 9 inches below the level of the waste wier, this therefore is the extent to which Long Lake can at present be drawn down. To obtain a greater depth for storage it would be necessary either to deepen the canal or to raise the dam at the outlet of the Lake. Both plans are practicable and probably they would not differ materially in cost. To deepen the canal however would necessarily interrupt the flow of water while the work was being executed. I estimate that the dam can be raised three feet at an expense of $5800. This would give an increased capacity to the Lake as a reservoir of about 300 million gallons, or sixty days supply of five millions, and would place its capacity beyond question. This expenditure would not probably be required for several years, or until the present consumption is increased by fifty per cent.

The existing mains are capable of supplying about two million of gallons per day.

To deliver five million gallons would require the present 12 inch pipe to be lifted and replaced by one of 24 inches diameter. The 12 inch could then be used as distributing pipe in the city.

ESTIMATE

of the cost of substituting a 24 inch main for the present 12 inch, from the Chain Lakes to St. Andrew's Cross; and raising dam at the outlet of Long Lake.

| | |
|---|---|
| 13,800 feet of 24 inch pipe, including lifting present 12 inch and enlarging trenches, at $6, | $82,800 |
| 5 stop and blow off cocks at $300, | 1,500 |
| New gate house & pipe chamber, | 2,000 |
| Raising Dam of Long Lake, 3 feet, | 5,800 |
| Miscellaneous and contingent expenses, | 4,000 |
| | $96,100 |
| Deduct value of 13,700 feet of 12 inch pipe lifted, to be used for distribution, at $1 90, | 26,030 |
| | $70,070 |

*2nd. From Birch Cove Lakes.*

These Lakes have been suggested from their greater elevation, as a suitable source for not only procuring water for fire purposes but also for the general supply of the city; and I have been requested to make out an estimate for the latter.

The Birch Cove Lakes consist of several bodies of water connected by narrow passages. Their surface area by Mr. Kelly's survey is 241 acres. There are several other Lakes emptying into them, which have not however been particularly surveyed. Fox Lake on the north contains by estimation from 60 to 70 acres; Horse Shoe Lake on the west about 40 acres; and Ash Lake about 60 acres; the latter however in freshets has an outlet in Black river.

The natural flow from the Birch Cove Lakes during the summer and autumn is represented as being small. A penstock of 9 by 12 inches to a washing wheel which formerly stood near the outlet, was represented by the proprietor as having conveyed the greater part of the water in a dry time. No survey has been made of the drainage area, and the season of the year at which my examinations were made—the ground being covered with snow and the lakes with ice, with occasional thaws—was not favourable for obtaining a reliable guage of the quantity. Streams either for the supply of cities, or for mill power—can only be properly guaged during the drouth of summer, as it is the quantity they can be relied upon to furnish at this season that determined the effectiveness of supply and the extent and capacity of storage reservoirs. I made repeated guagings of the quantity of water running from Long Lake and also from the Birch Cove Lakes, and found that from the latter there was generally about two-thirds of that from the former. The guagings on the several days giving from 1600 to 2400 cubic feet per minute from Long Lake, and 1200 to 1600 cubic feet from the Birch Cove Lakes. A supply of water then from this source would have to be obtained by making a storage reservoir of the Lakes by means of a dam. The banks are generally favorable except towards the east or outlet side. Here the confining bank or rim is at several places elevated but a few feet above the water, and to raise it ten feet, several dams would be required to prevent it from flowing over the front or face of the hill. This is the greatest elevation the water could be raised without going to a very considerable expense, and I am by no means certain, but that to obtain this height would be attended with considerable difficulty, as the surrounding rim is in some places composed largely of bowlders of granite, piled promiscuously together, and which might afford opportunities for extensive leaks which it would be difficult to stop.

Assuming however that the Lakes can be raised 10 feet, and made available to draw 8 feet of water, i. e., allowing two feet for evaporation and leakage, and that the average area for this depth would be 270 acres the capacity of the reservoir would be 588 millions of gallons, or 117 days full supply for the city. But as the mills on the stream below are sometimes stopped two months for want of water, the whole natural flow from the lakes during the summer and autumn would, if arrangements were not made to the contrary, have to be allowed to pass down. If this were the case, I do not think there could be calculated on more than four feet for the supply of the city, and which at the reduced water area would not furnish more than 46 days supply. As this would be an insufficient quantity it would be necessary to purchase the entire right to the water flowing from the Lakes, and possibly also to make storage reservoirs of one or two of the upper ones.

The owners of the land and water power ask extravagant prices. The land is of little intrinsic value, that around and including the lakes could not probably be sold for fifty cents an acre ; but as it would immediately acquire a value if required for a work of this kind, based on the amount that it might be possible to obtain for it, I have allowed $2 50 an acre for 1000 acres, including the Birch Cove and other lakes, which it may be found necessary either to purchase or control in the flowage.

For the right of way I allow $500 per mile on a distance of four miles, or $2000. For compensation to mill owners at Nine Mile House, owners of land on the stream for abstraction of water, and for Davis' Granite Quarry which would be flooded by raising the lake, I allow $35,500. This is less than one half of the amount asked, but I believe more than the property is worth, making in the aggregate $40,000 for land and compensation.

The character of the water does not probably differ materially from that of Long Lake and the Chain Lakes. The drainage area is of the same character, granite and whinstone rocks covering the surface to a large extent. The Birch Cove Lakes however are generally more shallow and the water may not be quite so pure as that of Long Lake.

*Estimate of Cost of bringing Water from the Birch Cove Lakes.*

| | |
|---|---|
| Clearing, grubbing and burning brush and timber, 150 acres at $8, | $1200 |
| Dams and waste weirs, | 17,000 |
| Gate houses and pipe chamber, | 3,000 |
| Land and compensation | 40,000 |
| 5½ miles of 27 inch main, from Birch Cove Lake to corner of Park and Cogswell Streets—including cuttings, embankments and culverts, 29,040 feet, at $8.25, | 239,580 |
| Reservoir on Shaffroth's Hill, including Land,—capacity 8 million gallons, | 30,000 |
| Eight stop cocks—at $400, | 3,200 |
| Miscellaneous and Contingent expenses, | 20,000 |
| | $353,980 |

As this estimate provides for bringing in sufficient water for the supply of the city, without using the present mains from the Chain Lakes to St. Andrew's Cross, their value should be deducted in order to exhibit a fair comparison with the other plan :

| | | |
|---|---|---|
| 13,700 ft of 12 inch pipe at $1.90, | $26030, | |
| 13,800 ft. of 15 inch pipe at 2.70, | 37260, | 63,290 |
| | | $290,690 |

### *3rd Distribution.*

The plan of distribution which I recommend is to divide the city into four districts ; to allow the present 12 inch pipes with their connections to remain, and to lay down additional mains leading to these districts without being tapped. By this means the effective head will be maintained as near as possible to the points of consumption.

The first district to embrace all of the city lying south of the line of Sackville Street. The second, all between Sackville and Jacob Street. The third all below Gottengen, and between Jacob and North Streets. The fourth district to include the high service—embracing all lying between Gottengen, Cogswell, Kempt Road and Richmond, also the Citadel.

Each of these districts contain equivalent to from 700 to 800 houses, and a population say of 6 to 7000.

To each of the first, second and third districts, I propose to lay down a 12 inch main, one on each side of Citadel Hill, to be connected through Grafton Street. The other main to pass down Cunard to Gottengen Street. Were not the 12 inch pipe on hand I would prefer making these mains larger, so as to let the whole volume of water down on the business portion of the city. By the plan proposed there will still be sufficient water brought to St. Andrew's Cross to fill two additional 12 inch pipes ; one of which may be required for the high service and the other can be led to whichever district may first require an additional supply.

In the business portion of the city I propose to lay down 9 inch pipes in the east and west streets, from the mains in Grafton Street to Granville Street ; and below this 6 inches—the increased head, and the draught by the service pipes allowing of the reduction. Through Granville and Water Streets I propose 9 inch pipes for the purpose of connecting the supply from the several mains and keeping up the circulation and a uniform pressure.

In arranging the plan I have kept in view to use the present pipes as far as practicable. Where larger ones are necessary the present to be taken up and used in other parts of the city.

The laying of 3 inch distribution pipes where fire-plugs are required is questionable—they have generally been abandoned for city use. In Boston nothing less than 4 inches, and in New York and Brooklyn nothing less than 6 inches are used. With the ordinary draught on a 3 inch pipe, only one stream in case of fire can be obtained. If more than one fire-plug is in use on the same line the effective head is almost entirely lost, whereas with larger pipes several effective streams can be obtained.

*Fire Plugs.* In the estimate I have allowed for 107 additional fire plugs, which together with the 43 now in use makes 150 in all—sufficient to place one at every intersection of streets. In Boston and New York, as a general rule, they are placed 300 feet apart. When placed far apart, the friction in the hose materially diminishes the elevation to which the water can be thrown from a pipe.

*Stock Cocks.*—As I am not aware of the position of the present stop cocks or of their number, I have not attempted to mark or carry out a system on the plan. Two objects should be held in view. 1st, to place them so that in emptying the mains for making repairs or forming new connections, the consumers will be inconvenienced as little as possible, and 2nd., to subdivide the city into convenient sections so that the water can be concentrated in the case of extensive fires. In the estimate I have allowed for 110 of different sizes, in addition to the number at present in use.

By laying down the pipe of the sizes shown in the plan, fire engines would seldom be needed below Gottingen street—certainly not until the population and consequent draught on the pipes had largely increased. To meet this increased draught, it would be very desirable to have a reservoir near St. Andrew's Cross, to accumulate the water during the latter part of the day and at night when the consumption is the least. This reservoir may be dispensed with for some time, but as soon as the head begins to fail from increased consumption, I would recommend that one be constructed.

The small effective head that can be maintained above Gottingen street, after making allowance for friction in the pipes and hose, would render fire engines necessary for this district unless a high service system is adopted.

The distribution pipes cannot be made smaller in size, and remain permanently effective for extinguishing fires by use of the hose alone. To make them larger would be advantageous. The loss of head in conducting water through small pipes in sufficient volume for fire purposes is very great, and it is only the surplus beyond the ordinary draught on them that can be rendered effective. To illustrate this:

Suppose an inclined pipe laid from a reservoir in the Citadel down to the harbor, with the lower end of the pipe left open, the water would then pass out with a velocity due to the total head, minus the friction of the pipe; the whole force would be exerted in a line parallel to the axis of the pipe; there would be no verticle pressure. It would be precisely the same as water moving in an open canal where there is no pressure tending to elevate the surface. An open box would serve the same purpose as the pipe; and, if in place of the lower end of the pipe being left open, the water is drawn off by numerous diverging pipes, as in the case of city distribution, the result would be the same—there would be no vertical pressure. If, however, the end of the pipe should be partially closed, or the draught on the diverging pipes not be sufficient to carry off the water as fast as it comes down, there would then result a vertical pressure proportional to the difference between the velocity due to the whole head and the velocity due to the actual discharge—the pressure being always equal to the (effective) head, minus the height due to the velocity in the pipe.

The following Table shews the loss of head in feet to overcome the friction in pipes of various diameters—one mile in length—to supply jets throwing 100 gallons per minute.

| Diameter of pipe in inches. | Loss of Head in feet, per mile, to supply Jets throwing 100 gals. per min. | | | | | |
|---|---|---|---|---|---|---|
| | 1 Jet. | 2 Jets. | 4 Jets. | 6 Jets. | 8 Jets. | 10 Jets. |
| | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. |
| 3 | 272.8 | 1091 6 | | | | |
| 4 | 64.5 | 258.1 | 1032.5 | | | |
| 6 | 8.5 | 33.9 | 135.8 | 305.5 | 543.2 | 848.7 |
| 9 | 1.1 | 4.5 | 17.9 | 40.2 | 71.5 | 111.7 |
| 12 | 0.26 | 1.0 | 4.2 | 9.5 | 17.0 | 26.6 |

The above table is calculated from Hughe's English formula—$H = \frac{2.3\ V^2}{D}$

Where $H$ = Head per mile in feet necessary to overcome friction.
Where $V$ = Velocity in feet per second.
Where $D$ = Diameter of pipe in feet.

This formula comes nearer perhaps to practical results than the more elaborate ones of Prony or Weisback, based to a large extent on experimental pipes, always more perfect than those laid for actual service.

*Estimate of cost for enlarging the Distribution.*

| | | |
|---|---|---|
| 13,700 feet of old 12 inch pipe, relaid, at $2 50, | | $34,250 00 |
| 1,500 feet of new 12 inch pipe, at $2 50, | | 2,250 00 |
| 15,000 feet of new 9 inch pipe, at $1 50, | | 22,500 00 |
| 19,000 feet of new 6 inch pipe, at $1 00, | | 19,000 00 |
| 6,500 feet of old 6 inch pipe, relaid, at 40c. | | 2,600 00 |
| 16,000 feet of old 3 inch pipe, relaid, at 35c. | | 5,600 00 |
| | | $86,200 00 |
| 10 12-inch stop cocks, at $75, | $750 00 | |
| 30 9-inch do at $60, | 1,800 00 | |
| 70 6-inch do at $35, | 2,450 00 | |
| 107 fire-plugs and hydrants, at $30, | 3,210 00 | 8,210 00 |
| Miscellaneous and contingent expenses, | | 5,000 00 |
| | | $99,410 00 |

*Note.*—In place of relaying the 3 inch pipe, to lay down new 4 inch, would increase the cost about $7500.

### *4th. High Service.*

The following plans have been suggested for supplying the upper part of the city, each based on furnishing 600,000 gallons per day.

1st. To bring water from Ragged Lake.

2nd. To pump water by steam power from near St. Andrew's Cross into a Reservoir on Shaffroth's Hill.

### *1st. From Ragged Lake.*

Ragged Lake lies 2¼ miles westerly from the gate-house at Chain Lakes and contains about 100 acres. It is elevated 325¼ feet above tide. Its surplus waters now run to the west into Indian Lake and Nine Mile River, but by excavating a canal of about 1600 feet in length can be discharged towards Halifax. From its lying near the summit level of the country it has a limited drainage area, and will not supply the same quantity of water in proportion to its surface as Long and Chain Lakes. The amount running from it March 7th, 1860, when I examined it, did not exceed 120 cubic feet per minute, or about one-tenth of that running from Long Lake on the same day.—Should its drainage area prove to be less than 700 acres, I would not consider it a reliable source to furnish the quantity required.

There is also another feature connected with it which would require minute investigation. The water had, at the outlet of the Lake, a perceptible stale taste—something like that first drawn from a wooden pump or old cistern.

The shallow depth of a large portion of the Lake, its muddy bottom, the numerous islands in it covered with vegetation, and part of the drainage coming from bog, I think sufficiently accounts for its present impure character. The same peculiarity of taste, I am informed, has been noticed in the Autumn, of the water from the Chain Lakes, and the Water Company, to correct it, have been in the habit of drawing them down and allowing them to fill from Long Lake. The causes in both instances are probably alike. The hot weather of summer promoting a rapid and extensive decomposition of the vegetable matter on the borders and in the shoal portions of the Lakes. There are no constant streams running into Ragged Lake. Two small springs were noticed along its margin, they appeared to be clear and excellent water. Probably by raising the surface 8 or 10 feet, which can be done at a moderate cost, and clearing the margin, and the islands which will be submerged, of vegetable matter, the water would be rendered comparatively pure, and would continue so unless drawn down so low in the summer or autumn as again to expose the shoal portions to the deleterious action of the sun. The quality of the water however is a point of so much importance, I could not recommend this source until it had been thoroughly examined and tried during the summer and autumn months.

The works required will be as follows:

*A Dam* at the outlet to raise the water say 10 feet. The proper outlet of the stream is confined between narrow banks, and can be easily dammed, but there are several other places which will require raising, probably in all there will be 7 or 800 feet in length of embankment required, averaging 12 feet in height.

*A Canal* will have to be cut through the ridge to drain the waters towards Chain Lakes. This Canal will be about 1600 feet in length, having its bottom at the level of the present surface of the Lake and will average about 9 feet in depth, the greatest depth being 16 feet. About one-third of the distance is through rock. It will be very similar in character to the present canal connecting Long and Chain Lakes.

*A Pipe Chamber* will be required at the easterly end of the canal. From this I would lead a 12 inch pipe to the gate house at the outlet of the Chain Lakes, to be there connected with the present 15 inch main. Then from St. Andrews Cross the distribution would be made to the upper service by continuing a 12 inch main across the common to Park street to be there connected with the service pipes.

The head would be sufficient to reach and supply the whole of the upper part of the city, also the Citadel, which is at present dependent on Tank water.

## Estimate of Cost of bringing Water from Ragged Lake for High Service.

| | | | |
|---|---|---|---|
| Clearing, grubbing, and burning brush and timber, 60 acres, at $8, | | | $480 00 |
| Dams and waste weir, | | | 7,000 00 |
| Canal, | | | 5,500 00 |
| Gate house and pipe chamber, | | | 1,250 00 |
| 4 stop cocks, at $75, | | | 300 00 |
| 10,800 feet of 12 inch pipe from Ragged Lake to Gate House, at $2 50, | | | 27,000 00 |
| 1800 feet of do. from St. Andrew's Cross to corner of Park and Cunard Streets, at $2 50, | | | 4,500 00 |
| Land and compensation, | | | 5,000 00 |
| Miscellaneous and contingent expenses, | | | 4,000 00 |
| | | | $55,030 00 |
| DISTRIBUTION. | | | |
| 2500 ft. of 9 inch pipe at $1 50, | $3,750 00 | | |
| 8500 do. of 6 inch do. at 1 00, | 8,500 00 | | |
| 12000 do. of 3 inch do. relaid, 0 35, | 4,200 00 | | |
| Stop cocks, &c., | 800 00 | | |
| 20 Fire Plugs, at 30 00, | 600 00 | | 17,850 00 |
| | | | $72,880 00 |

*2nd.—To pump water by steam power into a reservoir on Shaffroth's Hill.*

The quantity to be pumped I will assume at 600,000 gallons in 12 hours. This will be sufficient to supply a population of 6 or 7,000, and provide for leakage and waste. The present population that cannot be supplied from Long Lake, when the works are enlarged, exclusive of the citadel, is less than 1,000

The most convenient place to erect pumping apparatus will be near St. Andrew's Cross, say at the point marked A on the plan, being contiguous to the mains and near where the distribution pipes branch off. The level of the ground at this point is 160 feet. The distance thence to the top of Shaffroth's Hill is 1¼ miles; and the hill is elevated 249 feet above tide. I will assume that the high water level of the reservoir is made 255 feet above tide, the bottom 240 feet, and the capacity equal to three million gallons, requiring an average water area at 15 feet depth of 179 feet square.

By constructing a small reservoir to pump from, advantage can be taken of the head of water in the mains, so that including the friction on the one and a half miles of rising pipe the resistance to be overcome will not exceed a column of water 100 feet in height.

The duty of the engine, then, is to raise 600,000 gallons 100 feet in twelve hours. This is equal to raising 833⅓ gallons per minute; and 833⅓ × 100 feet × 10 lbs. is equal to 833,333 pounds raised one foot high per minute. To this must be added one-fifth for friction of pumps and machinery, making 1,000,000 pounds raised one foot high per minute, which divided by 33,000 pounds, the standard for a horse power, gives 30⅓ horse power as the power required for the engine, but to make ample allowance for contingencies, say 35 horse power.

In England the "Cornish Engine," so called, is that most usually preferred for pumping water. It is, undoubtedly, the most economical where a large quantity has to be raised, but much of this superiority is lost when constructed on a small scale. In the Cornish engine the steam is cut off at 1-10 to ¼ of the stroke and allowed to expand in the cylinder; and the boilers, cylinders and pipes are thoroughly protected to prevent loss of heat. Their first cost, from the increased size of the parts, including the foundation, is nearly twice that of an ordinary condensing engine, and four times that of a high pressure engine. In England some of them are reported as raising nearly 1,000,000 pounds of water one foot high by the consumption of one pound of coal, but their average performance does not exceed two-thirds of this amount.

The following table shows the duty of several engines used in pumping water, reduced to pounds raised one foot high by the consumption of one pound of coal:—

| | Pounds of water raised 1 foot by 1 lb. of coal. |
|---|---|
| East London water works single acting Cornish engine, | 944,000 |
| Do. do. Boulton and Watt condensing, | 416,000 |
| Average duty of Cornish engines, Brown's Reporter, 1855, | 622,000 |
| Belleville engine, Jersey City Water Works, Cornish, | 628,233 |
| Brooklyn engine, N. Y., | 601,407 |
| Hartford, Crank, | 614,426 |
| Cambridge, double cylinder, | 675,746 |
| Spring Garden, Philadelphia, Cornish, | 589,953 |
| Pittsburg water works, 1852, high pressure, | 178,000 |
| Detroit, high pressure, | 155,000 |

In the following estimate I have allowed for a condensing engine of 35 horse power to do the regular work, and also allowed for an auxiliary high pressure engine of the same power to be in readiness in case of repairs being necessary on the other. As the same amount of duty cannot be performed by the small engine required for the Halifax works, as with those of larger power, I will assume it at 400,000 lbs. raised one foot high per lb. of coal, equal to 600,000 gallons of 10 lbs. raised 100 feet with 1500 pounds of coal.

## ESTIMATE OF COST

*of Pumping by Steam Power into a Reservoir on Shaffroth's Hill.*

| | |
|---|---|
| Engine House and Coal Sheds, | $6000 00 |
| Dwelling House for Engine men, | 1500 00 |
| Engine and Pumps, 35 horse-power, condensing, | 8500 00 |
| Do 35 do do high-pressure, | 4500 00 |
| Inlet pipe, and reservoir tank, | 1000 00 |
| 7920 feet of rising main, at $3 00 | 23,760 00 |
| 2000 do of return service main at $2 50 | 5,000 00 |
| Six Stop Cocks, at $100 | 600 00 |
| Reservoir on Shaffroth's Hill, including land, capacity three million gallons, | 10,000 00 |
| | $60,860 00 |

*Cost of Working Engine.*

| | | |
|---|---|---|
| One Engine Worker, 365 days, at $1 75, | $638 75 | |
| One Fireman, 365 days, at $1, | 365 00 | |
| Oil, Tallow, and Cotton waste, | 150 00 | |
| Wear and tear of machinery and buildings, | 400 00 | |
| COAL, 1500 pounds per day will amount in 365 days, to 245 tons, but as the full power of the Engine will not be required for many years, I will allow 2-3 or 163 1-3 tons, (equal to raising 400,000 gallons per day) at $4 50 per ton, | 735 00 | |
| | $2288 75 | |
| And $2288 75 is equal to the interest at six per cent. on a capital of | | 38,146 00 |
| | | 99,006 00 |
| Add distribution, as per estimate, for Ragged Lake, | | 17,850 00 |
| | | $116,856 00 |

Another plan has sugested itself since I examined the ground. It is to take advantage of the stream running from the Chain Lakes to supply Hosterman's Mills, and pump up water into a stand pipe, from which, by gravitation, it would be discharged into a Reservoir on Shaffroth's Hill. At the time I examined the Chain Lakes there were from 400 to 500 cubic feet per minute of water running from them. This, with an over-shot pitch back water wheel of 24 feet diameter and 6 feet bucket, would be sufficient to raise 5 to 600,000 gallons per day to the height of 100 feet, about 7½ gallons being required on the wheel to raise one gallon to the top of the stand pipe.

It is probable, however, that there would be a scarcity of water during the summer months, but which, possibly, could be supplied by raising the Long Lake. For every foot Long Lake is raised it will store about 100 million of gallons, which is sufficient to raise 36,500 gallons per day, 100 feet high, for twelve months.

The first cost of the works on this plan would not probably vary much from pumping by steam, but the annual expenditure would be considerably reduced, and there would be no question as to the quality of the water. The practicability of the plan depends on the amount of water running from the Chain Lakes in a dry time, which I have not sufficient data to determine.

*Recapitulation.*

Collecting the several estimates, the following statement exhibits the cost on the several plans, including the sum proposed to be paid by the city for the present water works.

*From Long Lake.*

| | |
|---|---|
| New 24 inch main, and raising Long Lake Dam, | $70,070 00 |
| Distribution, | 99,410 00 |
| Purchase of present water works (£52,800), | 211,200 00 |
| | $380,680 00 |

*From Birch Cove Lakes.*

| | |
|---|---|
| Introducing water, (mains and other works,) | $290,690 00 |
| Distribution, | 99,410 00 |
| Purchase of present water works, | 211,200 00 |
| | $601,300 00 |

*High Service.*

| | |
|---|---|
| From Ragged Lake, mains and other works, | $55,030 00 |
| Distribution, | 17,850 00 |
| | $72,880 00 |

*Pumping by Steam Power.*

| | |
|---|---|
| Buildings, Steam Engines, mains and Reservoir, | $60,860 00 |
| Distribution, | 17,850 00 |
| Capital representing annual expense of pumping, | 38,146 00 |
| | $116,856 00 |

*Comparison of Plans.*

The Birch Cove Lake scheme, with a reservoir on Shaffroth's Hill, has the advantage of about twenty feet of additional head over the Long Lake, but would still be insufficient for the supply of the whole of the upper part of the city, either for domestic use or for fire purposes; and looking at the great difference in cost, I think there can be no doubt that to enlarge the capacity of the present works from Long Lake is the most advisable. From this source, from the increased size of the new mains and distribution pipes, the whole of the city can be supplied by gravitation, for domestic purposes, with the exception of the district lying to the north and west of Gerrish and Creighton Streets. To supply this district, and get effective head for fire purposes above Gottingen street, will require a high service system, either by bringing water from a higher source, or by pumping it into a reservoir.

From Ragged Lake the head is sufficient without a reservoir, although there would be some advantages gained by constructing one. The water would accumulate during the night, and when there was a large draught on the service pipes, they would be supplied both from the lake and the reservoir.

In pumping the steam power to Shaffroth's Hill, the high water level of the proposed reservoir will be 96.9 feet above the corner of Cogswell and Park street; 90.2 feet above corner at Wm. A. Blacks; 57.7 feet above street in front of Dr. Snellings, and 12 feet above the sill of the entrance gateway to the citadel. To supply the citadel during the hours of greatest draught, cisterns would be required to receive the water at the time of pumping. The reservoir cannot be placed higher without great additional expense.

The high service could be used to give additional head on the lower in cases of fire, by having one or more stop cocks to be opened connecting the two.

The revenue to be derived from the present population that will not be supplied from Long Lake, would scarcely warrant the expenditure for the high service for domestic purposes alone, but the increased facilities which would be afforded for extinguishing fires may be an object. The revenue for the use of the water by the present population may be estimated thus:

| | | |
|---|---|---|
| 200 houses at $10, | $2000 | |
| Citadel, | 1500 | |
| | | $3500 |

While six per cent on the estimated cost, from Ragged Lake is $4372.80; and, by pumping, $7011.36. Of course when the population sufficiently increased the revenue would pay interest on cost.

With respect to the advantages to be derived from introducing a more abundant supply of water into the city, it is perhaps unnecessary to say much. The recent fires, by which over $600,000 of property was destroyed, which a more effective supply would have extinguished with comparative ease, have convinced every one that the present works are inadequate. With the command of water proposed to be introduced, extensive fires would be rendered almost impossible, and the present high rates of insurance would be reduced. It is estimated that the *extra* insurance paid on property in the city since the fire of September last, amounts to from $30,000 to $40,000 per annum.

There would also be a considerable reduction of the expenditures connected with the

Fire Department, now estimated at $5000 per annum, while for watering streets, and cleansing sewers, and also for manufacturing uses, the supply of water would be abundant.

*Questions submitted by the Committee of the City Council.*

These questions I will now proceed to answer, and will do so, in the order in which they have been asked.

"The committee of the City Council refer to Mr. Laurie to report on the following questions.

*First.* What will it cost to bring into the City of Halifax an ample and effective supply of water for fire and general purposes from the Birch Cove Lakes." *Answer:* The cost as estimated in this report is as follows:

| | |
|---|---|
| For introducing water, | $290,690 |
| Distribution, | 99,410 |
| Purchase of present works, | 211,200 |
| | $601,300 |

"*Second.* Will the supply from the Birch Cove Lakes be sufficient to supply the present wants of the population of Halifax for fire and general purposes." *Answer:* The adequacy of the supply will be uncertain unless the right to all the water running from the Lakes is purchased.

"*Third.* Can that source be relied on at all seasons of the year, to meet the requirements of the population, and to what extent is it sufficient for the increase thereof." *Answer:* Could only be relied on by making storage reservoirs of the upper lakes.

"*Fourth.* Is Alderman Pugsley's scheme in conjunction with the present water works which the city have agreed to purchase, practicable, and what will it cost to carry the same into effect." *Answer:* Alderman Pugsleys scheme is perfectly practicable, but for the reasons stated in this report, I would recommend pumping into a reserveir instead of a stand pipe; also in place of a separate system of pipes for fire purposes to enlarge the capacity of the general distribution; and, that the water pumped up be used only for the service of the upper portion of the city, except in case of fires when it can be connected with the lower service. Thus modified, the cost, including the purchase of the present water works, would be:

| | |
|---|---|
| Introducing water, and enlarging lower service, | $169,480 |
| Upper Service; pumping by steam power, | 116,856 |
| Purchase of present water works, | 211,200 |
| | $497,536 |

"*Fifth.* Will the Birch Cove Lakes give the same head or force as Alderman Pugsley's scheme. If any, what will be the difference, and to what extent will the application of twenty eight jets (each jet throwing one hundred gallons per minute) reduce its head or force for fire purposes." *Answer:* The Birch Cove Lakes will not give the same head or force as Alderman Pugsley's scheme. Through a 15 inch pipe to supply ten jets throwing one hundred gallons per minute, the Birch Cove Lakes will only give a head of 20 feet over the present works when enlarged, at St. Andrew's Cross; while Alderman Pugsley starts with a head of 100 feet at that point. To supply twenty-eight jets would require a pipe of 24 inches diameter from the reservoir on Shaffroth's Hill to St. Andrews Cross, with a loss of head of 15 feet. The present mains from the Chain Lakes will only supply about one half the quantity required for 28 jets.

"*Sixth:* What size mains will be sufficient from the Birch Cove Lakes, to give a supply for twenty-eight jets, each jet delivering one hundred gallons per minute." *Answer:* To give a continuous supply for twenty-eight jets, the size of main required from the Birch Cove Lakes, with a descent or loss of head of 3 feet per mile, will be 28 inches, and with a descent of ten feet per mile, 24 inches diameter. It would not be necessary, however, to adopt a larger size of pipe than 15 or 18 inches from the Lakes to the reservoir for fire purposes only. A reservoir containing 4,000,000 gallons will supply 28 jets for 24 hours.

"*Seventh.* What quantity of water is available from each of the above named sources, in surface area." *Answer:* The quantity of water in present surface area is approximately as follows:

| | | | |
|---|---|---|---|
| From Long Lake, | | | 359 acres. |
| 1st Chain Lake, | | | 33 " |
| 2nd Chain Lake, | | | 22 " |
| | | | 414 |
| Peter's Rock Pond, estimated, | | 31 acres. | |
| Lake above do | do | 7 " | |
| Small Lake, | do | 5 " | |
| Byres Lake, | do | 20 | 63 |
| | | | 477 acres. |
| From Birch Cove Lakes, | | | 241 acres. |
| Duck Pond, estimated, | | 10 acres. | |
| Horse Shoe Lake | " | 40 " | |
| Ash Lake, | " | 60 " | |
| Fox Lake, | " | 70 | 180 |
| | | | 421 acres. |

"*Eighth.* Can the water at the Long and Chain Lakes be raised above its present level. To what extent, and at what cost? *Answer:* The water at the Long and Chain Lakes can be raised above the present level say three feet, at a cost of $5800. If raised much higher the cost would be largely increased.

"*Ninth.* What height above its present level can the water at the Birch Cove Lakes be raised." *Answer:* Eight to ten feet is the greatest height that I could recommend.

In the appendix will be found a statement showing the length of pipe of all sizes at present laid in the City of Halifax for the supply and distribution of water; also a table of distances and levels; also a statement of the heights of water in Long Lake from July 31st, 1857, to March 8th, 1860, which may be found useful for reference.

Respectfully submitted,
JAMES LAURIE, C. E.

## APPENDIX.

*Statement of the Length of pipe of all sizes at present laid for the supply of the City of Halifax with water.*

MAINS.

| | | |
|---|---|---|
| 12 inch main from Chain Lakes, to St. Andrews Cross, | 13,700 ft. | |
| 15 do do from do to do | 13,800 | |
| | | 27,500 |

DISTRIBUTION PIPES.

| | | |
|---|---|---|
| 12 inch pipe, St. Andrew's Cross to Spring Garden road, | 3,400 | |
| 12 inch do do through Cogswell street, to North Barracks, | 2,800 | |
| | | 6,200 |
| 9 in pipe in Cogswell, Barrack, and Jacob streets, | 840 | |
| 6 in pipe north of Jacob and Cogswell streets, | 4,760 | |
| 6 in pipe south of do do | 8,980 | |
| | | 13,740 |
| 3 in pipe north of Jacob and Cogswell streets, | 22,250 | |
| 3 in pipe between Jacob and Sackville streets, | 15,120 | |
| 3 in pipe all south of Sackville street, | 25,140 | |
| | | 62,510 |
| | | 110,790 ft |

=20 miles 5190 feet.

28 Fire Plugs,
15 combined Fire Plugs and Hydrants,
21 Hydrants.

*Table of Distances and Levels.*

DISTANCES.

| | miles. | feet. |
|---|---|---|
| St. Andrews Cross to Pipe House at Chain Lakes, | 2 | 2940 |
| Pipe House at Chain Lakes to Ragged Lake, | 2 | 1940 |
| St. Andrews Cross to top of Shaffroth's Hill, | 1 | 2640 |
| Shaffroth's Hill to Birch Cove Lakes, | 4 | |

HEIGHT OF IMPORTANT POINTS ABOVE CITY DATUM, OR MEDIUM LOW TIDE WATER.

| | Feet. | |
|---|---|---|
| Level of waste weir of Long Lake, | 202 | 2 |
| Ordinary surface of water in 1st. Chain Lake at Pipe House, | 199 | 8 |
| Top of pipe chamber, (15 inch pipe) | 200 | 8 |
| Bottom of pipe chamber, | 190 | 8 |
| Level of street at St. Andrew's Cross, | 163 | 0 |
| Level of street corner of Park and Cogswell streets, | 158 | 1 |
| Camp Hill, | 185 | 5 |
| Hill south of J. Kings, | 222 | 0 |
| Birch Cove Lakes, surface of water, | 239 | 0 |
| Top of Shaffroth's Hill, | 249 | 0 |
| Ragged Lake, surface of water, | 325 | 6 |
| Citadel, sill of entrance gateway, | 243 | 0 |

*Elevation of Streets above Tide.*

| Intersection of | and | Feet. above Tide. |
|---|---|---|
| South Street, | Kempt Road, | 119.8 |
| do | Queen, | 114.2 |
| do | Barrington, | 45.8 |
| do | Hollis, | 29.0 |
| Morris, | Kempt Road, | 138.9 |
| do | Summer, | 122.0 |
| do | Park, | 94.9 |
| do | Dresden Row, | 91.7 |
| do | Birmingham, | 102.8 |
| do | Queen, | 100.7 |
| do | Barrington, | 59.3 |
| do | Hollis, | 47.4 |
| do | Lower Water, | 25.1 |
| Spring Garden Road, | Kempt Road, | 142.5 |
| do | Summer, | 133.0 |
| do | Park, | 118.0 |
| do | Dresden Row, | 118.6 |
| do | Birmingham, | 116.8 |

| Intersection of | and | Feet above Tide. |
|---|---|---|
| Spring Garden Road, | Grafton, | 101.2 |
| do | Barrington, | 76.3 |
| Salter Street, | Granville, | 57.1 |
| do | Hollis, | 38.4 |
| do | Water, | 13.3 |
| Jubilee, | Kempt Road, | 160.8 |
| Sackville, | Summer, | 140.6 |
| do | Park, | 144.4 |
| do | Dresden Row, | 151.2 |
| do | Barrack, | 144.1 |
| do | Albermarle, | 125.6 |
| Sackville, | Grafton, | 105.8 |
| do | Argyle, | 87 3 |
| do | Barrington, | 68.6 |
| do | Granville, | 51.0 |
| do | Hollis, | 32.7 |
| do | Bedford Row, | 19.8 |
| do | Water, | 12.2 |
| Prince, | Barrack, | 139.4 |
| do | Albermarle, | 120.4 |
| do | Grafton, | 99.0 |
| do | Argyle, | 82.6 |
| do | Barrington, | 62.1 |
| do | Granville, | 46.4 |
| do | Hollis, | 30.4 |
| do | Bedford Row, | 18.6 |
| do | Water, | 8 6 |
| George, | Barrack, | 129.3 |
| do | Albermarle, | 113.6 |
| do | Grafton, | 92.0 |
| do | Argyle, | 72 6 |
| do | Barrington, | 56.6 |
| do | Granville, | 40.6 |
| do | Hollis, | 29.0 |
| do | Bedford Row, | 18.2 |
| do | Water, | 12.5 |
| Duke, | Barrack, | 118.1 |
| do | Albermarle, | 98.3 |
| do | Grafton, | 78.3 |
| do | Argyle, | 61.7 |
| do | Barrington, | 42.0 |
| do | Granville, | 26.3 |
| do | Hollis, | 15.1 |
| do | Water, | 10.1 |
| Buckingham, | Barrack, | 102.0 |
| do | Albermarle, | 83.9 |
| do | Grafton, | 66.9 |
| do | Argyle, | 51.8 |
| do | Barrington, | 36.0 |
| do | Granville, | 21.0 |
| do | Water, | 14.4 |
| Jacob, | Barrack, | 87.2 |
| do | Albermarle, | 70 5 |
| do | Grafton, | 55.0 |

| Intersection of | and | Feet above Tide. |
|---|---|---|
| Jacob, | Argyle, | 40.8 |
| do | Upper Water, | 16.6 |
| Cogswell, | Park, | 159.1 |
| do | City, | 149.3 |
| do | Creighton, | 145 5 |
| do | Gottingen, | 125.4 |
| do | Brunswick, | 83 9 |
| Cornwallis, | Park, | 160.0 |
| do | City, | 147.8 |
| do | Creighton, | 139.1 |
| do | Gottingen, | 123.0 |
| do | Maitland, | 105.7 |
| do | Brunswick, | 80.7 |
| do | Lockman, | 47.0 |
| do | Upper Water, | 16.8 |
| Cunard, | Kempt Road, | 158.3 |
| do | Park, | 162.4 |
| do | City, | 153.5 |
| do | Creighton, | 144.9 |
| do | Gottingen, | 129.4 |
| Gerrish, | City, | 162.0 |
| do | Creighton, | 153.9 |
| do | Gottingen, | 136.5 |
| do | Maitland, | 119.3 |
| do | Brunswick, | 94.[illegible] |
| do | Lockman, | 58.9 |
| do | Water, | 20.4 |
| Dockyard Lane, | Brunswick, | 106.0 |
| do | Lockman, | 65.0 |
| do | Water, | 25.5 |
| North Street, | Kempt Road, | 191.4 |
| do | Park Street, | 197.3 |
| do | City, | 188.1 |
| do | Creighton, | 180.4 |
| do | Gottingen, | 164.8 |
| do | Brunswick, | 124.0 |
| do | Lockman, | 81.5 |
| do | Water, | 33.9 |

***Statement showing the level of water in Long Lake, from July 31st, 1857, to March 8th, 1860, from Records kept in the W. ter Company's office.***

***Waste weir 75 feet in length.***

| Date. | | | Below top of waste weir. | Above top of waste weir. |
|---|---|---|---|---|
| | | | Inches. | Inches. |
| 1857, | July | 31 | 7 | |
| do | August | 21 | 1 | |
| do | September | 4 | Level. | Level. |
| do | do | 11 | 5 | |
| do | do | 18 | 8½ | |
| do | October | 16 | 17 | |
| do | November | 27 | | 4 |
| do | December | 5 | | 4½ |
| do | do | 18 | | 2½ |
| do | do | 24 | | 5 |
| 1858, | February | 12 | Level. | Level. |
| do | do | 19 | do | do |
| do | do | 26 | 5 | |
| do | March | 5 | | 6 |
| do | do | 12 | | 2½ |
| do | do | 19 | | 2½ |
| do | April | 9 | | 5½ |
| do | do | 16 | | 8 |
| do | do | 30 | | 6 |
| do | May | 14 | | 3 |
| do | June | 4 | | 1½ |
| do | do | 18 | | 4½ |
| do | July | 23 | 7½ | |
| do | do | 30 | 13 | |
| do | August | 6 | 15 | |
| do | do | 13 | 10 | |
| do | do | 20 | 6 | |
| do | September | 3 | 13 | |
| do | do | 17 | 18 | |
| do | October | 1 | 24 | |
| do | do | 15 | 16 | |
| do | do | 22 | 9 | |
| do | November | 12 | 12 | |
| do | do | 19 | 7 | |
| do | December | 3 | 9½ | |
| do | do | 10 | 8½ | |
| do | do | 24 | | 3½ |
| 1859, | January | 21 | | 2½ |
| do | do | 28 | 2½ | |
| do | February | 5 | 2½ | |
| do | do | 12 | | 12 |
| do | do | 18 | | 2½ |
| do | March | 7 | Level. | Level. |
| do | do | 11 | do | do |
| do | do | 18 | | 4 |
| do | do | 25 | | 4 |
| 1859 | April | 22 | | 2½ |
| do | do | 29 | | 2½ |
| do | May | 20 | | 1½ |
| do | June | 3 | | 3 |
| do | do | 10 | | 1½ |
| do | do | 17 | | 2 |
| do | do | 24 | | 2½ |
| do | July | 2 | | 1½ |
| do | do | 22 | | 3 |
| do | do | 29 | 3½ | |
| do | August | 12 | 6 | |
| do | do | 19 | 11 | |
| do | do | 26 | 8 | |
| do | September | 9 | 12 | |
| do | do | 23 | 12 | |
| do | October | 7 | | 8 |
| do | December | 16 | | 7 |
| do | do | 23 | | 4 |
| do | do | 30 | Level. | Level. |
| 1860, | February | 3 | 2 | |
| do | do | 17 | Level. | Level. |
| do | do | 24 | | 4 |
| do | March | 1 | | 1 |
| do | do | 8 | | 1½ |

***Statement of the length of different sizes of Pipes laid in Boston; and the number of Stop Cocks, Hydrants, &c, January 1st, 1860.***

| Dia. of Pipe. | Length in Feet. | No. of Stop Cocks. |
|---|---|---|
| 40 inch. | 22,412 | 3 |
| 36 do | 20,429 | 4 |
| 30 do | 32,472 | 8 |
| 24 do | 5,773 | 10 |
| 20 do | 24,127 | 11 |
| 16 do | 7,619 | 22 |
| 12 do | 83,676 | 152 |
| 6 do | 364,670 | 638 |
| 4 do | 99,503 | 240 |
| | 660,681 | 1088 |

| | |
|---|---|
| No. of Hydrants in Boston proper, | 902 |
| No. of do in South and East Boston, &c., | 461 |
| | 1363 |

| | |
|---|---|
| Population, | 178,000 |
| No. of Water takers, | 23,271 |
| Receipts, | $316,290 97 |

WAVERLY HOUSE,
March, 19th, 1860.

SIR,—

Being employed by the City authorities of Halifax to investigate and report on several plans suggested for procuring a supply of water for the service of the more elevated portions of the city, and for effective use in extinguishing fires, I take the liberty of enquiring at what elevation above tide level it would be necessary to deliver water (should it at any time be deemed expedient) to supply the citadel.

Respectfully, I am, sir,
Your obe'd. servant,
(Signed) JAMES LAURIE.

To Colonel Nelson,
Com'g. Royal Engineers.

ROYAL ENGINEERS' OFFICE,
Halifax, N. S., 20th March, 1860.

SIR,—

I am directed to inform you, in reply to your note of yesterday, addressed to Commanding Royal Engineers, that it will be advisable to estimate for delivering at six feet above the level of the highest point of the citadel parade.

By current reports, the height of the sill of the entrance gateway is considered to be 243 feet above the sea, but it is not known whether this refers to the level of high or low water.

I have the honor to be, sir,
Your most obed't. humble serv't.,
WILLIAM GORDON,
Clerk of Works.

To James Laurie, Esq.,
Civil Engineer, Waverly House.