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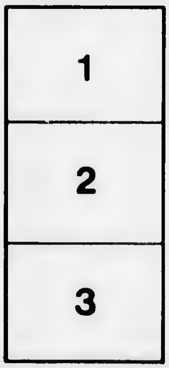

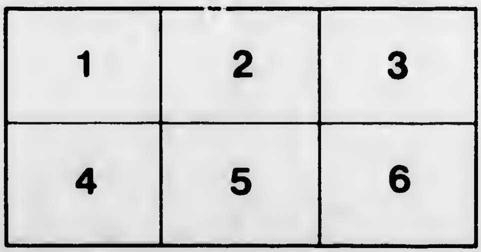

SPECIAL REPORT

ON THE

WATER SUPPLY OF SAINT JOHN
(EAST)

AND

TOWN OF PORTLAND.

BY
GILBERT MURDOCH, Esq., C. E.
M. Am. Soc. C. E.

TO THE
COMMISSIONERS
OF
SEWERAGE AND WATER SUPPLY.

SAINT JOHN, N.B.:
J. & A. McMILLAN, 98 PRINCE WILLIAM STREET.
1883.

OFFICE OF
THE COMMISSIONERS OF SEWERAGE AND WATER SUPPLY,
CITY HALL, PRINCE WILLIAM STREET,
Saint John, N. B., February 28th, 1882.

GILBERT MURDOCH, ESQ., C. E.

Sir,—

The following resolution was passed this day at a meeting of the Commissioners:

"*Whereas*, There are numerous complaints from Water Takers of "an insufficient Supply of Water for house and fire purposes, on and "near the summits of Saint John and Portland,

"*Therefore Resolved*, That Gilbert Murdoch, Esq., C. E., Superin-"tendent of Water Supply, be requested to report, as soon as prac-"ticable, the extent and present condition, in respect to pressure "and quality, of the Water Supply of Saint John and Portland; "together with the best means of improving the same, so that a "purer and more efficient supply may be had for House and Fire "purposes than is now obtained from *Little River*. Also, plans and "estimates of cost, and such other information as may seem necessary "to the formation of a correct judgment on the several points and "questions involved in an effective summit supply."

I am,

Yours truly,

A. CHIPMAN SMITH,

Chairman.

REPORT.

ENGINEERING DEPARTMENT,
SEWERAGE AND WATER WORKS,
SAINT JOHN, December, 1882.

A. CHIPMAN SMITH, Esquire,
Chairman of Sewerage and Water Commission.

DEAR SIR,—

The Water Supply of Saint John and Portland is taken from Little River at a point which is about 4½ miles from the Aboideau, or 5 miles from the City Court House.

This has been the source of supply for upwards of thirty years, having been chosen in 1849 by the Old Water Company, after the resolution had been formed to abandon the pumping system then in vogue, and obtained by gravitation a more constant and copious supply, as well as a better class of water, than was then furnished to the City.

Previous to this change the water brought to the City was taken from

LILY LAKE,

which was selected as a source of supply in 1836, by the advice of Col. Baldwin, a then celebrated American Engineer.

This Lake has a surface area of about 27 acres and an elevation above City datum of about 80 feet.

The first water was given to the City from this source in October, 1838, and it was first used for fire purposes during the great conflagration of August 17th, 1839, which swept both sides of Dock and Nelson streets as well as the North Market Wharf and part of Union street, and destroyed in its progress upwards of eight hundred thousand ($800,000) dollars worth of property.

The fire plug used on this occasion stood on "Barlow's corner" (N. W. corner of King and Prince William streets), and was noticed as follows in the *Courier extra* of August 19th, 1839: "The "supply of water furnished by the fire plug of the Saint John

"Water Company, at Messrs. Barlow's corner, proved of most "essential service, as from it we believe all the engines stationed "in the Market Square were supplied, while the water obtained "from it was also conveyed to the South Market Wharf and pre- "vented the destruction of nearly the whole of the City, which at "times was threatened."

The new supply was not long in operation, however, unti. it was discovered that its quality was not well suited for house or steam purposes; and the obtainable quantity altogether inadequate for the requirements of the City—limited as it then was; and the difficulties named were aggravated by the Messrs. Gilbert having a first claim on the water for Milling purposes.

The area and capacity of this Lake could have been increased to some extent by the erection of a dam at or near its outlet, yet the smallness of its collecting ground and storage capacity made and continues to make it useless as a source of supply for City purposes.

The water that flowed from the Lake was first taken to the Mill (when working) and then conveyed by a small wooden trunk to a tank at the Aboideau pumping station, and from this it was taken and forced by steam power into a small distributing reservoir on "Block-house hill." In this operation it will be observed the water was allowed to fall about 80 feet and then lifted again, at a heavy cost, to be sent to Block-house hill.

The reservoir just mentioned was built of stone, supported on its outside by an earthen embankment. It was designed to contain. when full, about 350,000 gallons, but in consequence of defective workmanship, its storage capacity was reduced, from the first day it was used, to about 170,000 gallons. It is still in use, and having received extensive repairs in 1877, is now capable of containing about three hundred thousand gallons. This quantity is constantly held in reserve, to supplement the summit supply in case of fire. The last time this reservoir was open for fire purposes was on the 17th day of February, 1880, when the Leinster street Baptist Church was on fire.

From 1846 till 1851 the supply was almost wholly intermittent, the hours of supply having been from 6 to 8 A. M., daily, and the quantity delivered rarely exceeded during the hours named 50,000 to 60,000 gallons, for all purposes.

A sufficient supply had to be drawn during the *two* hours the "water was on" to last for the *twenty-two* it was off; and when a fire broke out in these slow old times, no water could be had for its suppression until the "Tank" or reservoir on "Block-house hill" was opened and the mains filled. The time usually lost in this way was from *fifteen* to *thirty* minutes, but sometimes it was much more, when from any cause the alarm was long in reaching the "turnkey," whose special duty it was to let on and shut off the water; and when the fire was serious, or threatened to be so, a messenger had to be dispatched to the "Marsh Bridge" pumping station to get steam raised and the engine put to work, to supplement the supply held in the reservoir, which seldom exceeded 150,000 gallons, and often not one-half of this, as the engine was only run tri-weekly.

It was with a view to terminate this most undesirable state of things — to obtain a more copious and constant supply for fire purposes and a softer and healthier water for steam and house use — that the change was made from a *pumping* to a *gravitation* supply, from an intermittent to a constant one, and from the hard and dirty waters of Lily Lake to the softer and purer and healthier waters of Little River, as a first step in the direction of Loch Lomond.

The first surveys undertaken with a view to this change were made by the late R. C. Minnette, Esq., C. E., City Surveyor, but the work done was little more than a *reconnoisance*, and did not extend beyond Lake Douglas — the head water of Little River.

When it was found that the elevation of Little River was sufficient to send water to the City by gravitation, the old "Scott Mill" property was bought from Thomas E. Milledge, Esq., and Charles E. Fairbanks, Civil Engineer, of Halifax, employed to make more exact and extensive surveys and advise as to the extent and character of the required works.

Mr. Fairbanks was an Engineer of experience and had been Superintending Engineer of the Halifax Water Works during their construction. He reported in the spring of 1849, approved of the site chosen for a reservoir, and recommended the erection of a dam about 10 feet high and the laying of a 12 inch pipe from thence to the City.

Before proceeding with t is work, however, further surveys were made by the late John Wilkinson, C. E. (Fredericton), with a view to test still further the accuracy of the preceding ones, particularly in relation to the elevation of Little River at the "Scott Mill-dam" and the selection of a pipe line.

Extra pains were taken to avoid mistake on the point of elevation, as the possibility of bringing water from Little River to the City was doubted by many worthy citizens, and stoutly denied by a few of the more knowing ones, whose scepticism continued, despite of surveys and everything else, until the water was actually brought to the Aboideau.

The work performed by Mr. Wilkinson was executed with his usual care and accuracy, and the line then selected has been followed generally since.

In the Report submitted by Mr. Wilkinson in 1850 the opinions expressed by Mr. Fairbanks were generally confirmed, and a wooden dam recommended. Elaborate plans in detail of the latter were also submitted, but on mature consideration an earthen embankment was preferred on the ground of economy as well as durability.

Work was commenced on Little River in October, 1850, under the direction of George H. Bailey, C. E., of Boston. In December the dam and gate house were completed, and Mr. Bailey returned to Boston to fill a more lucrative appointment.

During the winter of 1850-51 the pipe line was brushed out and the pipes sledded on to the ground. Pipe laying was commenced in the spring of 1851, and on the 10th day of September following the water was formally let on to the City by Mayor Harding.

This was a gala day in the City. The Volunteer Fire Department — called into existence by the York Point fire of March, 1849 — was then in its prime and turned out in great force, with engines and hose, bands and banners, to honour the occasion, as did also the City Council and many of the trades and leading citizens. Lieut-Governor Sir Edward Walker Head came from Fredericton to honour the event and turn the water on to the King Square fountain, which had been finished a few days before.

Since this time the supply to the City has been constant by day and night, unless when interrupted for short seasons for inspections or repairs.

The old boilers and engines, as well as lands and buildings at the Aboideau, were sold in July, 1854, for $8,920, and the proceeds applied to perfecting the new works and in extending the distributing system. An effort was made about this time by the late Thomas Allan, Esquire (of Harris & Allan), to organize a Company to supply Portland with water, but after one or two public meetings had been held in the old Market House, the scheme was abandoned for want of support.

The whole length of piping connected with the Water Supply of the City, when operations were commenced on Little River in 1850, measured about nineteen thousand seven hundred (19,700) feet—service pipes included—and the water takers numbered about one hundred and ninety (190). The rates charged at this time were $10.00 per family of five or under, and $2.00 additional for each individual (young and old) over five; horses and cattle $4.00 each, and steam engines $10.00 per horse power.

LITTLE RIVER RESERVOIR.

The bed of the river at the point selected for a reservoir is 140 feet above City datum, and the surface of the water in the reservoir, when full to overflowing, 160 feet; the additional height having been obtained by the erection of an earthen dam, which is still in use and in excellent condition. This reservoir has a surface area of about 37½ acres and a natural supply of water largely in excess of present requirements; but its elevation is insufficient to give an effective force for house and fire purposes on the higher levels of the City and Portland—as its bottom is only about ten feet, and its surface, when full, thirty feet above the intersection of Leinster and Wentworth streets.

TRANSFER OF THE COMPANY'S WORKS.

In June, 1855, Commissioners of Sewerage and Water Supply for Saint John (East) and Parish of Portland were appointed by authority of an Act of the Local Legislature (18 Victoria, Cap. 38), and in August following the Stock and Works of the Water Company were transferred to the newly appointed Board—John Sears (Chairman), John M. Walker, and John Owens.

A pressing and principal duty of the Commissioners was to provide a proper Water Supply for Saint John (East) and Portland—the want of which had been strikingly manifested during the cholera visitation of 1854; and with a view to this, a Special Report was submitted to the Commissioners by the then Engineer of the Works (the writer of this Report), advising a

24 Inch Main to be Laid

from the Aboideau to Little River Reservoir, as the best and speediest way of adding to the City's water supply.

Before deciding, however, on a matter of so much importance, the Commissioners wisely determined to seek outside advice, and to this end consulted James Slade, Esquire, City Engineer of Boston. In 1856, Mr. Slade had new surveys made between the City and Loch Lomond, *via* Lake Douglas, by T. W. Davis, C. E., the present accomplished City Surveyor of Boston, Mass., and the lakes and routes leading thereto examined by H. S. McKean, Esquire, an Hydraulic Engineer of much erudition and experience. The report submitted by Mr. McKean, and endorsed by Mr. Slade, discussed very fully most of the questions involved in the contemplated supply for Town and City, and sustained the advice given in relation to the laying of a 24 inch pipe between the Abodiean and Little River Reservoir.

As soon as this report was received, steps were immediately taken for the speedy execution of the work, and by the fall of 1857 the new main was placed, and the daily supply increased from about 550,000 to upwards of 5,000,000 imperial gallons, and the water was turned on to Portland, for the first time, on the 10th day of November, 1857, but at this date the mains did not extend beyond "Orange corner."

By the laying of this main the summit supply was immediately restored, so far as it could be, from Little River, and continued satisfactory for a good while after. But as the Works were extended and the consumption increased, the pressure began again to weaken and the supply to fail, until in 1870 and 1871, it had all but ceased in the vicinity of Block-house hill and similar summits. It was partly to remedy this evil that the

SECOND 24 INCH MAIN

was laid in 1873, and partly with a view to *duplicate* the pipes leading to the City, so that, in case of an accident happening to either, requiring the water to be shut off for a longer or shorter period, the City would not be wholly deprived of water.

From the last point of view alone, this extension was of immense importance, and has often proved of great value since, when flushings or repairs had to be made on either of the large mains, as they could be done more leisurely and thoroughly, and without practical inconvenience to any one, excepting consumers on the very summits of Saint John and Portland.

LEADING MAINS.

The water is now brought to the City by three (3) cast iron pipes, one of which is 12 inches in diameter and two (2) of 24 inches each. The first, as already remarked, was laid by the Old Water Company in 1851, and the two last in 1857 and 1873, respectively, by the Commissioners of Sewerage and Water Supply.

The combined length of the three (3) leading mains is sixty-nine thousand three hundred and twenty-five (69,325) feet; their united sectional areas ten hundred and seventeen (1017) square inches, and their estimated capacity of discharge ten million eight hundred thousand (10,800,000) gallons per day or 450,000 gallons per hour, when new and free from incrustation. Their present capacity, however, is not estimated at more than 350,000 gallons per hour; the loss being occasioned by reduced area and impeded velocity through internal accretions.

DISTRIBUTION.

The daily supply of water brought to the City by the three (3) leading mains is distributed by two hundred and seventy-eight thousand, one hundred and twenty-eight (278,128) feet of pipe of the following lengths and sizes—

15 Inch Pipe—	Saint John,	4,150		
	Portland,	8,027		
			12,177	
12 Inch Pipe—	Saint John,	13,955		
	Portland,	10,722		
			24,677	
10 Inch Pipe—	Saint John,	7,821		
	Portland,	2,151		
			9,972	
8 Inch Pipe—	Saint John,	11,295		
	Portland,	9,049		
			20,344	
6 Inch Pipe—	Saint John,	40,678		
	Portland,	14,057		
			54,735	
4 Inch Pipe—	Saint John,	34,046		
	Portland,	8,386		
			42,432	
3 Inch Pipe—	Saint John,	4,855		
	Portland,	158		
			5,013	
2 Inch Pipe—	Saint John,	400		
			400	169,750
3,733 service pipes from 0½ inch to 4 inch diameter,			108,750	
49 Free Hydrants,			998	
				109,748
Total Distributing Pipe,				279,498

Adding to the above the 69,325 feet of leading mains between the aboideau and Little River reservoir, the total present pipeage in connection with the Water Supply of Saint John and Portland is three hundred and forty eight thousand eight hundred and twenty-three (348,823) feet, or upwards of 66 miles.

Attached to this pipe are forty-nine free hydrants for the use of the poor, three thousand seven hundred and thirty-three (3,733) service pipes, for house supply, one hundred and twenty-seven metres and indicators, four thousand four hundred and ninety-seven (4,497) main and service stop-cocks, and two hundred and seventy-six (276) fire plugs.

COST OF OUR WATER SUPPLY.

The cost of the above named Works, including land damages and reservoirs, as well as debentures sold to make good assessment deficiencies and losses, caused by the great fire of 1877, was on the 31st day of December last (1881) $988,000 (in round numbers), or a per capita average of about $25.00 for each man, woman and child residing in the several streets and districts supplied with water and subject to assessment.

The amount may seem large, and is sometimes spoken of as excessive, but such is *not* the case; on the contrary, there are few cities on the continent supplied with water more cheaply than Saint John, and none so abundantly for the same amount of money. In many places the cost has been 50 to 75 per cent. more than with us (measured by population) for works of less than one-half the supplying capacity of ours, per day, with heavy annual charges besides for pumping.

This will be made plain by an inspection of the following tables, which have been carefully collated from recent Official Reports, and show at a glance the

Cost to Thirty Well Known Cities

in the United States and Canada, of their respective Water Services —measured by population, miles of pipe laid and quantity of water delivered or deliverable daily without adding materially to the running expenses.

TABLE No. 1.

Cities Supplied by Pumping.

Name of City.	Population Latest Census.	Miles of Pipe Laid.	Daily Delivery in Wine Gallons.	Approximate Cost of Works.	Average Cost. Per Capita.	Average Cost. Per Mile of Pipe Laid.	Capital Cost per Million Gallons Daily.
				$	$	$	$
Brooklyn,	567,000	347	33,000,000	11,250,000	19.84	32,420.00	340,909.00
Bangor,	16,900	24	2,000,000	500,000	29.58	20,833.00	250,000.00
Chicago,	503,300	463	58,000,000	8,979,523	17.84	19,006.00	151,707.00
Cleveland,	160,200	114	9,500,000	2,500,000	15.60	21,930.00	263,158.00
Dayton,	38,700	33	1,100,000	710,000	18.32	21,515.00	645,454.00
Detroit,	116,400	209	15,200,000	2,751,000	23.63	13,162.00	180,986.00
Erie, Pa.,	27,800	35	2,200,000	700,000	25.18	20,000.00	318,181.00
Hamilton,	36,000	63	2,200,000	1,160,000	32.22	18,412.00	527,777.00
Lowell,	59,500	63	2,500,000	2,187,000	36.75	34,714.00	874,800.00
Lawrence,	39,200	44	1,900,000	1,714,700	43.74	38,970.00	902,474.00
Lynn,	38,300	41	1,300,000	1,000,000	26.11	24,390.00	769,231.00
Montreal,	140,900	133	11,700,000	6,500,000	46.13	48,872.00	555,555.00
Manchester,	32,600	34	1,200,000	802,000	24.60	23,588.00	668,333.00
New Bedford,	26,900	42	2,100,000	981,000	36.47	23,357.00	467,143.00
Newark,	136,400	136	11,600,000	3,259,000	19.60	19,644.00	230,370.00
Ottawa,	27,500	44	3,500,000	1,100,000	40.00	25,000.00	314,286.00
Providence,	104,900	152	3,200,000	4,700,000	44.80	30,920.00	1,468,750.00
Toledo,	50,200	47	3,300,000	1,146,000	22.82	24,383.00	347,575.00
Toronto,	86,500	114	6,000,000	2,000,000	23.12	17,544.00	333,333.00
Waltham,	11,700	24	500,000	306,000	26.15	12,750.00	612,300.00
AVERAGES.					28.67	24,550.00	511,116.00
St. John and Portland,	37,000	67	10,000,000	988,000	26.70	14,970.00	98,800.00

The above table, briefly summarized, gives the following results:

	Table No. 1. Pumping.	Saint John Gravitation.
Highest per capita cost,......	$46 13	
Lowest do., ...	15 60	
Average do., ...	28 66	$26 70
Highest cost per mile of pipe laid, ...	48,872 00	
Lowest do. do., ...	12,750 00	
Average, do. do., ...	24,550 00	14,970 00
Highest capital cost per Million Gallons,	1,468,750 00	
Lowest do. do.,	151,707 00	
Average, do. do.,	511,116 00	98,800 00

And in relation to this table it should be explained that no allowance is made for the cost of pumping. Had this been capitalized, as it should have been for exact comparison with our *gravitation* works, the results would have been still more in our favour. As it is, however, their relative economy and cheapness are strikingly apparent in the three essential standards of comparison, viz., population, miles of pipe laid, and capacity of daily supply without substantial increase to ordinary running expenses.

TABLE No. 2.

CITIES SUPPLIED BY GRAVITATION.

Name of City.	Population Latest Census.	Miles of Pipe Laid.	Daily Capacity of Delivery in Wine Galls.	Approximate Cost of Works.	Average Cost. Per Capita.	Average Cost. Per Mile of Pipe and Aqueduct.	Average Cost per Million Wine Gallons Deliverable Daily.
				$	$	$	$
Altoona,	19,700	16	1,000,000	300,000	15.23	18,750.00	300,000.00
Boston,	362,600	570	40,000,000	18,500,000	51.07	32,456.00	462,500.00
Halifax,	36,000	70	7,000,000	741,000	20.58	10,585.00	105,857.00
Hartford,	37,200	71	5,000,000	2,000,000	53.76	28,170.00	400,000.00
Holyoke,	21,900	21	1,000,000	322,500	14.68	15,357.00	322,500.00
New York,	1,206,600	545	95,000,000	37,529,300	30.27	68,861.00	395,045.00
Portland,	33,800	70	9,000,000	1,800,000	53.25	25,714.00	200,000 00
Quebec,	62,500	28	3,000,000	1,300,000	20.80	46,500.00	433,333.00
Rochester,	89,400	110	9,000,000	3,500,000	39.15	31,818.00	388,889.00
Washington, Georgetown,	160,000	190	26,000,000	4,500,000	28.12	23,684.00	173,077.00
AVERAGES.					32.69	30,189.00	318,120.00
St. John and Portland,	37,000	66	10,000,000	988,000	26.70	14,970.00	98,800.00

The prominent features of this table briefly summarized and compared with our own Works are as follows:

GRAVITATION WORKS.	Cost by Table No. 2.	Cost to Saint John.
Highest per capita cost, ...	$53 76	
Lowest do. do., ...	14 68	
Average do. do., ...	32 69	$26 70
Highest per mile of pipe laid, ...	68,861 00	
Lowest do. do., ...	10,585 00	
Average do. do., ...	30,189 00	14,970 70
Highest capital cost per Million Gallons, ...	462,500 00	
Lowest do. do., ...	105,857 00	
Average, do. do., ...	318,120 00	98,800 00

It should be remarked, also, in reference to this table, that in some of the places named—notably, Boston and New York—that although the general supply is by gravitation, yet to reach their respective summits steam power has to be used to a greater or less extent.

Boston has its Highland, Brighton, East Boston, and Mystic pumping stations, and New York its Ninth Avenue and Ninety Second street high service stations. To get a nearer approach to accuracy, the annual expenses attending these Works should be considered; but this has not been done, as all that is sought by either table, is to show approximately the cost of works, for water supply, to other cities larger and smaller than our own, and in doing so avoid as far as practicable anything that might tend to complication or to apparently forced results.

And in this connection it may be further noted, that in some of the cities named, large expenditures—additional to those given in the Tables—are either in progress or contemplated in the near future, to keep pace with the ever growing demand for vaster volumes of water and greater pressures than now prevail.

Quebec, for instance, has recently resolved, under the advice of its eminently accomplished City Engineer, the Chevalier Baillairge, to get rid of its hampered intermittent supply by laying a new and larger main to Lorrette, at an estimated cost of $500,000. And the City of Boston, that has spent within a few years upwards of $5,000,000 on extensions, has works on hand and in contemplation that are likely to cost millions more before they are completed. This is the case also with Washington, D. C., where a new Aqueduct is about to be built at a cost of $1,500,000; and New York, after many years of suffering, has a project in hand for improving its water supply which is to cost about $14,000,000.

The main features of this great project are the construction of a new reservoir below the site of the present Croton dam, capable of containing thirty-three thousand millions of gallons of water, and a subterranean aqueduct—to be constructed for the greater part of the way (nearly 38 miles) in tunnel—fit to carry to the City about two hundred and fifty millions of gallons daily, in addition to the present supply.

This new reservoir is to have a dam of masonry, a maximum depth of 185 feet, and a water shed of about 23 square miles. The tunnel-aqueduct is to have a circular form, a diameter of 14 feet, a fall of 9 inches per mile, and a 12 inch lining of brick.

A bill to authorize these works has received the sanction of the State Legislature, and doubtless a few years hence will see this—the boldest and greatest scheme of the age for supplying any City with water—an accomplished fact, and New York rivaliing ancient Rome in the sumptuousness of its water supply. The authors of this magnificent work are E. S. Chesborough, consulting Engineer, and Isaac Newton, Engineer to the Croton Aqueduct Board. Both gentlemen stand high in the profession, and Mr. Chesborough's reputation as a great and successful Hydraulic Engineer is world-wide. Under such guidance, failure is impossible.

Cases might easily be multiplied, in reference to this constant call for more water, by cities that have become accustomed to its use, but enough has been done to show that though the cost to the cities named in Tables 1 and 2, exceed generally the cost of our Works, yet their several supplies are far from satisfactory, and still farther from completion. There is still a reaching out for more water, and much has yet to be done before this growing desire is fairly satisfied.

No live City can afford to stand still and do nothing in the matter of its Water Supply. Its very existence as a place to live in and work in, depends on the extent and c[illegible] and character of the water provided for its people; and as they become schooled into the use and value of water, as a labour-saving agent in the family as well as in the factory—as a protection of health as well as of property, the present meagre supplies and pressures must be supplemented by larger and more effective ones, suited, alike in purity and pressure, in quality and quantity, to every purpose of modern domestic life and manufacturing industry and enterprize,—even to the providing for winter waste when the natural supply is copious and convenient of adaptation to city wants, as in Saint John. Above all other municipal requirements this is *the* one that cannot be overlooked or neglected with impunity.

HOW OUR WORKS ARE SUPPORTED.

The amount of money required annually to pay for interest on capital expended and for maintenance and other current expenses is, or rather should have been raised (1) by an annual assessment on owners in fee and lease-holders for renewable terms of all lands and tenements through or along which Water Mains pass, also on the owners of, or traders in stocks-in-trade, wares or merchandise, furniture and personal property—whether the water is taken and used on the premises or not—in accordance with a scale to be fixed from year to year by the Commissioners of Sewerage and Water Supply; and (2), by a general assessment, should the sum realized from the Commissioners' rating be insufficient to pay interest, maintenance, and current expenses.

Unfortunately, since the inception of the Works no general assessment has ever been made, deficiencies having been met from time to time by the sale of debentures. In consequence of this, the actual or debenture cost of our Works is greater than it would have been had the law been strictly complied with, as it embraces an indefinite amount for interest and working expenses, which should have been met by increased rates or a general assessment on Saint John and Portland.

The assessment for water made and collected by the Commissioners is levied *pro rata* on all properties and persons subject thereto, the same scale and principles of valuation being applied to City and Town alike—according "to value made, occupation, and probable consumption of water."

Before making the assessment for any one year an independent and personal house to house survey is made of all the premises and property subject to rating, and particulars obtained as to the number of families, baths, water closets, shops, taverns, horses and cows, values of stocks-in-trade, furniture, and personal property.

The returns obtained in this way in the Water Districts of Saint John and Portland give the following results for the year ending with the 1st day of May, 1882, viz:

FAMILIES, &c., SUBJECT TO ASSESSMENT.

	St. John.	Portland.	Totals.
Families, number of	3,878	2,[illegible]7	6,235
Hotels and Boarding Houses, ...	66	6	72
Schools, ...	11	3	14
Offices, ...	196	27	223
Saloons, Shops and Taverns, ...	663	264	927
Factories, Mills and Workshops,	304	85	389
Steam Engines, ...	33	19	52
Water Closets, ...	1,949	84	2,033
Baths, ...	717	43	760
Country Stabling, Stalls, ...	112	151	263
Horses, ...	634	232	866
Cows, ...	24	71	95

Totals of Assessment Valuations.

	St. John.	Portland.	Totals.
	$	$	$
Stock in Trade $400 and upwards,	2,820,200.00	680,500.00	3,500,700.00
Furniture, &c. $600 do.	858,700.00	139,600.00	998,300.00
Real Estate & Leasehold Property,	9,983,150.00	2,631,550.00	12,614,700.00
Totals, ...	13,662,050.00	3,630,850.00	17,113,700.00

Revenue from Assessment and Agreements.

	St. John.	Portland.	Totals.
	$	$	$
Assessments, Gross Amount, ...	53,449.60	14,650.30	68,099.90
Agreements do. ...	5,158.51	4,120.82	9,279.33
Totals, ...			77,379.23

The foregoing figures give a summarized view of the capacity and extent of our Works at the present time; their cost and mode of maintenance, together with the number of families and factories depending on them for their daily water supply. In so far as the

Quantity of Water

brought to the City daily is concerned, it is more than ample for all ordinary purposes, and greatly in excess of present requirements. Indeed few places in America have a fuller and more copious supply than we have, when measured by population, but notwithstanding this the

SUPPLY TO THE SUMMITS IS DEFECTIVE

in consequence of the relative lowness of the "fountain head," or reservoir, compared with the higher levels of Saint John and Portland. In the neighborhood of Block-house hill, and corresponding elevations, the water

Rarely Rises Above the Basements

of the houses into which it is led, and in consequence of this, resort must be had to expensive and inconvenient mechanical arrangements, before the water can be used for bath or water closet purposes in these localities.

This is an inherent defect in the present system and is occasioned, as already remarked, by the site of the present reservoir (selected by the Water Company in 1849) not having sufficient elevation to lift or force the water, as in lower levels, to third and fourth stories. The same causes that make our present supply insufficient for ordinary house purposes near the City summits

Destroy its Practical Value

in case of fire, and in consequence of this the risks are greater and rates of insurance relatively higher in such localities than in the lower and more favored districts.

The owners of property, therefore, in the vicinity of such summits are placed at a serious disadvantage, compared with owners on lower levels, and justly complain of the inconvenience and cost to which they are put through this lowness of head or pressure, while the rates imposed and paid by them, on account of water supply, are equal to those of the most favored sections of the City, where water is to be had in abundance for all purposes, from basement to attic, without resort to artificial aid. The evils resulting from this natural lowness of head are

Aggravated during the Winter Season

by the water being freely used in the lower districts to keep pipes and closets from freezing. The amount of water which is wasted in this way is enormous and entirely beyond control. Its suppression has baffled the best efforts of every city on the Continent, and is likely to do so until water, like gas, is sold by measure, for house as well as for trade purposes.

What chiefly tends to put this winter waste beyond control, is the fact that the greater part of it occurs at times and in places that are beyond the reach of ordinary inspection—as, for instance, in private apartments and in the night time, when doors are locked and entrance for inspection purposes impossible.

Pipes and Hydrants that are placed in open and exposed positions, as they usually are on the premises of the poor, can be seen in cold weather, and kept in some degree of control by frequent visitation; but this ceases to be the case when the water is carried to kitchens and wash basins, urinals, baths and water closets, and ample facilities provided for carrying it quietly and quickly away, when allowed to run through carelessness or wilfulness.

Nor can this waste be detected by external inspections, as is done in some places, as the severity of our climate and depth of snow usually found on our streets makes the "*Deacon*" system of night inspection all but impossible, or useless, for practical purposes, when most needed, in our circumstances.

The influence of this waste in weakening the force and contracting the limit of supply where the margin of pressure is so low as with us, may be understood by a short study of the following reports, made by our Inspectors in the discharge of their ordinary routine of duty, on the 5th and 6th days of January last (1882), the waste in each case having been carefully timed and measured.

And, it may be remarked, in submitting the following samples of waste, that the names and the waste written opposite them are taken in rotation from the Inspectors record, just as it stands, and are not selected from a desire to make out a stronger case than the facts would fairly warrant. Unfortunately this is not necessary.

SAMPLES OF MEASURED WASTE.

No. of Report.	Premises.	Street.	Rate of Waste. Gallons per minute.	Rate of Waste. Gallons per day, 24 hours.
1	Patrick Gallagher,..........	Richmond,....................	4.00	5,760
2	John Murray,.......	St. Patrick,.................	1.25	1,800
3	George Keeffe,.............	St. Patrick,.................	4.00	5,760
4	Peter Jennings,.	Clarence,....................	.50	720
5	Mary Mitchell,.............	Clarence	1.00	1,440
6	Fred. J. Doherty,...........	Frederick,...................	1.00	1,440
7	Patrick McMininan,.......	Marsh Road,................	1.00	1,440
8	Joseph C. Wood,...........	Marsh Road,................	2.00	2,880
9	Andrew Pratt,............ ..	Old Westmorland Road,	2.50	3,600
10	John McGowan,............	City Road,...	2.00	2,880
11	Hugh Maynes,..............	City Road,..................	4.00	5,760
12	John Beamish,.............	City Road,..................	6.00	8,640
13	John Wilkinson,...........	City Road,.....	4.00	5,760
14	William Foster,............	Marsh Road,..	3.00	4,320
15	James L. Law,..............	Marsh Road,...	1.50	2,160
16	Richard Ryder,.............	Meadow,..............	1.00	1,440
17	James Green,...............	City Road,..................	6.00	8,640
18	Thomas Dale............. .	City Road,..................	2.00	2,880
19	Sarah Doak,................	Blair,.................... ...	2.00	2,880
20	Thomas Grady,.............	Pond,..........	4.00	5,760
	Aggregate of Waste,.			75,960

Average Consumption per Service Pipe,........................3,798 Gallons.

The above figures indicate what is going on, to a greater or lesser extent, during cold weather, over the entire water area of

Saint John and Portland, and show plainly why it is that the line or limit of supply is lowered and the force for fire purposes seriously reduced during the winter months.

When it is considered that at the present time there are upwards of 3,311 service pipes in active use, and there is attached to these 11,200 unmetred orifices of discharge, all of which may be employed in letting water run to waste as often and as long as domestics may think it necessary to guard against frost, or wash out sinks and sewers, it will cease to be a matter of wonder that the summits are badly supplied at such times, notwithstanding the large body of water brought to the City daily for distribution.

The evil effects of this pernicious practice are heightened, also, by the topographical features of our City and the great differences that exist, within comparatively short distances, in elevation or respective planes of supply, as already noticed.

The average consumption of water by each of the above named service pipes was nearly 3,800 imperial gallons daily, and the average of 154 reported at the same time was 3,037 gallons. The lowest of these rates is at least *ten* times more than it should be under any justifiable circumstances (as consumption is viewed at present), and probably *twenty* times as much as it would be, were all the water used measured and paid for at a reasonable rate.

Inspections and penalties may palliate the injurious effects of this waste, but they are quite inadequate for its total suppression. They have failed everywhere to meet the difficulty; and one of two courses is now generally recognized as the true way to remedy this evil — (1) the general application of metres, or (2) to accept this winter consumption as a necessity of our climate and provide for it accordingly. The last named course is most consistent with advanced thought on the hygienic value of copious supplies of wholesome water, and is likely to become the more popular of the two, when water can be had in abundance at a reasonable outlay.

Immediate steps were taken, of course, to have the above and all smaller as well as larger waste stopped, and with some degree of success; but the pressure gauge, and continued complaints of short supply, showed that a large waste still existed beyond the reach of discovery.

During the coldest days of the winter 1881–82, when the draft was greatest in the lower levels of the City, the supply to the basements—even of some of the summit houses—failed occasionally altogether, and could only be maintained by an adjustment of stop cocks, which [illegible]ied the supply to the lower levels of the City and turned it into the higher ones.

This arrangement, however, is not a desirable one at any time, as it tends to weaken the practical power of the water in other parts of the City, a circumstance that might prove of serious importance under a sudden outburst of fire. But as the higher levels are as much dependent on, and as well entitled to, a share of the water brought to the City for family purposes as the lower levels are, the risk must be borne with until a fuller supply and greater head is obtained.

With a greater nominal head, the supply might be divided advantageously into a *high* and *low* service, but such a division is not desirable in our present circumstances, unless as a matter of necessity.

Beyond doubt, this short supply difficulty will increase with the advance of time and the extension of our distributing system, until it will be necessary to return to the old intermittent system, with all its inconveniencies and dangers, unless steps are taken in time to avert the coming evil.

SUPPLY PLANES AND AREAS.

The relative supply planes and areas of the City, with their approximate *Pressures*, *Mains* and *Fire Hydrants*, are shown on the accompanying map or plan (A.) of Saint John (East), and are numbered 1, 2, 3 and 4, respectively.

No. 1 District (tinted light yellow), has an area of about 1,162,700 square yards, and embraces all those streets, and parts of streets, as are at their *highest* points 120 feet *below* the surface level of Little River Reservoir, and at their lowest 160 feet. This district has sixty-one (61) fire hydrants within its bounds and an actual pressure, under present conditions of supply, of about 36.3 lbs. to 58.8 lbs. per square inch.

No. 2 District (tinted green), has an area of about 805,300 square yards, and embraces such streets, and parts of streets, as are at their highest points 80 feet below Little River reservoir, and at their lowest 120 feet below the usual level of this reservoir. This district has fifty-eight (58) fire hydrants, and an active pressure under ordinary circumstances of about 20.3 lbs. to 38.5 lbs. per square inch.

No. 3 District (tinted pink), has an area of about 503,760 square yards, and embraces such streets, and parts of streets, as are at their highest points 40 feet, and at their lowest points 80 feet, below Little River reservoir. This district has 50 fire hydrants, and a pressure of about 6 to 23 lbs. when the usual daily supply is being drawn from its mains.

No. 4 District (tinted dark brown), has an area of about 38,300 square yards, and embraces the Leinster and Coburg streets summits. Its highest point is 30 feet below the surface of Little River reservoir, and its lowest 40 feet. There are four (4) fire hydrants only in this district, with a pressure varying from 2 lbs to 7½ lbs. For protection purposes, these hydrants are all but useless, at any time, and not unfrequently during the winter season, when the consumption is great, they are left without water altogether.

Districts 3 and 4, from their superior elevations, suffer most from relative lowness of head, and have greatest cause of complaint.

In olden times, when baths and water closets were luxuries enjoyed by the few only, and hot and cold water taps were confined to kitchens and basements, a lower service and smaller volume of water was sufficient for the daily wants of these districts even; but a great change has taken place in these respects within a few years, and notably so since 1877.

The extension of baths and water closets, since the great fire, has been very great; and as many of these are placed on second and third stories, a more copious supply of water at a higher pressure has become indispensable to health and comfort. As a question, therefore, of domestic economy, the low head of water which now prevails is a much more serious evil than ever it was before, and the conditions and elements that combine to make it so are not likely to be removed or weakened by time, but rather increased and strengthened.

But besides the domestic view of the question, which from a sanitary and economic standpoint is of immense importance, there is also the

PROTECTIVE PHASE,

which is equally urgent and almost equally important. Every one who has given any attention to the subject, knows that the force of water obtainable from any of the fire plugs within the districts specified (3 and 4), is not sufficient within itself to be thrown from the street to the upper stories of our modern buildings, under the most favorable conditions of wind and weather.

At some points the water may be conveyed through hose placed on ladders, or carried up inside by stairways, to such upper stories; but even then, the stream obtainable is generally weak and insufficient, when velocity and volume are needed to overpower and quench the flames. In consequence of this, valuable time is frequently lost waiting for an engine to come, or in connecting therewith, should its steam be up and ready for use when it arrives on the scene, which is seldom the case.

It may be thought that with a nominal head of from 40 to 80 feet the fire hydrants of district No. 3 should possess more power than has been ascribed to them, and so they would were the whole of the nominal head due to their respective positions really available. But this is not the case; as it is greatly reduced—not only in the higher, but in the lower as well—by friction in the pipes and local consumption. This, however, will be better understood by an example or two, showing the nominal and actual pressure obtainable from particular hydrants on the 17th day of November.

Take for instance the fire hydrant on the corner of Duke and Carmarthen streets. Its position, it will be seen, on reference to the plan of the City, is just on the dividing, or boundary line, between districts 2 and 3, and is therefore about midway between high water datum and Little River reservoir. Its nominal head or pressure therefore is 80 feet, and this is about the height to which the water would really rise were it closely confined and found no lower outlet or way of escape. The pressure due to this head is nearly 34.8 lbs. per square inch, but the actual pressure on the day named was only 19 lbs., or that which is due to 43.9 feet, showing a loss by friction and local drafts of 36.1 feet.

Take again the hydrant which is situated on the corner of Leinster and Carmarthen streets, the position of which is about 40 feet below the surface of the reservoir, and which should show a pressure of 17⅓ lbs. fully, if free from disturbing influences, yet the pressure found here on the day named was only 6½ lbs., or that due to 15.0 feet,—the balance having been absorbed or lost by friction and local consumption at lower levels. As the hill is ascended the loss in this way becomes more marked and serious until the summit is reached, when the pressure may be said to disappear altogether, or is just sufficient to make the water flow sluggishly from the nozzle or outlet orifice of the hydrant on the corner of Leinster and Wentworth streets. In November, 1881, the pressure of this hydrant was 3 lbs. only, or about 7 feet; and this was frequently reduced during the winter season to zero.

The influence of friction and increased consumption, through the changes and extensions of the past few years, but chiefly since 1877, is shown by the following tables of

HYDRANT PRESSURES,

obtained in November, 1881, at the several City hydrants; the pressures having been reduced to feet, and the hydrants grouped in districts, according to the contour plans herewith submitted.

Column No. 1 gives the position of the fire plug. No. 2 gives, approximately, what may be called the theoretical head, or the difference of level between the hydrant's outlet and the surface of Litttle River reservoir. No. 4 shows the pressure obtained in the course of our regular Fall inspections during the year named in column 3. No. 5 gives the pressure that prevailed in October and November, 1881, and shows what may be taken as the present actual pressure at the points named, when free from disturbing local and seasonal influences. Column 6 shows the pressure loss of the last few years; and No. 7 the present difference between the *actual* and what has been called the theoretical or nominal pressure given in column 2.

No. 1 DISTRICT.—NOMINAL PRESSURE 120 TO 160 FEET, BELOW LITTLE RIVER RESERVOIR.

		Nominal Pressure.	Actual Pressure. Fall of	Feet.	Fall of 1881.	Loss in Feet.	Present difference between Nominal and Actual.
1	Brussels street, and City Road, ...	160	1875	148	136	12	24 feet.
2	do. and Hanover street,......	146	1876	132	121	11	25 "
3	do. opposite Middle street,	137	1875	124	113	11	24 "
4	do. near Everitt's, ...	125	1877	113	100	13	25 "
5	St. David, near Courtenay street, ...	134	1875	117	107	10	27 "
6	Erin street, opposite Fraser's yard, ...	153	1875	140	127	13	26 "
7	do. and Brunswick street, ...	155	1875	139	128	11	27 "
8	do. and Clarence street, ...	136	1875	120	107	13	29 "
9	St. Patrick street, near Stanton's, ...	127	1875	112	99	13	28 "
10	Waterloo and Brussels streets, ...	152	1875	141	128	13	24 "
11	North and Smyth streets, ...	156	1876	133	117	16	39 "
12	Mill street near Moore's Factory, ...	157	1878	138	124	14	33 "
13	do. and Pond street, ...	154	1878	133	121	12	33 "
14	do. and North street, ...	135	1878	113	100	13	35 "
15	Pond and George streets, ...	146	1876	127	115	12	31 "
16	do. and Hazen streets, ...	152	1878	138	122	16	30 "
17	Mill and Union streets, ...	122	1878	100	86	14	34 "
18	Pond and Sewell streets, ...	145	1876	127	117	10	28 "
19	Pond, at Phœnix Foundry, ...	152	1878	132	120	12	32 "
20	Dorchester street, at Railway station,...	143	1877	131	115	16	28 "
21	Dock street and Market Square, ...	147	1877	124	108	16	38 "
22	do. near Ferguson's, ...	136	1877	117	100	17	36 "
23	Nelson street and Fire-proof Alley,.. ...	156	1877	138	120	18	36 "
24	Drury Lane, at centre, ...	131	1877	108	95	13	36 "
25	Market Square and Water street, ...	156	1877	136	118	18	38 "
26	do. at centre, ...	150	1877	129	112	17	36 "
27	Water street, at Jardine's,......	155	1877	133	117	16	38 "
28	do. at Duke street, ...	154	1878	130	116	14	38 "
29	Ward street and Gilbert's Alley, ...	156	1878	136	121	15	35 "
30	Prince William and Church streets, ...	145	1878	126	109	17	36 "
31	do. and Princess streets, ...	135	1878	115	99	16	36 "
32	do. at Barnes's, ...	132	1878	113	95	18	37 "
33	do. and Duke streets, ...	134	1878	113	98	15	36 "
34	do. at Custom House, ...	132	1879	110	98	12	34 "
35	Germain and Britain streets, ...	148	1878	127	114	13	34 "
36	do. and St. James streets, ...	129	1879	113	94	19	35 "
37	Charlotte and St. James streets, ...	136	1878	117	101	16	35 "
38	do. and Britain streets, ...	152	1878	131	115	16	37 "
39	Sydney and St. James streets, ...	145	1878	124	109	15	36 "
40	do. and Britain streets, ...	145	1878	122	108	14	37 "
41	do. and Main streets, ...	142	1878	120	104	16	38 "
42	do. and Sheffield streets, ...	145	1877	121	107	14	38 "
43	Carmarthen and Britain streets, ...	128	1879	104	91	13	37 "
44	do. and St. James streets, ...	135	1878	113	99	14	36 "
45	Pitt and Sheffield streets, ...	145	1878	120	107	13	38 "
46	Pitt and Mecklenburg streets, ...	124	1878	101	86	15	38 "
47	Pitt and Main streets, ...	134	1878	109	95	14	39 "
48	Main and Charlotte streets, ...	158	1878	138	120	18	38 "

No. 1 District.—*Continued.*

	Nominal Pressure.	Actual Pressure. Fall of	Feet.	Fall of 1881.	Loss in Feet.	Present difference between Nominal and Actual.
49 St. James and Prince William streets,	136	1878	117	102	15	34 feet.
50 Harding street, at centre, ...	125	1877	100	87	12	38 "
51 Queen and Prince William Streets,......	127	1877	106	90	16	37 "
52 do. Sydney streets,......	122	1877	97	84	13	38 "
53 do. Carmarthen streets, ...	129	1878	108	92	16	37 "
54 Princess and Water streets, ...	153	1877	131	115	16	38 "
55 King and Prince William streets, ...	143	1877	124	105	19	38 "
56 do. Canterbury streets, ...	123	1876	104	90	14	33 "
57 Union street, East end, ...	131	1875	115	104	11	27 "
58 do. and Smyth streets, ...	149	1875	127	112	15	36 "
59 City Road, opposite Fairbanks', ...	150	1878	138	122	16	38 "
60 do. do. Fowler's, ...	143	1876	133	117	16	26 "
61 do. and Dorchester street, ...	135	1879	115	104	11	31 "
62 do. and Gilbert's Lane, ...	162	1879	150	138	12	20 "

No. 2 DISTRICT.—NOMINAL PRESSURE 80 TO 120 FEET, BELOW LITTLE RIVER RESERVOIR.

	Nominal Pressure.	Actual Pressure. Fall of	Feet.	Fall of 1881.	Loss in Feet.	Present difference between Nominal and Actual.
1 Brussels and Clarence streets, ...	112	1877	101	89	12	23 feet.
2 do. near Dean's, ...	105	1877	91	78	13	27 "
3 do. and Richmond streets, ...	100	1878	87	75	12	25 "
4 do. opposite Baptist Church, ...	97	1876	83	71	12	26 "
5 do. and Carmarthen streets, ...	107	1878	92	82	10	25 "
6 do. and Union streets, ...	104	1877	88	76	12	29 "
7 St. Patrick and Richmond streets, ...	115	1875	95	85	10	30 "
8 Waterloo street, opp. St. Mary's Church,	110	1875	97	84	13	26 "
9 do. opp. White street, ...	85	1875	71	59	12	26 "
10 do. and Peter street, ...	90	1877	72	61	11	29 "
11 do. and Union street, ...	96	1875	81	67	14	29 "
12 Garden and Charles streets, ...	105	1876	90	77	13	28 "
13 Hazen and Dorchester streets, ...	95	1877	76	69	7	26 "
14 Germain street, at Country Market,......	94	1877	76	62	14	32 "
15 do. and King street, ...	108	1877	85	73	12	35 "
16 do. near Masonic Hall,......	94	1878	74	61	13	33 "
17 do. and Princess street,.....	85	1878	67	52	15	33 "
18 do. and Horsfield street,...	89	1877	69	55	14	34 "
19 do. and Duke street, ...	93	1878	74	60	14	33 "

No. 2 District.—*Continued.*

		Nominal Pressure.	Actual Pressure.			Loss in Feet.	Present difference between Nominal and Actual.
			Fall of	Feet.	Fall of 1881.		
20	Germain street and Queen street, ...	98	1879	78	63	15	35 feet.
21	Charlotte street, opp. Y. M. C. A.	78	1875	63	49	14	29 "
22	do. opp., Horsfield street,	82	1877	60	47	13	35 "
23	do. and Duke street, ...	92	1877	72	57	15	35 "
24	do. No. 1 Engine House,	93	1879	74	56	18	38 "
25	do. opp. Queen Square,....	99	1877	78	63	15	36 "
26	do. and Harding street,....	120	1878	99	83	16	37 "
27	Sydney street, at Grave Yard, ...	80	1875	64	53	11	27 "
28	do. and Mecklenburg streets,	92	1878	71	56	15	36 "
29	Carmarthen and Main streets, ...	117	1878	94	82	12	35 "
30	Wentworth and Britain streets, ...	105	1878	85	69	16	36 "
31	Barracks, west of Carmarthen street,...	114	1878	87	79	8	35 "
32	do. Wentworth street, ...	107	1878	....	72	35	.... "
33	do. east of Carmarthen street,.....	106	....	76	69	7	37 "
34	Pitt and Duke streets, ...	108	....	85	74	11	34 "
35	do. St. James streets,.....	102	1878	83	66	17	36 "
36	do. Britain streets, ...	117	1878	98	81	17	36 "
37	St. James and Wentworth streets, ...	116	1877	93	79	14	37 "
38	Sheffield and Carmarthen streets, ...	108	1878	85	75	10	33 "
39	do. Wentworth streets, ...	112	1878	92	78	14	34 "
40	Main and Wentworth streets, ...	98	1878	78	66	12	32 "
41	Queen and Canterbury streets, ...	117	1877	92	75	17	35 "
42	do. at McFarlane's, ...	106	1878	87	70	17	36 "
43	do. and Pitt streets, ...	108	1878	87	72	15	36 "
44	do. and Wentworth streets, ...	119	1878	100	86	14	33 "
45	Mecklenburg and Wentworth streets,...	116	1877	95	83	12	33 "
46	do. and Carmarthen streets,....	105	1878	84	68	16	37 "
47	Duke and Wentworth streets, ...	89	1875	69	54	15	35 "
48	Leinster and Crown streets, ...	103	1877	84	75	9	28 "
49	King street, at Wright's, ...	92	1877	77	63	14	29 "
50	do. and Crown street, ...	93	1877	71	64	7	29 "
51	Elliott Row and Crown street, ...	98	1877	79	70	8	28 "
52	Union and Crown streets, ...	114	1877	97	86	11	28 "
53	do. and Pitt streets, ...	101	1876	85	7	8	24 "
54	do. and Wentworth streets, ...	98	1876	83	74	9	24 "
55	do. at Peters' Tannery,........	105	1877	89	80	9	25 "
56	do. at Union Alley, ...	90	1877	71	58	13	32 "
57	do. and Prince William streets, ...	82	1877	65	54	11	28 "
58	do. and George streets,........	108	1877	85	80	5	28 "
59	Canterbury street, opp. News Office,........	115	1878	94	78	16	37 "

No. 3 DISTRICT.—NOMINAL PRESSURE 40 TO 80 FEET BELOW LITTLE RIVER RESERVOIR.

		Nominal Pressure.	Actual Pressure.			Loss in Feet.	Present difference between Nominal and Actual.
			Fall of	Feet.	Fall of 1881.		
1	Exmouth, near Richmond street, ...	68	1877	62	41	11	27 feet.
2	do. near Church, ...	78	1875	61	52	9	26 "
3	Richmond, opposite Exmouth street, ...	75	1875	61	49	12	26 "
4	Waterloo, opposite Golding street, ...	58	1878	46	35	11	23 "
5	do. opposite Richmond street, ...	63	1879	46	38	8	23 "
6	do. and Cliff streets, ...	70	1876	56	45	11	25 "
7	do. and Paddock streets, ...	80	1878	64	52	12	28 "
8	Castle street, at Christie's,......	66	1878	53	43	10	23 "
9	Cliff street, at centre, ...	77	1877	62	49	13	28 "
10	Paddock street, at centre, ...	71	1877	58	44	14	27 "
11	Peter street, at centre, ...	61	1877	46	33	13	28 "
12	Hazen street, at Milligan's, ...	48	1877	33	22	11	26 "
13	Coburg street, opposite Adams', ...	59	1877	44	30	14	25 "
14	do. and Carleton streets, ...	49	1877	35	23	12	26 "
15	do. and Paddock streets, ...	48	1877	33	22	11	26 "
16	do. and Cliff streets, ...	48	1877	33	21	11	27 "
17	Garden and Hazen streets, ...	72	1876	58	46	14	26 "
18	Sewell and Coburg streets, ...	47	1876	33	20	13	27 "
19	do. at Marshall's, ...	80	1876	68	53	15	27 "
20	Dorchester and Sewell streets, ...	65	1876	49	36	13	29 "
21	do. and Carleton streets, ...	54	1876	37	24	13	30 "
22	Wellington Row and Carleton street,...	63	1877	48	36	12	27 "
23	Charlotte street and King Square, ...	70	1877	52	37	15	33 "
24	do. and King street, ...	78	1877	62	44	18	34 "
25	Charlotte and Princess streets, ...	73	1877	53	39	14	34 "
26	do. and Union streets, ...	80	1877	63	49	14	31 "
27	Sydney and King streets, ...	67	1877	50	38	12	29 "
28	do. at No. 2 Engine House, ...	57	1878	43	29	13	28 "
29	do. and Princess streets, ...	58	1878	40	30	10	28 "
30	do. and Orange streets, ...	68	1878	51	39	12	29 "
31	Pitt street and Elliott Row, ...	70	1878	54	46	8	24 "
32	do. and King street, ...	66	1878	50	42	8	24 "
33	Duke and Sydney streets, ...	75	1878	58	41	17	34 "
34	Duke and Carmarthen streets, ...	78	1878	55	44	11	34 "
35	Orange and Pitt streets, ...	75	1878	58	47	11	28 "
36	do. and Wentworth streets, ...	48	1878	33	20	13	28 "
37	do. and Carmarthen streets, ...	59	1878	44	28	16	31 "
38	Princess and Carmarthen streets, ...	47	1878	30	17	13	30 "
39	Princess and Pitt streets, ...	67	1878	51	40	11	27 "
40	Leinster street, at Humbert's alley,.. ..	49	1878	32	20	12	29 "
41	Leinster and Carmarthen streets, ...	43	1878	27	14	13	29 "
42	do. and Pitt streets, ...	63	1878	46	39	7	24 "
43	King and Carmarthen streets, ...	49	1876	33	26	7	23 "
44	Elliott Row and Wentworth street,......	64	1877	48	42	6	22 "
45	do. and Carmarthen street, ...	78	1877	62	55	7	23 "
46	King Square, North side, ...	77	1877	59	46	13	31 "
47	do. South side, ...	54	1877	37	24	13	30 "
48	Union street, at No. 3 Engine House,...	77	1877	62	48	14	29 "
49	Union and Germain streets, ...	70	1877	55	41	14	29 "

No. 4 DISTRICT.—0 TO 40 FEET BELOW SUPPLYING RESERVOIR.

	Nominal Pressure.	Actual Pressure. Fall of	Feet.	Fall in 1881.	Loss in feet.	Present difference between Nominal and Actual.
King and Wentworth streets, ...	39	1878	24	17	7	22 feet.
Leinster street, at Pipe Yard, ...	32	1878	12	5	7	27 "
do. and Wentworth streets, ...	31	1878	14	7	7	24 "
Princess street, near Centenary Church,	38	1878	23	10	13	28 "

SUMMARY OF FOREGOING TABLES.

PRESSURE IN FEET.	No. 1 District.	No. 2 District.	No. 3 District.	No. 4 District.
	Feet.	Feet.	Feet.	Feet.
Greatest loss during 6 years, ...	19	18	18	13
Lowest do. do.	10	7	7	7
Average of loss, ...	14.34	12.52	12.00	8.5
ACTUAL AND NOMINAL PRESSURES:				
Greatest difference, ...	39	38	34	23
Least do.	20	23	23	22
Averages of differences, ...	33.70	31.74	27.65	22.7

The foregoing pressures are not given as absolutely correct, but they are sufficiently near for practical purposes, and the lessons to be learned from them are (1), that the *effective* head is being gradually reduced by increasing consumption; and (2), that large and valuable sections of the City are imperfectly supplied and poorly protected against the attacks of fire.

For some years after the first 24 inch main went into use, as already noted, there was ample water at the summits for all ordinary purposes, so far at least as basements were concerned; but for several winters before the second 24 inch pipe was laid, it had fallen away to such an extent, through increased consumption, that it had practically become intermittent, no water whatever reaching the basements, unless when shut off from other parts of the City; and doubtless the same experience will be repeated in the course of another two or three years, should the City continue to grow as it is hoped to do, unless something is done in the mean time to keep its water supply abreast of its progress in other respects. What is immediately wanted is

INCREASE OF PRESSURE,

such an increase as would give a free flow of water and a larger margin of oscillation to the upper stories of summit houses, and such a force for fire purposes as would make each hydrant equal in power to a medium sized fire engine.

The importance and value of such a supply can scarcely be overrated on the ground of convenience, economy, and security. With such a pressure, the costly and inconvenient arrangements that are now so common in districts 3 and 4 could be dispensed with, and two or more of the present steam fire engines, which, in itself, would be a considerable annual saving.

Besides this, with a proper disposition of hose, and a pressure at each plug equal to what is ordinarily obtained at present from the engines, the fire risks in districts 3 and 4, as well as in 1 and 2, would be greatly reduced; and greater security would bring a

REDUCTION OF INSURANCE RATES

that would amount in the aggregate to a large sum of money, and represent the annual interest on a very large outlay of capital,—greatly more indeed than could possibly be required to make the improvements so urgently needed.

There is no exact data from which to estimate what this yearly saving would be, but it will not be unreasonable to assume that there is in St. John (East) and in the Town of Portland insurable property amounting to at least $20,000,000 in round numbers, and that the reduction in annual premiums, with the pressure contemplated, would be at least one-eighth of one per cent. On this basis, the yearly saving in premiums alone would amount to $25,000; or the interest at 5% on a capital outlay of fully $500,000, and the saving named is less by a great deal than gentlemen well versed in the business of insurance and the influence a high pressure water supply has in lowering premiums, think it would be, after a year or two's experience.

To obtain the pressure necessary to secure to the City the advantages named, and remove existing complaints, an auxiliary *pumping* system must be adopted, or one or more of the mains that now supply the City extended to Lake Douglas, Lake Latimer, or Loch Lomond. The question as between

PUMPING OR GRAVITATION

was virtually settled thirty-three years ago when the old Water Company abandoned its then pumping station at the Aboideau in consequence of the bad quality, as well as insufficient quantity of water obtainable from Lily Lake, and had a supply brought from Little River by gravitation.

The r asons that led to this step still exist, and have not been weakened by lapse of time, nor by the changed conditions of the City.

Were a copious supply of water obtainable near the City, which was equally suitable for domestic and manufacturing purposes, to that which is to be had from Little River, Lake Latimer, or Loch Lomond, the question of choice, as between pumping and gravitation would be narrowed down to one of relative economy,—as to whether the first cost and annual outlay on pumping works would be more or less than the amount of interest which would be payable annually on the capital required to bring the same quantity of water by means of pipes from either of the sources named above.

If the annual cost of pumping were less than the annual amount payable on the capital required for reservoirs, gate houses and mains, to Little River or Loch Lomond, on the ground of economy, such a system would be fairly considerable; but as there is no such body of water obtainable, unless in the direction of Little River and Loch Lomond, and as the respective elevations of these separate sources are sufficient in themselves to send the water forward to the City without the aid of artificial power, the question of pumping as against gravitation appears to be fairly and finally settled.

This was the view taken by the old Water Company in 1849, and the works then constructed on Little River and all subsequent additions thereto, have been made with a view to the permanency of the gravitation system then introduced, and a subsequent

EXTENSION TO LOCH LOMOND,

the vast volume, elevation, softness and purity of whose waters give it very superior claims as a source of supply for city purposes,—whether they are viewed from a protective, a sanitary, a culinary, or manufacturing standpoint.

Here every condition requisite for a perfect water supply is combined, to an extent which is rarely met with in other places, as will appear from a short study of the accompanying map or plan, showing the

RELATIVE POSITIONS OF LITTLE RIVER

Reservoir and its several feeders—Lake Long, Lake Buck, and Lake Douglas; also Lake Latimer, Lake Donaldson, and Loch Lomond, with the several lake feeders of the latter, viz., Lakes Otter, Terrio, Godsoe and Chambers.

The drainage basins or water sheds of Little River above our present reservoir, and of Loch Lomond, are likewise outlined, and the several routes indicated by which the ampler and nobler waters of the latter may be brought to the City and utilized.

This map has been prepared specially for this Report from the personal surveys of my assistant Mr. William Murdoch, and is much more complete and exact in details than any preceding one relating to this section of country.

DRAINAGE BASINS, OR AREAS.

The drainage area of Little River Basin, as outlined on this map, is about 9,500 acres, and that of Loch Lomond 27,700 acres. The former is the area from which our present supply is drawn; and the latter, the area that would be added by an extension to Loch Lomond.

Before proceeding to point out and consider the several ways by which this most desirable extension may be accomplished, and the cost of each, a few brief remarks on the physical features of the principal Lakes that may be converted into storage, or compensation reservoirs within the districts named, may not be out of place.

The Lakes, to which chief reference will be made, are the following, viz.:—

	Elevation above City datum.	Lake Areas.	Total of Lake Areas.
LITTLE RIVER DISTRICT:			
Reservoir, ...	160 feet.	37½ acres	
Lake Long, ...	318 "	30 "	
Lake Buck, ...	255 "	100 "	
Lake Douglas, ...	230 "	55 "	
Lake Fitzgerald, ...	294 "	75 "	297½ acres.
LOCH LOMOND DISTRICT:			
Lake Latimer, ...	302 "	210 acres.	
Lake Donaldson, ...	302 "	75 "	
Loch Lomond, No. 1, ...	300 "	1790 "	
do. No. 2, ...	300 "	450 "	
do. No. 3, ...	300 "	240 "	
Lake Otter, ...	uncertain.	120 "	
Lake Terrio, ...	"	65 "	
Lake Godsoe, ...	"	25 "	
Lake Chambers, ...	"	100 "	3,075 acres.

LITTLE RIVER RESERVOIR,

it will be observed, has a smaller surface area than either of the Lakes belonging to its district (excepting Lake Long), and would be altogether inadequate for the work it has to do, were it not for the constant and copious supplies which are brought to it daily from its extensive collecting ground. This supply is so abundant, that for the greater part of the year there is a surplus running to waste beyond what is drawn for City use; and it is only in seasons of extreme drought that a supplemental supply has to be taken from Lake Latimer.

The greatest annual surface oscillation or maximum difference between the highest and lowest levels since 1862 is 6 feet 11 inches in 1877, and the least 10 inches in 1873; and the average of twenty (20) years from bi-daily observations 2 feet 2½ inches.

The water obtained from this reservoir is generally soft and clear, and well suited fc ty purposes, but it is subject to periodical discolorations when a warm and dry season is followed by heavy rains.

This discoloration makes it unpleasant to the eye, and unfits it to some extent for domestic use, such as the washing of clothes, but it does not lessen its generally salubrious character. This is a point on which the best authorities are fully agreed, however much they may differ in respect to certain other organic and inorganic impurities commonly found in well and river waters.

The coloring matter which gives the water the brownish hue just noticed, is extracted from the peaty portions of the collecting ground which form the valley of Little River, and cannot be removed by any known process of filtration.

So far as volume and general softness and purity are concerned, the daily supply of water obtainable from this reservoir is ample, and generally suitable for present requirements; but in point of quality, it is inferior to the waters of Loch Lomond and Lake Latimer, as will be shown hereafter; and it has not the altitude that is necessary to make the supply what it should be at higher levels of the City and of Portland.

LAKE LONG.

This Lake occupies an elevated position on what is known as the "Church Lands" in the Parish of Simonds, and has a water area of about 30 acres. It lies to the northeastward of our present reservoir, and is three (3) miles distant therefrom. Its water surface is 318 feet above City datum, or 18 feet higher than Loch Lomond.

The Brook that flows from it is one of the principal tributaries of Little River; but from the swampy nature of its collecting ground and the character of the country through which it flows, its waters are not infrequently of a deep brownish hue.

Excepting its elevation, this Lake has nothing in itself, nor its surroundings, to commend it to consideration as a service reservoir. It might be used in the distant future for storage purposes, but its flat banks and muddy bottom make this even doubtful; and its limited drainage area shows that it is wholly inadequate for the daily supply of the City, supposing its waters in other respects were all that could be desired.

LAKE BUCK.

This Lake is likewise a chief feeder of Little River reservoir, and is about 4¼ miles from the City and one mile to the southeastward of the reservoir. Its surface is 255 feet above high water datum, and its area is somewhere about 40 acres.

Its elevation and comparative nearness to the City, were it otherwise eligible, would make it a very desirable reservoir, but, like Lake Long, its collecting grounds are swampy and small, and make it wholly unfit for this duty. It is from this quarter that much of the coloring matter comes which destroys the transparency of Little River water, and gives it the unpleasant tint just noticed. These objections are fatal to this Lake ever being able by itself to take the place of a service reservoir for St. John.

LAKE FITZGERALD,

the next on the list, has an elevation above City datum of 294 feet, and a surface area of about 75 acres. It is also a feeder of Little River, and is distant (eastward) from our present reservoir about 3 miles.

Its physical features have a strong resemblance to those of Lake Buck, and its waters are equally objectionable for potable purposes. Being perched on the very summit almost of the ridge of land which divides the water sheds of Mispeck and Little River, its collecting ground is small, and being shallow and swampy, it sends at times a liberal supply of mossy water into Little River. For the reasons stated, it too is unfit in itself for a service reservoir.*

LAKE LATIMER

is the highest and deepest and largest of the Lakes that are found on the ridge of land which divides the valley of the Mispeck from that of Little River. At one point it is only 400 feet distant from Lake Fitzgerald; but while the discharge of the one is into Little River, the outflow of the other was (until 1851) into the Mispeck. The ridge which divides these Lakes has an appearance in places of a wall or dyke of stone and earth thrown loosely together, through which the water of Lake Latimer passes freely when near its maximum.

But notwithstanding the closeness of these Lakes to each other, their characteristics are widely different. The one is surrounded by a flat mossy margin, and its water is shallow, dark, and swampy; while the other has a sandy beach and bottom, and a body of water of surpassing brilliancy and beauty.

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* The owner of this Lake having discovered, since the above was written, that its bottom contained a valuable deposit of diatonaceous earth, or "fossil meal," has had the greater part of the water drawn off, with a view to its utilization.

In point of softness and purity, the water of Lake Latimer is only inferior to that of Loch Lomond, and greatly superior to what is commonly found in Little River, as will be shown hereafter.

Its original or natural outfall, as already remarked, was into the Mispeck, but in the Fall of 1851 this was closed by an earthen dam, and an outlet opened for its waters, *via* Lake Fitzgerald, into Little River. This was done immediately after the 12 inch main was laid to Little River to compensate the Reed, or Botsford Mill for the water taken from the river for City use. And before this was done, a money compensation was paid to the Mispeck Mill owners (Dimock & Ball) for the water thus diverted from the stream, the amount of which was fixed by arbitration.

The water of this Lake is still held in reserve for compensation purposes, in dry seasons, but has rarely been required for more than a few days at a time; and often whole years have passed without any draft having been made thereon. This Lake is an important and valuable adjunct to our present system of supply, and may be more so in the future, should it be converted, in connection with Loch Lomond, into a high service reservoir, and connected with our Little River mains.

It has a surface area of about 210 acres, a great depth, and an elevation of 302 feet fully above City datum. Its distance from Little River reservoir, by the lines shown on the map, is about 3 miles; and from the City line at the Aboideau about 7½ miles. Its drainage area, however, is exceedingly small, as may be inferred from its position, and much of its water is popularly believed to be the product of springs, which does not seem improbable when the geological contour and character of the country are considered.

LAKE DOUGLAS

is the head or source of Little River. It is long and narrow, and moderately deep; but its waters, though greatly superior to those of Lakes Buck and Fitzgerald, are inferior to those of Lake Latimer. Its superficial area is about 55 acres, and its distance from Little River reservoir 3¼ miles, or 7½ miles from the City line at the Aboideau.

Like all the other lake feeders of Little River, it has but a small collecting ground, and one of its chief sources of supply is the water of what is known as "Victoria spring," which comes to the surface at a point about 104 rods to the northwestward of the lake, and which is supposed, from its clearness and coolness, as well as position, to come from Lake Donaldson or Loch Lomond.

That this lake is too small, in itself, to meet the requirements of the City and Portland, is apparent from the fact that it is only one, and not the largest either, of the four lakes that discharge into Little River above the site of our reservoir; and that in some seasons their united volumes are insufficient, without assistance from Lake Latimer, to meet the daily draft that is made on them and maintain an average level at the gate house.

Its surface level is about 230 feet above City datum, or 70 feet above our present reservoir. By the erection of a dam at its outlet this natural difference could be increased to a small extent without much trouble; and if this were done, and a main or mains laid of suitable size from thence to Little River and connected to our present supply pipes, this much additional head, or pressure, would be added to what we now have. But to qualify it for the work of a service reservoir, a connection would have to be made between it and Loch Lomond, and the waters of the latter brought thither. Without this it would be altogether inadequate.

This is one of the projects that have been contemplated ever since the old Water Company abandoned Lily Lake, and the old pumping system, and transferred their Works to Little River. But this lake has never been looked on as the final stopping place in the progress of our Water Works, but only as a second step or stage in the direction of Loch Lomond.

LAKE DONALDSON

appears to occupy a neutral position between the water sheds of the Mispeck and Little River, as it has no visible outlet into either. It has been surmised that this Lake has some mysterious connection with Loch Lomond, but no satisfactory reason can be found for such a belief. Indeed, its superior elevation to the latter, seems to point to an opposite conclusion: for, if there was any substantial underground connection between them, it would no doubt assimilate their levels to one another; but, so far from this being the case, carefully conducted surveys have shown its surface to be from *two* to *three* feet higher than Loch Lomond. This could scarcely be the case did any material subterranean connection exist between them.

This Lake has a superficial area of about 75 acres, and an elevation above City datum of about 303 feet; but its water shed is barely sufficient to supply its loss by evaporation. In *itself*, therefore, it is insufficient for a service reservoir, though its altitude and close proximity to Loch Lomond suggest it as an auxiliary to any system of supply which may seek Loch Lomond, in this direction, as its final source or fountain head. Its waters, however, are said to be copiously supplied with leetches and lizards, and for this reason are unpopular.

LOCH LOMOND

is the next and only other Lake to be briefly noticed; and this is so well known already that it would be superfluous to enter minutely into a description of its natural properties and features; yet a few words touching such points as relate to our present enquiry may not be out of place.

This Loch, or Lake, is admirably adapted for the purposes we have in view, and combines, to a remarkable extent, every essential of a first class water supply, viz., volume, elevation, depth, brightness, taste, purity and softness; and is the only source from which a bountiful supply of really good water can be obtained, as may have been observed by the brief notices given of the largest lakes belonging to the water shed of Little River.

RAIN FALL.

There are no reliable data from which to estimate the rain fall of its extensive gathering ground, nor for our present purpose is this information necessary, as the large volume of water that runs from it constantly during the driest seasons of the year puts its ability to supply Saint John and Portland, for generations to come, beyond a doubt or peradventure.

STORAGE CAPACITY.

The superficial area of this Loch, or rather, series of Lochs,—the lower, the middle, and the upper,—is about 2,480 acres; and this may be still further increased by converting its principal feeders (Lakes Otter, Terrio, Godsoe and Chambers) into storage reservoirs, as could be done easily were such required for compensation or other purposes.

Exclusive of these, however, each foot in depth of the area named would be equivalent to about *sixty-seven* (67) days supply at a rate of *ten millions* of gallons per day; or a depth of 6 feet to a whole year's supply at the same rate, supposing no water was to find its way into the Loch for the time named beyond what was necessary to make good its loss by evaporation. A very small dam therefore at its outlet would suffice to store a body of water which would be sufficient for the daily wants of the City, without impairing the flow to the Mispeck and the mills depending on it for their motive power.

This Lake alone is sixty-six (66) times larger than our present reservoir, and has *nine* (9) times the superficial area of all the lakes that flow into Little River above the site of our works. By adding the areas of its several lake feeders to that of its own, the difference in its favor would be as *eleven* (11) to *one*, nearly, and would exceed this considerably were their relative capacities measured by cubic contents,—as the Loch Lomond system of lakes are better adapted for storage purposes than are those of Little River.

In respect therefore to the immense quantity of water that could be collected and stored by this Lake and its tributaries, for compensation and City use, there can be no shadow of doubt, even in the absence of reliable records relating to annual and available rain fall from the surrounding country.

SURFACE ELEVATION OF LOCH LOMOND.

The ordinary elevation of this Loch, or Lake, is 300 feet above City datum, and its distance from the City by the road, about 10½ miles. It is 140 feet higher than Little River reservoir, and 70 feet higher than Lake Douglas. Its altitude, therefore, as well as the vast body of water it contains, makes it a most desirable source of supply from every point of view.

A direct connection with this Lake would give an initial pressure at each fire hydrant in the City, as well as in the Town of Porland, sufficient to throw copious and powerful streams over our highest summit buildings, without the aid of engines. A change such as this, would be of incalculable advantage, and could not fail to give great additional security to property of all kinds. But, besides elevation and volume, the

QUALITY OF THE WATER

is unexceptional in every particular, and fitted in every way for the several purposes to which a town supply is usually put, being eminently free from organic matter, and exceedingly soft and clear, and pleasant to the eye as well as to the palate.

It is greatly superior to the water that is now brought to the City from Little River, and is seldom surpassed anywhere on either side of the Atlantic, as will appear by an inspection of the following table, showing the general

CHEMICAL CHARACTER

of the waters furnished by some of the principal towns and cities of Great Britain, the United States and Canada, compiled from late and reliable sources.

In doing this, however, it is not to be understood that the water that contains a large amount of solid matter is, for this circumstance alone, unwholesome. This would be a serious mistake. The value of one water compared with another, from a hygienic standpoint, depends more on the *quality* than the quantity of solid matter it contains.

In chemical parlance, all foreign substances held in solution or suspension, are "impurities," and are classed generally as *organic* and *inorganic*. The latter, however, ordinarily speaking, is seldom or never hurtful to health, and indeed both may be present in considerable quanties without doing the least bodily harm to their user; but yet, *organic* matter is treated with universal suspicion.

The reason for this is found in the fact that it may be of vegetable or animal origin, or both; and while the former is innocuous and may be swallowed with safety, the latter, or that which comes from decayed or decaying animal matter, is uniformly dangerous. And as science is yet unable to discriminate and say, with any degree of certainty, what is of vegetable and what is of animal origin,—on prudential grounds, that water is considered best and safest for dietary purposes, other things being equal, which is freest from this "impurity."

This last remark does not apply, however, to water derived from shallow wells, as such may be comparatively free from organic matter, and still be highly dangerous. With these explanations, therefore, it will be understood that the following *resumé* of analytical results is not intended to do more than show approximately and relatively the qualities of the waters named compared with those of Little River, Loch Lomond, and Lake Latimer.

RESUME OF ANALYTICAL RESULTS.

TOWN OR CITY.	SOURCE.	Inorganic Matter.	Organic Matter.	Total Solid Matter.	AUTHORITY.
		In grains per Imperial Gallon.			
Syracuse, N. Y., ...	Reservoir, ...	14.55	2.16	16.71	Prof. Chandler.
Rochester, N. Y., ...	Gennessee river,	14.42	1.48	15.90	do.
Detroit, Michigan, ...	City hydrant, ...	9.06	1.05	10.11	" Stearns.
Newark, N. J., ...	Passaic river, ..	5.49	3.43	9.92	" Horsford.
Toronto, Ontario, ...	Filtering basin,...	8.21	0.54	8.75	" Croft.
Hamilton, Ontario,	Lake Ontario, ...	......	......	8.40	" McElroy.
Charlottetown, P. E. I.,..	Winter river, ...	5.05	2.96	8.01	" Hayes.
Cleveland, Ohio, ...	Lake Erie, ...	5.69	1.83	7.52	" Cassels.
Chicago, Illinois, ...	Lake Michigan,..	5.96	1.27	7.23	Drs. Blaney and Mariner.
Montreal, P. Q., ...	St. Lawrence, ...	5 01	2.01	7.02	Prof. Edwards.
Moncton, N. B., ...	Harris river ...	4.65	2.00	6.65	do.
Liverpool, England,......	Rivington Pike,	5.74	0.19	5.93	" Frankland.
Lawrence, Mass , ...	Merrimac river,	4.73	1.08	5.81	" Hayes.
New York, ...	Croton river, ...	4.93	0.80	5.73	" Chandler.
Halifax, N. S., ...	Chain Lake, ...	2 44	2.68	5.12	" Lawson.
Lynn, Mass., ...	Flaxpond, ...	2.59	2.21	4.80	" Hayes.
Brooklyn, N. Y., ...	Ridgwood res'vr,	4.04	0.71	4.75	" Chandler.
Philadelphia, ...	Schuylkill river,	2.76	1.44	4.20	" Horsford.
Ottawa, Ontario, ...	Ottawa river, ...	2.70	1.50	4.20	" Edwards.
New Bedford, ...	Acushnet, ...	1.64	2.48	4.12	" Nichols.
Philadelphia, ...	Delaware river,...	3.51	0.54	4.05	" Wurtz.
Aberdeen, Scotland,......	Dee, ...	2.18	1.82	4.00	W. Humber.
Greenock, Scotland,......	Reservoir, ...	3.42	0.38	3.80	Prof. Frankland.
Manchester, England,...	Reservoir, ...	2.60	1.00	3.60	" Penny.
Boston, Mass., ...	Cochituate, ...	1.94	1.46	3.40	" Nichols.
Manchester, Mass., ...	Massabessie, ..	1.39	1.99	3.38	" Hayes.
Springfield, Mass., ...	Cheopee, ...	1.97	1.27	3.24	" do.
Hartford, Conn,, ...	....	1.82	1.26	3.08	" Silliman.
Inverness, Scotland,......	Ness river, ...	2.10	0.90	3.00	" Taylor.
Providence, R. I., ...	Patuxet river, ..	1.54	1.15	2.64	....
Glasgow, Scotland, ...	Loch Katrine, ...	1.98	0.12	2.10	" Mills.
Lowell, Mass., ...	Merrimac river,..	1.07	1.01	2.08	" Appleton.
Saint John, N. B., ...	Loch Lomond, ...	0.81	0.82	1.63	" Robb.
Do., ...	Lake Latimer, ...	0.68	0.86	1.54	" do.
Do., ...	Little river, ...	3.03	3.07	6.10	" do.

A brief examination of the above *resumé* will make apparent the general superiority of the waters of Loch Lomond, and their admirable adaptability to public purposes.

In regard to *organic* matter, they stand seventh on the list, and their total of solid "impurities" is less than the lowest of all the places named. Compared with the water of Little River, their organic matter is as 82 to 307, and their inorganic as 81 to 303; or, in other words, the organic and inorganic matter found in Little River by the late Dr. Robb was 374 per cent. in excess of Loch Lomond,—the waters of both having been taken at the same time and treated in the same way.

It is evident therefore that the popular opinion in favour of this

Lake is well founded, and that there are few cities more favourably circumstanced than St. John in the item of water supply. In amplitude, in elevation, in proximity, in freedom from engineering difficulties, in purity, in flavour, in colour and softness, the waters at its command, from this source, stand almost unrivalled.

The next and last question to consider in connection with this enquiry, is

IN WHAT WAY AND AT WHAT COST

can these waters be brought to the City and Portland for distribution?

To reach this most desirable end one of three ways may be followed: (1), by way of Lake Douglas; (2), by way of Lake Donaldson; or (3), by way of Lake Latimer,—as indicated by continuous and broken red lines on the accompanying map.

(1). BY WAY OF LAKE DOUGLAS.

The works required to convert this Lake into a high service reservoir would consist chiefly of a dam, waste way and gate house, at or near the present outlet; the laying of a pipe or pipes from thence westward to connect with our present supplying mains at Little River reservoir; the connecting of Loch Lomond and Lake Donaldson by a capacious conduit of brick or wood, and the construction of a sluice of suitable size to carry the waters of the last named lake (Donaldson) to Lake Douglas.

Dam.—The required dam would be a small affair, say seven (7) feet high, exclusive of foundation, and fifty (50) to sixty (60) feet long from bank to bank. The materials contemplated in its construction are earth and stone, which are plentiful in the neighborhood, and of excellent quality.

By means of this dam the natural surface of the Lake would be raised about three (3) feet above what it now is, and that much added to its storage capacity, or to the extent of about forty-five (45) million gallons. To raise it above this would cause it to overflow its banks, in places, and add a large section of shallow water to its surface area, which is very undesirable.

At the point named the new surface would be seventy-three (73) feet above Little River reservoir, and two hundred and thirty-three (233) above City datum. This additional head, if devoted to high service only, would lift the water to the highest stories of the present summit buildings and add considerably to their protection.

Gate House.—The gate house and influent chamber would be of stone or brick, and placed at some convenient point in the natural bank on the northern side, where deep water could be reached with a minimum of labour.

The proposed pipe or pipes for supplying the City would begin here, and the water entering them be carefully strained, and freed, as far as practicable, from suspended matter. The strainers and chambers for this purpose should be in duplicate, so that either could be inspected and cleared without interruption to the general supply.

Waste Way.—As the surrounding drainage area is small, the waste way will not require to be large, and may be placed on the opposite bank from the gate house, or directly over the dam, as appeared best when the works were being constructed.

Proposed Main Pipe.—About seventeen thousand (17,000) feet of pipe will be required to connect Lake Douglas to our present works on Little River. This pipe should be of cast iron, and not less than 33 inches in diameter.

One of our present 24 inch mains, fed by a pipe of this size at Little River reservoir, and discharging at a point or into a reservoir placed 50 feet above the intersection of Leinster and Wentworth streets (say 180 feet above City datum), would be able to supply 16,133 gallons an hour, or 3,872,000 gallons per day; a deduction of 20% having been made for internal crustation and other reducing influences.

This supply it is proposed to devote, in the mean time, to *high* service exclusively, taking the *low* service as at present from Little River. And should it be desired hereafter to draw the whole of our supply from Lake Douglas, another pipe of equal or greater capacity would have to be laid between this lake and our present works on Little River.

With this connection formed, our daily capacity of supply would be about as follows, viz.:

Low service 24 inch pipe,	....	3,895,000 gallons.	
do 12 inch pipe,	....	605,000 "	4,500,000
High service 24 inch pipe,	....	"	3,872,000
Total per 24 hours,	......		8,372,000

This represents a per capita supply of 120 gallons to a population of nearly 70,000; and in this connection it may be remarked that the theoretical discharge of the *low* service 24 inch pipe has been reduced 20%, as in the case of the *high* service one and the 12 inch pipe 25% for loss of area, etc.

Pipe Line.—The best obtainable route has been selected, but it is somewhat rough and broken. It is pretty free, however, from curvature, and wholly exempt from rock. About 1500 feet of the required digging would be fully 20 feet deep, but the balance would be moderate, and no heavy embanking would be required. It is easy of access from the road, and presents good facilities for flushing and draining.

Conduits.—To bring the waters of Loch Lomond to Lake Douglas, about four thousand three hundred and fifty (4,350) feet of conduit will be required, 1,900 of which will be light and easy, and 2,450 heavy and difficult to construct.

The lighter and cheaper portion (section 3) extends from Lake Douglas upward in the direction of Lake Donaldson, or between A and B on the annexed map, and the heavier sections (1 and 2) from this onward to Lake Donaldson (B to C), and thence to Loch Lomond (D to E) through the ridge of land that divides the waters of the two lakes.

The line selected for section one is believed to be free from rock, and the excavation generally would be in clay and gravel. As this part of the work will be to some extent temporary, it is proposed to use plank or light timber in the construction of its conduit,—this material being greatly cheaper than iron, and abler than brick work to resist the erosive action of the water in its rapid descent of 60 feet in nineteen (19) hundred.

Coming to the heavier sections, No. 2 is about 1150 feet long, and No. 3 about 1300 feet. The digging in both will be, as far as known, in earth composed of loose shingly gravel, sand and clay, with infiltrations of water from the lakes and surrounding high ground. In section No. 2 (B to C) the average depth of digging will be about 30 feet, and in No. 3 (D to E) upward of 35 feet. This part of the work, it is feared, will be more than usually troublesome, and may overrun the estimates.

The estimate is for a brick conduit of 4½ feet inside diameter, for each section, with suitable strainers, gate houses and gates to regulate the flow. The contemplated fall is 13 inches per 1000 feet, and with this descent the capacity is placed by safe hydraulic formula at one million gallons per hour, or twenty-four millions per day.

This is greatly in excess of present wants, but as this part of the work could not be enlarged without much difficulty and cost, it should be made sufficiently substantial and capacious to last for ages without renewal or enlargement. It would be poor policy to curtail its capacity for a present saving of a few thousand dollars.

The bottom line, or invert of No. 2, is to be placed 14 feet below the present surface level of Lake Donaldson; and that of section 3, 11 feet below that of Loch Lomond.

These lines would allow 6 feet of water to be drawn from Loch Lomond, or 3,659,000,000 gallons, without impairing the estimated maximum capacity of the conduit.

The cost of the works on this route is estimated at $215,740.00, briefly as follows, exclusive of water rights:

Sec. 1. Bringing the waters of Loch Lomond to Lake Donaldson, 1,300 feet:		
Land damage,	$200 00	
Clearing, grubbing and road making,	500 00	
Excavation and back filling earth, 50,000 cubic yards, @ 30c.,	15,000 00	
Brick conduit, 1,300 feet, @ $6.00,	7,800 00	
Gate houses, gates and gearing,	4,000 00—	$27,500 00
Sec. 2. From Lake Donaldson westward 1150 feet:		
Land damage,	200 00	
Clearing, grubbing and road making,	500 00	
Excavation and back filling in earth, 30,000 cubic yards, @ 30c.,	9,000 00	
Brick conduit, 1,150 feet, at @ $6.00,	6,900 00	
Receiving chambers and gates,	6,000 00—	22,600 00
Sec. 3. From receiving chamber to Lake Douglas, 1,900 feet:		
Land damage,	200 00	
Clearing, grubbing and road making,	300 00	
Excavation and back filling in earth, 2,200 cubic yards, @ 30c.,	660 00	
Conduit, in wood, 1900 feet, @ $1.50,	2,850 00—	4,010 00
Sec. 4. Works on Lake Douglas:		
Land damage, 40 acres, @ $20.00,	800 00	
Clearing and grubbing 30 acres @ $50.00,	1,500 00	
Dam at outlet,	750 00	
Wasteway,	250 00	
Gate house and inlet channel,	4,000 00—	7,300 00
Carried forward,		$61,410 00

	Brought forward,		$61,410 00
Sec. 5 From Lake Douglas to present Works on Little River:			
2,960 tons of 33 in. pipe, @ $34.00,	....	100,640 00	
4 Main stop cocks, @ 600.00,	....	2,400 00	
4 Flushing " @ 50.00,	....	200 00	
20 tons specials, @ 60.00,	....	1,200 00	
25 tons lead, @ 120.00,	......	3,000 00	
30,000 pine wedges, @ 2c.,	....	600 00	
Spun yarn, coal and oil,	....	750 00	
6 air valves, @ $20.00,	....	120 00	
111,000 feet lumber, @ $10.00,	....	1,110 00	
Land damage, 19 acres, @ $20.00,	....	380 00	
Clearing and grubbing 19 acres, @ $50.00,		950 00	
Excavation and re-filling in earth, 34,000 cubic yards, @ 35c., ...	....	11,900 00	
Pipe laying, etc., ...	....	3,000 00	
Handling and cartage of pipes in city,	......	2,368 00	
3,050 tons cartage to pipe line, @ $2.00,		6,100 00—	134,718 00
Engineering, superintendence and extras,		....	19,612 00
			$215,740 00

The substitution of a rectangular wood conduit with arched brick cover, as shown in the annexed diagram, would reduce the cost of the above work about $5000, and a still farther reduction could be made by using a smaller iron pipe.

For instance, were a 30 inch pipe substituted for the 33 inch one, a saving of about $11,000.00 would be effected on the first outlay; and the adoption of a 24 inch pipe would make a reduction of about $39,475.00.

With conduits 1 and 2 in wood instead of brick, and 33 inch pipe, the cost would be reduced to about $208,580.00; with wood conduit and 30 inch pipe, to about $197,580.00, and wood conduits and 24 inch pipe to about $169,105.00.

To conduits in wood, there could be no substantial objection. Properly constructed and constantly submerged, they would be practically imperishable; but it would not be judicious, even in view of the saving named, to adopt either of the smaller pipes. Either would give a fair *high* service supply for a time, but neither would be able, in *itself*, to maintain the general supply and an *effective summit pressure* when it was found necessary to detach the low service from its usual source of supply—Little River—and draw the *whole* of the water being used for town and city purposes from Lake Douglas.

In illustration of this, it may be remarked that the present *actual* capacity of the mains leading to the City from Little River is estimated at about 8,500,000 imperial gallons per day; while the supply obtainable from a 33 inch pipe, extending from Blockhouse-hill to Lake Douglas (reduced for internal crustration, etc.), would be about 7,040,000 gallons; from a 30 inch one, 5,538,000; and from a 24 inch one, 2,523,000 gallons only.

From the margin of area in favour of the mains now in use, compared with either of the pipes named, there is ground to believe that each would do something better than this, if required to do the *whole* work of high and low service, but there is no good reason to believe that either of the smaller pipes, the 24 or 30 inch, could perform the duty satisfactorily.

These several quantities may be taken, therefore, as the relative and approximate capacities of the pipes named, were the supply cut off from Little River, and taken wholly from Lake Douglas; as would be the case practically, to a greater or less extent, every time the high service was called into operation to aid in suppressing fire in the *low* service districts.

With a heavy general consumption, the effect, under such circumstances, would be an almost instantaneous diminution of head or pressure at the summit levels, as well as to the City generally; and a relative destruction of the advantages accruing from an effective high pressure service.

This reduction in pressure would correspond in a measure to the hourly delivery of the mains as compared with the hourly consumption. As long as the former exceeded the latter, an effective pressure would be maintained, but as soon as the hourly draft rose above what the mains could furnish, at their assumed point of delivery, the pressure would begin to fail and would continue to recede until it reached a point corresponding to the head or fall required to maintain the then existing draft.

It is this principle that comes into operation during the winter season, when waste abounds, and causes so much annoyance to the upper sections of the City; and it is with a view to avoid this difficulty and insure an effective summit pressure for house and fire purposes, on all occasions, that the larger pipe is recommended. Should this route be accepted and a change made at all in the pipe, it should be to a larger rather than a smaller size. No city was ever known to err in this direction, no matter how large the mains, and copious the supply furnished daily to its citizens.

BY WAY OF LAKE DONALDSON.

To follow this course means the conversion of this Lake into a high service reservoir, and connecting to it our present supplying mains by one or more pipes extending from our present works, or Little River to Lake Donaldson.

By doing so, 140 feet would be added to our present nominal head, and a pressure obtained at Blockhouse-hill and similar summits about equal to that which now prevails in Prince William street.

With such a pressure, the City could be safely sectioned or divided into high and low service districts, as already intimated, and steam engines be all but discarded, were such deemed desirable.

No location surveys have been made yet for a pipe line by this route, but sufficient data have been obtained to show that an excellent and easily worked line can be had, if needed.

The outlet would be at the same point as that proposed for Lake Douglas, where suitable strainers, gate house and gates would be placed to regulate the inflow and outflow of the water.

The works contemplated for bringing the waters of Loch Lomond to Lake Donaldson, and from thence to the gate house or effluent chamber, are similar in every respect to those described in connection with the Lake Douglas schemes, and are common therefore to both routes.

The chief difference between routes 1 and 2 consists in the laying of an iron pipe from H to B instead of the 1,900 feet of wooden sluice that has been suggested in connection with the former (A to B).

The difference in cost, however, would not be represented by the difference in cost between a wooden sluice and that of an iron pipe alone, as the superior elevation of Lake Donaldson would permit a smaller pipe to be used *between Lake Douglas and Little River*, with equal or better results in the way of daily delivery.

Proposed Pipe.—A pipe of 30 inches diameter is proposed in this instance, in place of the 33 inch one recommended in project No. 1.

A pipe of this size would be capable of supplying (alone) under a Lake Donaldson pressure, fully 7,760,000 imperial gallons daily, at 50 feet above Blockhouse-hill; and one of our present 24 inch mains fed at Little River by a pipe of this size, 5,440,000 gallons. The latter would be the ordinary high service supply, and in addition to what would be taken by the remaining 12 and 24 inch pipes for *low* service, estimated at about 4,500,000 gallons per day.

The united capacity therefore of our high and low service works by this route, would be about 9,940,000 gallons per day, or 120 gallons per head to a population of 82,833, as follows, viz.:

Low service 24 inch pipe,	......	.. ...	3,895,000	
do. 12 inch pipe,	......	......	605,000—	4,500,000
High service 24 inch pipe,	. ....	......		5,440,000
Total combined capacity,		......		9,940,000

For high service alone, a smaller pipe might answer for the present, but the motives and the reasoning that led to the adoption of a 33 inch main for Lake Douglas, justify the use of a 30 inch one in this instance.

The cost of this route is estimated, approximately, at $236,819.00, exclusive of water rights, as follows:

Connecting Lakes, including Conduits, Gates and Gate Houses, as in previous estimate,		....		$50,100 00
3,600 tons 30 inch pipe, @ $34.00,		....	$122,400 00	
5 Main stop cocks,	" 500.00,	....	2,500 00	
6 Flushing "	" 50.00,	....	300 00	
7 Air valves,	" 20.00,	....	140 00	
25 tons specials,	" 60.00,	....	1,500 00	
30 tons lead,	" 120.00,	....	3,600 00	
36,000 pine wedges,	" 2c.,	....	720 00	
Spun yarn, coal and oil,	....	....	1,000 00	
150 M lumber,	" 10.00,	....	1,500 00	
Land damage, 25 acres,	" 20.00,	....	500 00	
Clearing and grubbing 20 acres @ $50.00,		....	1,000 00	
Excavating and re-filling 45,000 cubic yds. @ 35c.,			15,750 00	
Laying and jointing pipes,	....	....	4,000 00	
Handling and cartage of pipes in city,		....	2,880 00	
Cartage, 3,700 tons to pipe line, @ $2.00,		....	7,400 00	165,190 00
Engineering, superintendence, and extras,		....		21,529 00
Total estimated cost,	....	....		$236,819 00

The substitution of conduits in wood and brick, as suggested in Route No. 1, would reduce the foregoing estimate to $231,819 00.

BY WAY OF LAKE LATIMER.

This is a new route; but its general character and practicability have been very carefully explored and tested by instrumental surveys, and with highly satisfactory results.

It contemplates the bringing of the waters of Loch Lomond to Lake Latimer, and converting this beautiful body of water into a high service reservoir,—for which it is admirably adapted, by the quality, depth, and area of its waters,—particulars in which it greatly excels Lake Donaldson, as already noticed.

Both of the two previously mentioned routes lie to the northward of Little River, but the greater part of this line is to the southward of that stream.

The surveys show that the ground is exceptionally favorable, from an engineering and economic point of view. It is almost entirely free from rock and heavy cuttings, eminently direct and easy of access, and not inferior to either of the other lines in light grades and gentle curves.

A brief study of the accompanying map will show the general direction and salient features of this route, and its contour is outlined on profile No. 3.

To bring the waters of Loch Lomond to the City by this way, the following works would be required, viz.:

(1). A dam across the Mispeck, with suitable waste ways and gate chamber near the outlet of what is known as Lake Robertson.

(2). A covered conduit in brick or wood, or partly both, from the Mispeck to Lake Latimer which is spoken of hereafter as conduit No. 1.

(3). A covered conduit of a similar description (named No. 2,) from Lake Latimer westward to what is known as lot 10, owned at present by Mrs. Charles Hazen.

(4). The construction of an intermediate reservoir with gate houses and straining chambers to receive the water brought thither by conduit No. 2; and

(5). The laying of a cast iron pipe or pipes of suitable size from thence to our present mains at Little River.

The Dam.—The site contemplated for the dam on the Mispeck is about a mile below the present outlet from Loch Lomond, or the bridge at Raymond's, and is shown on the general map or plan.

The erection of a dam here would add about 34 acres, or 65½ million gallons to the storage capacity of the Loch, and bring its waters about one mile nearer to the City than they are at present, at their nominal level of 300 feet above City datum.

The length of this dam would be about 500 feet, and its height above the present bed of the river, about 9 feet. Its foundations would be in rock, and an excellent supply of the materials contemplated in its construction (stone and earth) can be had in its immediate vicinity.

An ample and substantial waste way would be required in connection with this dam to give safe and easy exit, not only to the daily run from the Loch, but also to its biggest freshets, which are sometimes no less sudden than copious. Suitable gates and gate chambers will also be required to regulate the outflow for City purposes.

Conduit No. 1.—The advisability of having this an open, or covered channel, has been carefully considered. An open conduit would be the cheaper of the two, but this is the only point in its favor. In all other respects it is decidedly objectionable. So far as practicable, every part of a city system of water supply should be perfect in itself,—beyond the reach of contamination from surface drainage or interruption from "anchor ice." Open channels are exposed to both dangers, and are therefore discarded, and covered ones recommended.

The length of No. 1 conduit would be about 7000 feet. Its contemplated capacity, one million gallons per hour, and its bottom line the same as Lake Donaldson, eleven (11) feet below the raised surface of the Mispeck, or that of Loch Lomond.

The estimates are for a circular conduit in brick, laid in English cement, with an inside diameter of 4 feet 6 inches, and a fall of about one in 1056. Should wood, however, be substituted for brick, as suggested in routes 1 and 2, the sectional form will require to be changed.

The excavation would be mostly in earth, but some of it would be in rock of a moderately hard and compact character. The average depth of digging for 6200 feet would be about 12 feet, and the balance, of say 800 feet, in tunneling. See profile No. 3.

Conduit No. 2.—This conduit is designed to carry the waters of Lake Latimer city-ward as far as point F, or G, as may be chosen hereafter for its termination.

Should the first named point be selected, the water would be taken from thence to our present mains on Little River by one or more cast iron pipes; and should the second, or point G, be chosen, the water carried by this conduit would be discharged into an *intermediate reservoir*, and drawn from thence by cast iron pipes. The last named would be the more expensive, but the best arrangement of the two, for reasons that will be given hereafter.

For the first named, the required length of brick conduit would be about 7400 feet, with 10,200 feet of iron piping; while the last would require 10,500 feet of brick or wood conduit and 7600 feet of cast iron pipe. The digging would be wholly in earth, with an average depth of 12 feet along the line of aqueduct and about 7 feet along the line of pipe.

The sectional area, shape and gradients of this conduit will be regulated, to some extent, by the material selected for its construction, but its daily discharging capacity should not be less than that of No. 1.

The present intention is, to place the bottom grade line of this conduit at a point 20 feet or so below the present surface of Lake Latimer, so that 13 feet of water could be drawn off without impairing the maximum usefulness of the conduit. This depth of water represents fully 625 millions of gallons, and is equal to 125 days supply at the rate of *five* millions per day of 24 hours.

A controling idea in placing the conduit at this low point is the desire to test, practically, the ability of this Lake to furnish, with the aid of an intermediate reservoir, a high service supply, without extending to Loch Lomond. Should it prove able for this duty, the whole of the heavy expenditure on section 1 would be saved,—for a time at least,—and a serious question of water rights avoided.

I am not sanguine of its capacity in this particular, but some people are decidedly so; and it may be, if fed from springs, as is alleged, that its hydrological basin is really greater than is indicated by its surface collecting ground, and that its recuperative power will *increase* as its depth and surface area are diminished. A change in the existing hydrostatic pressure may possibly quicken the inflow, and should this turn out to be the case, the daily yield may be increased to a considerable extent, with the additional advantage that the water discharged from the springs would have undergone a complete process of natural filtration before coming to the lake. As the experiment will not interfere to any material extent with our general plans, and may result in a saving of $81,270.00, it is worthy of a trial, should this route be adopted in preference to the other two.

Intermediate Reservoir.—The greater part of the projected intermediate reservoir would be located on land owned at present by Mrs. Charles Hazen, and known as Lot No. 10, where there is a natural depression or basin, which could be converted easily into a reservoir by the erection of an earthen embankment, as shown on the plan.

A reservoir placed here would have a surface area of about 25 acres, an extreme depth of 15 feet, and an average of about 11 feet. Its capacity would be about sixty-five (65) million gallons, or 13 days supply at the rate of 5,000,000 gallons per day, which is probably a greater quantity than would be taken from this source for many years to come, if the City were districted, and the *low* service supply drawn, as at present, from Little River.

To impound this quantity of water would require a dam about 600 feet long, with a maximum height of 18 feet above the surface of the ground at its point of location. Test-pits have shown that good foundations can be had without much trouble, and material suitable for its construction exists in abundance in the immediate neighborhood.

Gates and Gate Chambers, to regulate the inflow and outflow of the water, are contemplated, but not in connection with the artificial embankment.

Distance and Elevation.—The location of this reservoir would be about 1½ miles to the eastward of our present works on Little River and its water surface, when full 275 feet above City datum, or 145 feet above Blockhouse-hill.

Iron Piping.—From the western side of this reservoir it is proposed to lay, for the present, a single line of 30 inch pipe to be connected to the 24 inch main laid in 1873, and devoted to high service exclusively,—unless, in times of serious fire in the low service districts, when, by an adjustment of stop cocks, the full pressure would be transferred to the threatened locality. The length of pipe required for this connection would be 7600 feet.

The maximum discharging capacity of a pipe of this diameter, at a point 50 feet above Blockhouse-hill, would be about 8,400,000 gallons daily; and the delivery, at the same elevation, of a single 24 inch pipe, fed by a 30 inch one at Little River, about 5,200,000 gallons.

The first named amount represents, approximately, the daily quantity obtainable from the 30 inch pipe discharging into both 24 inch mains at Little River, with the whole City placed under a high pressure supply; and the second quantity, the supply derivable from *one* 24 inch pipe for high service purposes, at 180 feet above City datum.

By this route therefore the united discharges obtainable daily from high and low service sources would be about 9,700,000 imperial gallons; or, in round numbers, 120 gallons per head to a population of 81,000 nearly,—as follows, viz.:

Low service 24 inch pipe,	....	3,895,000	
do. 12 inch pipe,	....	605,000	4,500,000
High service 24 inch pipe,	....		5,200,000
Total combined delivery,	....		9,700,000

ESTIMATES OF COST.

The cost of the works thus outlined, with conduits in brick, is estimated at $254,370.00, as follows, viz.:

Section 1. On the Mispeck—Dam and Gate House:		
Land damages, 40 acres, @ $20.00, ...	$ 800 00	
Clearing and grubbing 30 acres, @ $50.00,	1,500 00	
600 cubic yards rubble masonry, " 7.00,	4,200 00	
2,000 cubic yards embanking, @ 30 cents,	600 00	
Inlet channel, ...	1,500 00	
Gate house, gates and gearing, ...	3,500 00	
Waste-way, ...	500 00	12,600 00
Section 2. Mispeck to Lake Latimer—Conduit and Tunnel:		
Land damages, 6 acres, @ $20.00, ...	120 00	
Clearing and grubbing 6 acres, @ $50.00,	300 00	
Excavating in earth, 18,000 yards, @ 30c.,	5,400 00	
do. rock, 1,100 yards, @ $1.50,......	1,650 00	
Brick Conduit, 6,200 feet, @ $6.00,.........	37,200 00	
Tunneling, 800 yards, @ $30.00, ...	24,000 00	68,670 00
Section 3. Work on Lake Latimer and Conduit No. 2:		
Land damages, 12 acres, @ $20.00, ...	240 00	
Clearing and grubbing 12 acres, @ $50.00,	600 00	
Excavating and re-filling 33,000 cubic y'ds, @ 30 cents, ...	9,900 00	
Brick Conduit, 10,500 feet, @ $6.00,.........	63,000 00	
Outlet channel, ...	2,000 00	
Gate houses, gates and gearing, ...	5,000 00	80,740 00
Carried forward, ...		$162,010 00

Brought forward, ...		$162,010 00
Section 4. Intermediate reservoir and gate chambers:		
Land damage, 70 acres, @ $10.00, ...	700 00	
Clearing and grubbing 30 acres, @ $50.00,	1,500 00	
Removing soil and vegetable matter, ...	2,000 00	
Dam, 18,000 cubic yds. embanking, @ 25c.,	4,500 00	
Dam 2,500 cubic yards, puddling, @ $1.00,	2,500 00	
Rip-rap, 2,000 square yards, @ 80c., ...	1,600 00	
Gate chambers and gates, ...	3,000 00	
Wasteway, ...	500 00	16,300 00
Section 5. Cast iron pipe, from intermediate reservoir to Little River:		
1,200 tons 30 inch pipe, @ $34.00, ...	40,800 00	
3 Main stop cocks, " 500.00, ...	1,500 00	
3 Flushing " " 50.00, ...	150 00	
8 tons special castings, " 60.00, ...	480 00	
11 tons lead, " 120.00, ...	1,320 00	
12,600 pine wedges, @ 2 cents, ...	252 00	
Spun yarn, coal and oil, ...	250 00	
52 M lumber, @ $10.00, ...	520 00	
8,000 cubic yards excavating and re-filling, @ 35 cents, ...	2,800 00	
Pipe laying, ...	1,400 00	
Land damage, 9 acres, @ $20.00, ...	180 00	
Clearing and grubbing 9 acres, @ $50.00,	450 00	
Handling, and cartage of pipes in city,.........	960 00	
Cartage to pipe line, 1,250 tons, @ $1.50,	1,875 00	52,937 00
Engineering, Superintendance, and extras,		23,123 00
Total estimated cost, ...		$254,370 00

By using wood instead of brick in conduits 1 and 2, as shown in diagram No. 2, a saving would be effected from the above of about $33,400.00, and by dispensing with the *intermediate reservoir*, for the present, a further reduction would follow of about $20,000.00. With these modifications, therefore, the cost by this route would stand about as follows:

No. 3. A. With Intermediate Reservoir, and Conduits in brick and English cement, ...	$254,370 00
No 3. B. With Intermediate Reservoir, and Conduits in wood, arched brick covering, ...	220,970 00
No 3. C. *Without* intermediate Reservoir, Conduits in wood, and brick covering, ...	200,970 00

A condensed view of the leading features as to cost, capacity, and water resources of each of the foregoing routes will be had from an inspection of the following tabulated particulars:

SUMMARIES OF ESTIMATED COST, CAPACITY AND WATER RESOURCES OF EACH OF THE FOREGOING ROUTES.

	Lake Douglas, No. 1 Route.	Lake Donaldson, No. 2 Route.	Lake Latimer. No. 3, A.	Lake Latimer. No. 3, B.	Lake Latimer. No. 3, C.
Maximum supplying capacity per day of pipes and conduits, in imperial gallons, at 1½ miles from present mains on Little River, or 6¼ miles from city, ...	7,040,000	7,760,000	24,000,000	24,000,000	24,000,000
At a point above city datum, of	215 feet.	264 feet.	275 feet.	275 feet.	276 feet.
Maximum supplying capacity through both 24 in. mains, at 50 feet above Block-house hill, or 180 above datum,	7,040,000	7,760,000	8,400,000	8,400,000	8,230,000
Maximum supplying capacity through one 24 in. main, at 50 feet above Block-house hill, or 180 above datum,	3,872,000	5,440,000	5,200,000	5,200,000	5,250,000
Combined capacity of High and Low service per day, ...	8,372,000	9,940,000	9,700,000	9,700,000	9,750,000
Sufficient at a rate of 120 imperial gallons per head, for a population of	69,766	82,833	80,833	80,833	81,250
Water Resources of the Several Routes in Millions of Imperial Gallons:					
From Loch Lomond, 6 feet, ...	3,659.0	3,659.0	3,659.0	3,659.0	3,659.0
" Lake Douglas, 3 "	44.9				
" Lake Donaldson, 6 "	122.5	122.5			
" Lake Latimer, 14 "			625.0	625.0	625.0
" Lake Robertson, 6 "			65.3	65.3	65.3
" Intermediate Reservoir, 13 "			65.0	65.0	
Totals, ...	3,826.4	3,781.5	4,414.3	4,414.3	4,349.3
Estimates of cost of High Service works, ...	$215,740 00	$236,819 00	$254,370 00	$220,970 00	$200,970 00
Cost per million gallons of new High Service supply, ...	$55,718 00	$43,533 00	$48,917 00	$42,494 00	$38,280 00

A short study of the foregoing tabulated statement will show the superiority of the Lake Latimer route, in one or other of its modified forms, to routes 1 and 2. By following this course, with the works outlined, St. John would stand pre-eminent among the cities of the world for its water supply; tested by the quality and quantity at its command, the primary cost and pressure at which it was delivered, and the ease and economy with which future extensions could be made to meet increasing demands.

In its intermediate reservoir it would have a storage capacity of 65 million gallons to maintain its high pressure supply when No. 2 conduit was shut off, or emptied to clean or repair; and in Lake Latimer it would have a surplus reserve of about 625 million gallons to draw from, when it was necessary to cut off the draft from the Mispeck for the benefit of the mills, or for any other cause. And, in addition to both supplies named, it would have another 65½ million impounded in *Lake Robertson* for extra service in dry seasons.

I am not of the opinion that Lake Latimer alone, aided even by an intermediate reservoir, will be able to furnish all the water wanted by St. John, without the aid of Loch Lomond, but the extra quantity obtainable in this direction would prove not only useful when repairs or inspections were being made to either of the conduits, but would enable us in dry seasons, when the full natural volume of the Mispeck was required for milling purposes, to stop the City draft from this source and continue the supply for a longer or shorter period from the waters held in reserve, and thereby lessen, to a material extent, riparian claims for damage.

This would be effected by Lake Latimer and the intermediate reservoir having been filled to their maximum capacities from the surplus waters of Loch Lomond during wet seasons, and applying this surplus or reserve to City service during droughts, or when the ordinary flow of the Mispeck was required for other purposes.

The quantity of water that could be stored in this way would be sufficient to supply 5,000,000 gallons for upwards of four (4) months without taking any water from Loch Lomond. And not only could we abstain from drawing water at such times from the Mispeck or Loch Lomond, but we would be able to put the whole of the extra water impounded in Lake Robertson into the river without injury to ourselves or impairing the capacity of conduit No. 1.

This in itself would be an important item of supply in dry seasons, as it would be additional to the natural run from Loch Lomond.

But besides this compensation, another important advantage gained by following this route is the ability to deliver *twenty-four million gallons daily* at a point *one and a half miles* only *from our present works on Little River.*

In consequence of this our future supply could be increased—doubled or tripled—did the growth of the city require it, at a much less additional outlay than by either of the other routes. As a practical illustration of this, let it be supposed that a second main of equal size to those estimated for, had to be laid to either of the proposed supplying sources, the relative cost in each case would be about as follows, viz.:

To Lake Douglas, ...	$ 148,190 00
Lake Donaldson, ...	181,710 00
Intermediate Reservoir, ...	58,230 00

Looking to the future, therefore, this route has a very decided advantage over either of the others.

My personal inclination is to route No. 3 A; that is *via* Lake Latimer, with intermediate reservoir and conduits in brick, laid in English cement. The cost is higher than either of the others, but the estimate is for first class work—masonry that should be as enduring as the aqueducts of ancient Rome, some of which are still in use and free from symptoms of decay.

Should, however, the cost of this line be above the City's present means, as it probably is, my next choice would be No. 3 B., that is, with *intermediate reservoir* and conduits in wood, as shown in diagram No. 2; and next to this No. 3 C., that is, with conduits in wood but *without* an intermediate reservoir. This scheme is the cheapest of all, and would not be worse, without a reservoir, than routes 1 or 2—indeed, the risk of accident would not be so great, as it would have a much less length of iron piping.

Of the other two routes, Lake Donaldson is to be preferred for its superior elevation and capacity of supply; but before a final selection is made of either line, I would suggest consultation with some competent hydraulic Engineer of large and varied experience, such as James B. Francis, of Lowell, or E. S. Chesborough, of New

York (late of Chicago), both of whom have an European as well as American reputation for professional ability and integrity of character.

Before concluding this report a few general remarks on the

VALUE OF AN INTERMEDIATE RESERVOIR

may not be out of place. One great advantage that would accrue from a reservoir placed on lot No. 10, is the assistance it would give when inspections were required or repairs needed on conduit No. 2. With a large body of water stored here, this conduit could be shut off for two weeks or more at a time, without interruption to the ordinary high service supply. But this could not be done if the conduit terminated in a gate chamber only.

Without a reservoir, an interruption to the daily flow in No. 2 conduit would mean, to the greater part of the high service area, a total deprivation of water for a longer or shorter period of time, with all the risks and inconveniencies that this implies. To the household furnished with what is known as "modern conveniencies," this would be an intolerable nuisance; while to the workshop and factory, a stoppage for a short time even would prove not only an inconvenience, but to such establishments as depended on pipe water for a continuance of their daily operations, a substantial loss in time and money, measured by the period of suspension.

But important as these considerations are, a much stronger reason in its favor is the danger that would be run *without* it should a fire break out on either of the summit districts while the water was shut off from No. 2 conduit by choice or otherwise.

Viewed in the light of our experience, the consequences that might follow such a contingency are appalling to contemplate, as a fire of a few hours duration might readily sweep away many times the value of the whole extra cost of this reservoir and its several adjuncts.

Similar remarks would apply to a single line of pipe from the termination of conduit No. 2, westward, to our present works, with or without an *intermediate* reservoir. And as a matter of prudence, it would be preferable to have *two* connecting mains, of less diameter, than trust to *one* with a capacity equal to the two,—as, did an accident happen to either, the supply would be maintained to some extent by the other. The substitution of a double line of 24 inch pipe in place of a single line of 30 inch, would cost about 50 per cent. more; but the increased security and convenience that would come of duplication, would do more than compensate for the additional outlay.

A minor advantage that would accrue from an intermediate reservoir and duplication of the connecting mains, is the *extra time* they would allow to be taken for *inspection* and *repairs*.

Every one who is practically acquainted with the management of water works knows, that the hurry which must necessarily be made when a single main is broken or leaking, or a single source of supply is stopped, as by "anchor ice," is not conducive to good workmanship nor perfection in repairs. The overmastering thought under an interrupted supply is to get it restored again with the least possible delay, and to this consideration everything else must yield.

No city is safe unless the mains on which it depends for its daily water supply are properly duplicated in all their essential parts; and no reasonable amount of outlay should be allowed to stand in the way of this being done.

CHANGES REQUIRED.

To adopt our present distributing system to *high* and *low* service, some important changes will be required in the piping of Saint John and Portland; but it is not necessary to enter into a discussion of these at present.

Some trouble may be expected, also, from old and feeble pipes when placed under a heavier pressure; but as the main and service pipes we have been using for many years past have been extra strong, the trouble in this way should not be great.

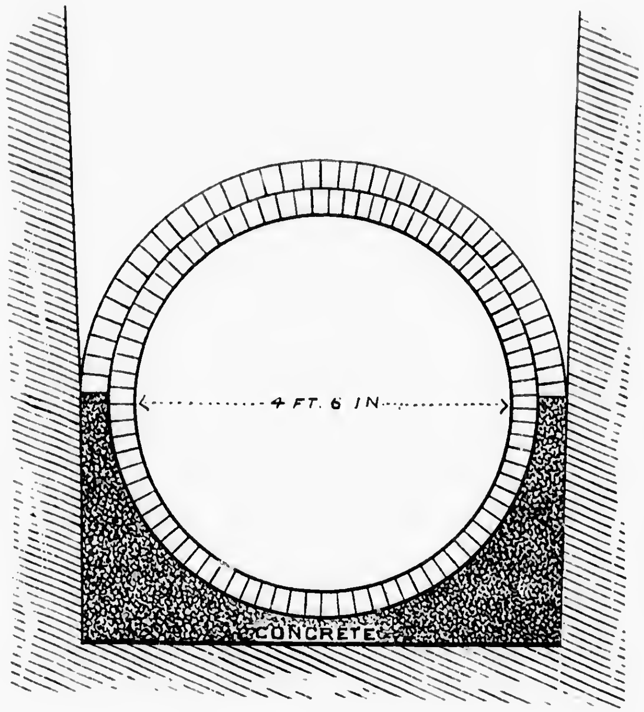
Respectfully submitted,

GILBERT MURDOCH,

Engineer and Sup't Sewerage and Water Supply.

DIAGRAM No. 1.

CONDUIT IN BRICK.

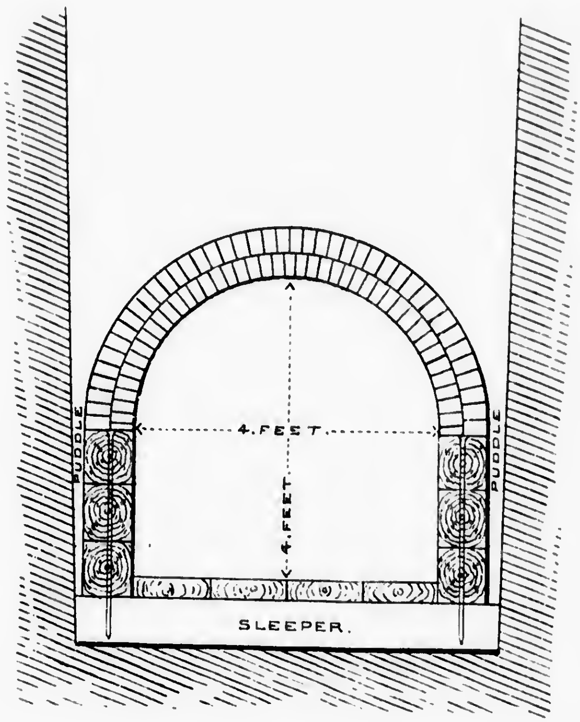


SCALE, 3/8. INCH TO 1. FOOT.

Maritime Steam Lith. Co. St. John N.B.

DIAGRAM No. 2.

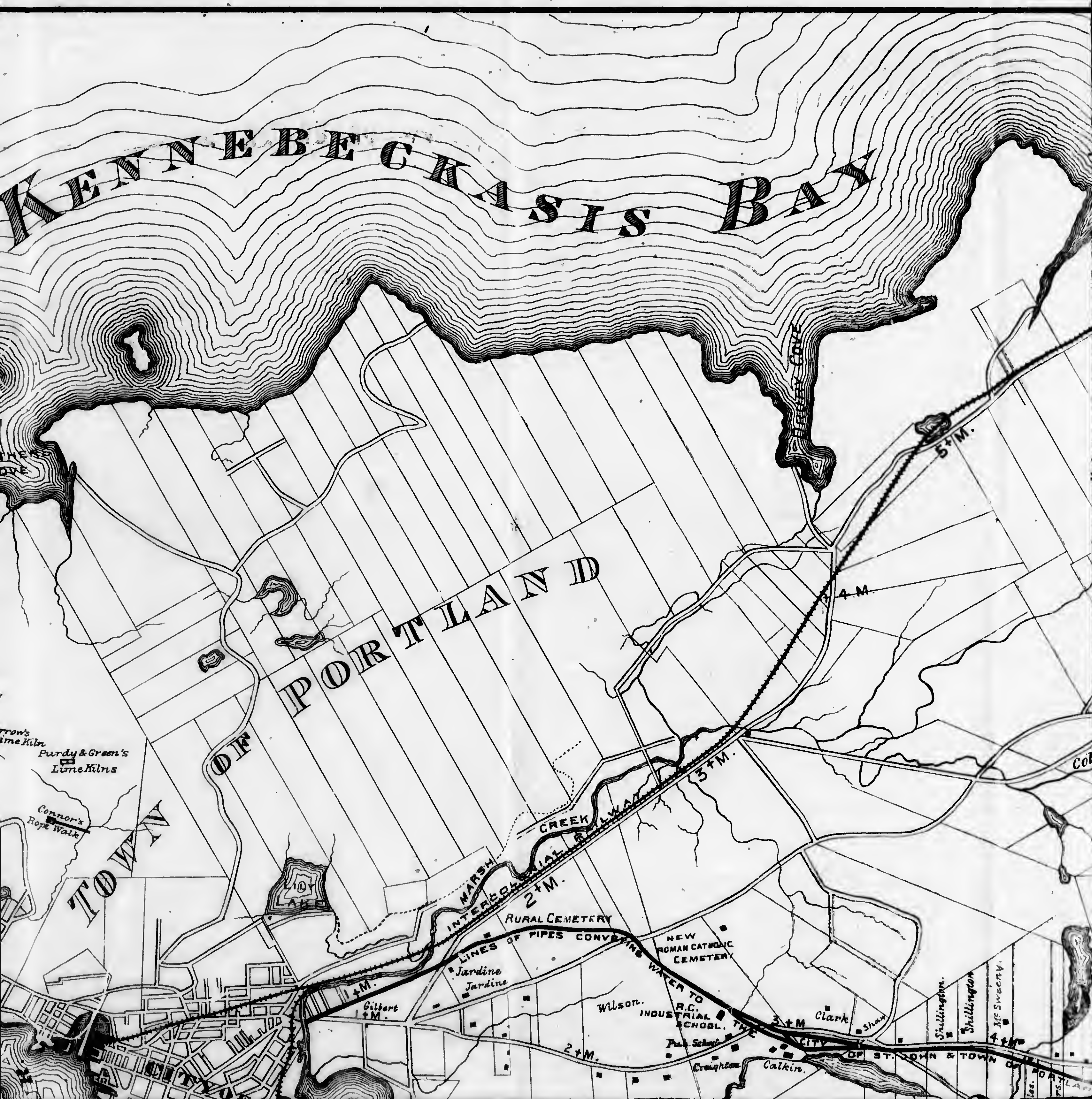
CONDUIT IN WOOD & BRICK.

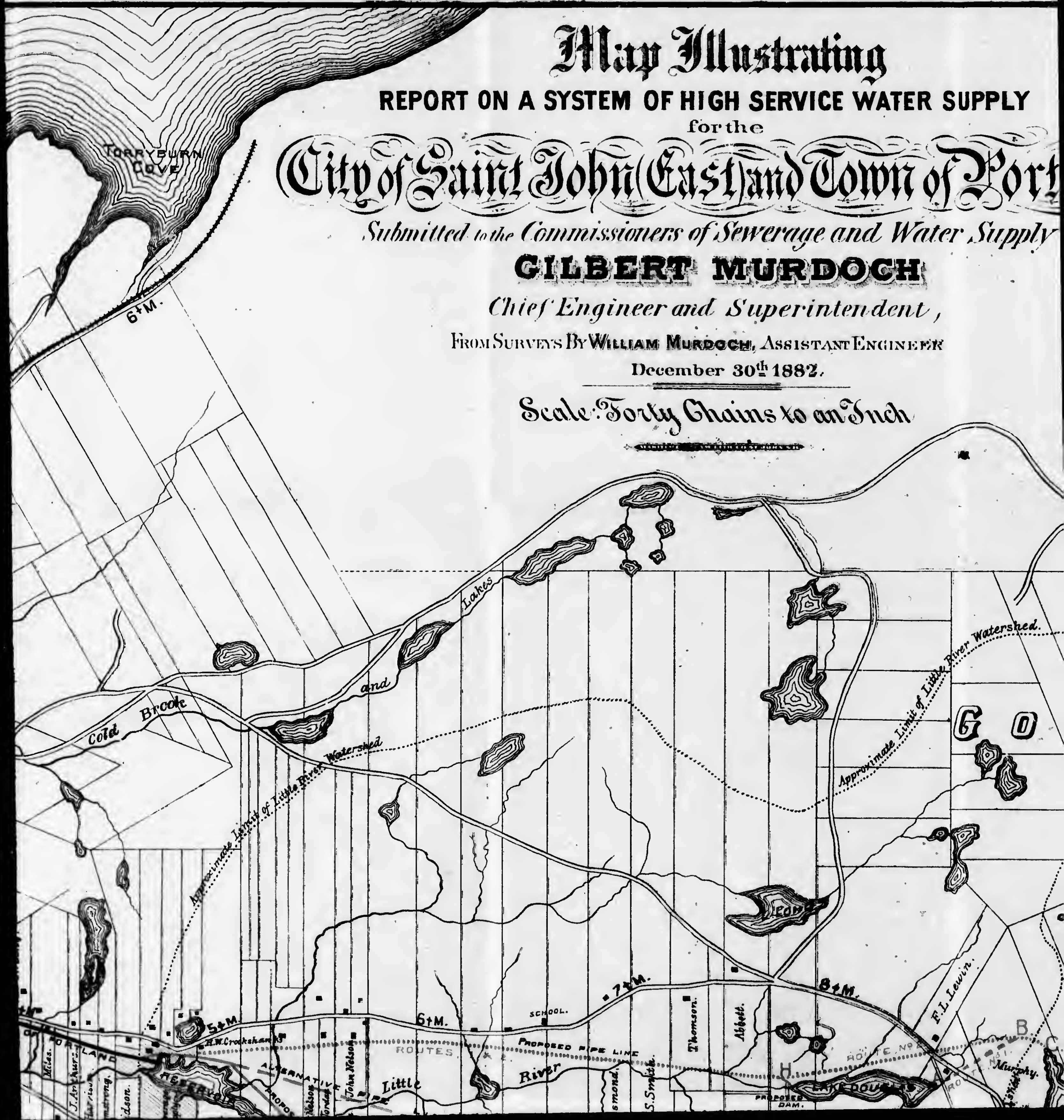


SCALE, 3/8. INCH TO 1. FOOT.

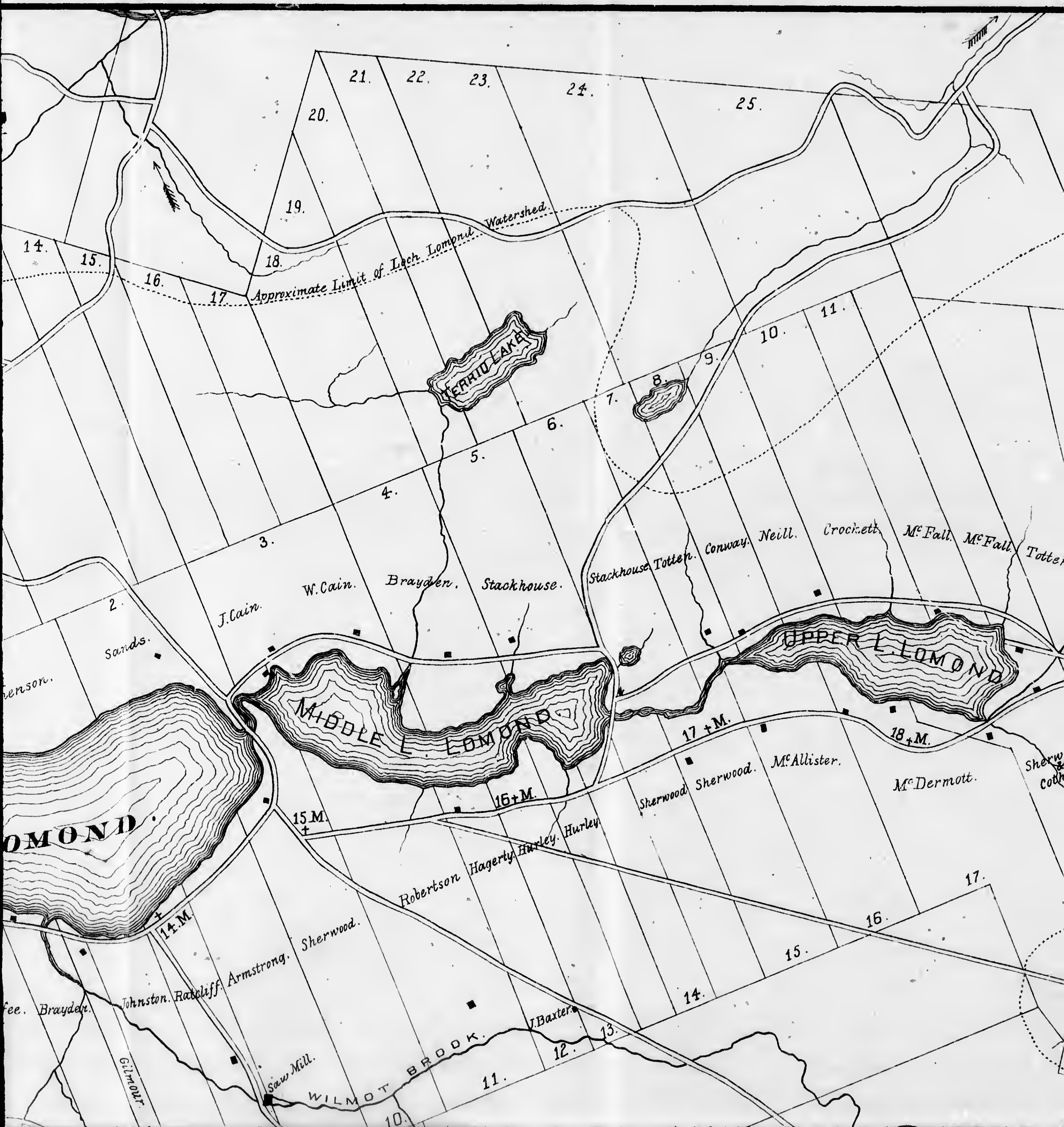
Maritime Steam Lith Co. St John N.B

KENN
NORTH
RAGGED POINT
BOAR'S HEAD
BROTHERS COVE
GREEN HEAD
Armstrong's Lime Kilns.
ST. JOHN
Macreadie
Morrow's Lime Kiln
Purdy & Green's Lime Kilns
SOUTH BAY.
Carvell
Connor's Rope Walk
Millers Lime Kilns
TOWN
RIVER
ST. JOHN & MAINE RAILWAY

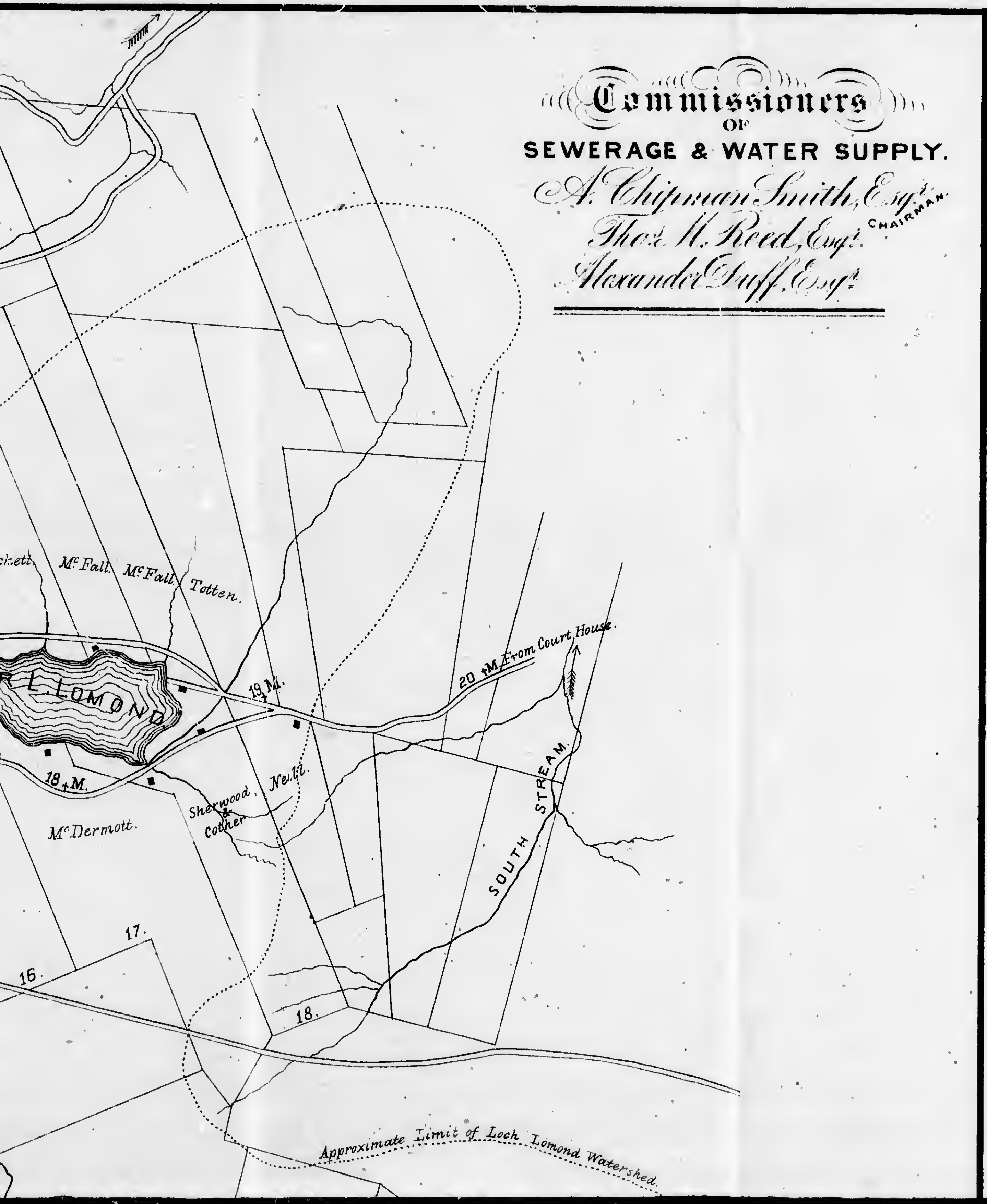

KENNEBECKASIS BAY
TOWN OF PORTLAND
Purdy & Green's Lime Kilns
Connor's Rope Walk
LILY LAKE
MARSH CREEK
INTERCOLONIAL RAILWAY
RURAL CEMETERY
LINES OF PIPES CONVEYING WATER TO CITY
NEW ROMAN CATHOLIC CEMETERY
R.C. INDUSTRIAL SCHOOL
Jardine
Jardine
Gilbert
Wilson
Pub. School
Creighton
Calkin
Clark
Shaw
Shillington
Shillington
McSweeny
1 M.
2 M.
3 M.
4 M.
5 M.

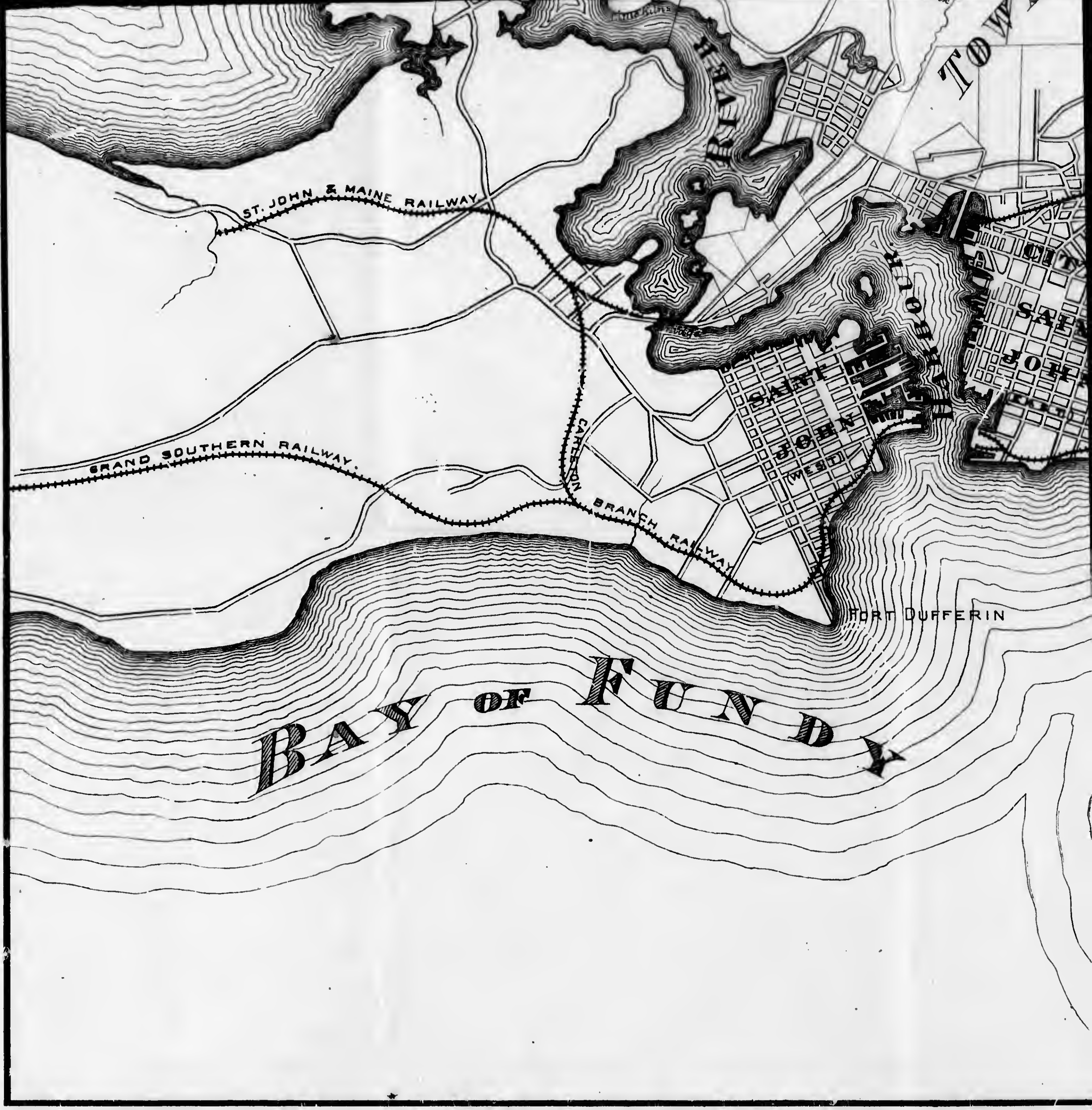

Map Illustrating
REPORT ON A SYSTEM OF HIGH SERVICE WATER SUPPLY
for the
City of Saint John (East) and Town of Port
Submitted to the Commissioners of Sewerage and Water Supply
GILBERT MURDOCH
Chief Engineer and Superintendent,
FROM SURVEYS BY WILLIAM MURDOCH, ASSISTANT ENGINEER
December 30th 1882.
Scale: Forty Chains to an Inch
TORRYBURN COVE
6+M.
Lakes
and
Cold Brook
Approximate Limit of Little River Watershed
Approximate Limit of Little River Watershed.
G O
5+M
6+M.
7+M.
8+M.
SCHOOL.
H.W.Crookshank
PROPOSED PIPE LINE
ROUTES
ROUTE No. 1.
ALTERNATIVE PIPE
Little River
RESERVOIR
LAKE DOUGLAS
PROPOSED DAM.
Thomson.
Abbott.
F.L.Lewin.
S.Smith.
John Nelson
J.Arthurs.
Murphy.
B
H

ng
WATER SUPPLY
own of Portland
nd Water Supply by
OCH
ndent,
ENGINEER
Inch
TO HAMMOND RIVER
LAKE CHAMBERS
GOOSE
GROVE
GOLDEN
DEAD BROOK
Approximate Limit of Little River Watershed.
Wootton.
McGuire
Stevenson.
McBrine.
Stephenson.
Sands
LOWER LOCH LOMOND
13.M.
12.M.
Bunker.
F.L.Lewin.
Commissioners of S&
Brown.
Murphy.
Church.
Sentell.
Sentell.
Brayden.
Johnston.
McAffee.
Brayden.
Wootton.



21.
22.
23.
24.
25.
20.
19.
14.
15.
16.
17.
18.
Approximate Limit of Loch Lomond Watershed.
TERRIO LAKE
11.
10.
9.
8.
7.
6.
5.
4.
3.
2.
Stackhouse. Totten.
Conway.
Neill.
Crockett.
McFall.
McFall.
W. Cain.
Brayden.
Stackhouse.
J. Cain.
Sands.
UPPER L. LOMOND
MIDDLE L. LOMOND
LOMOND.
17 M.
18 M.
16 M.
15 M.
14 M.
Sherwood.
Sherwood.
McAllister.
McDermott.
Robertson.
Hagerty.
Hurley.
Hurley.
Hurley.
Sherwood.
Armstrong.
Ratcliff.
Johnston.
Brayden.
17.
16.
15.
14.
13.
12.
11.
10.
J. Baxter.
Saw Mill.
WILMOT BROOK.
Gilmour.

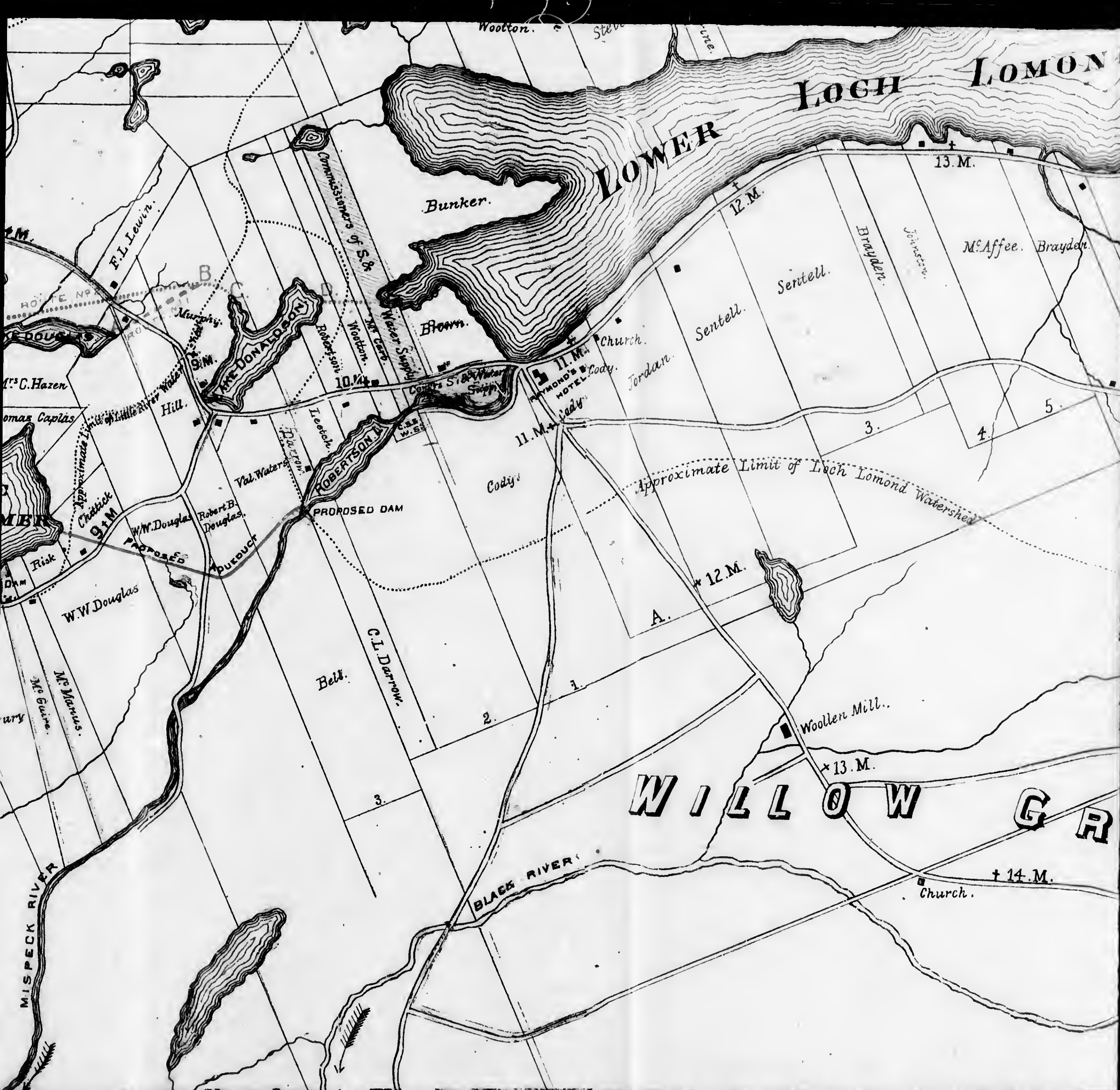

Commissioners
of
SEWERAGE & WATER SUPPLY.
A. Chipman Smith, Esqr. CHAIRMAN.
Thos. M. Reed, Esqr.
Alexander Duff, Esqr.
L. LOMOND
Mc Fall.
Mc Fall.
Totten.
Mc Dermott.
Sherwood & Cother
Neill.
18 M.
19 M.
20 M. From Court House.
SOUTH STREAM.
16.
17.
18.
Approximate Limit of Loch Lomond Watershed.



ST. JOHN & MAINE RAILWAY
GRAND SOUTHERN RAILWAY
CARLETON BRANCH RAILWAY
SAINT JOHN (WEST)
FORT DUFFERIN
BAY OF FUNDY

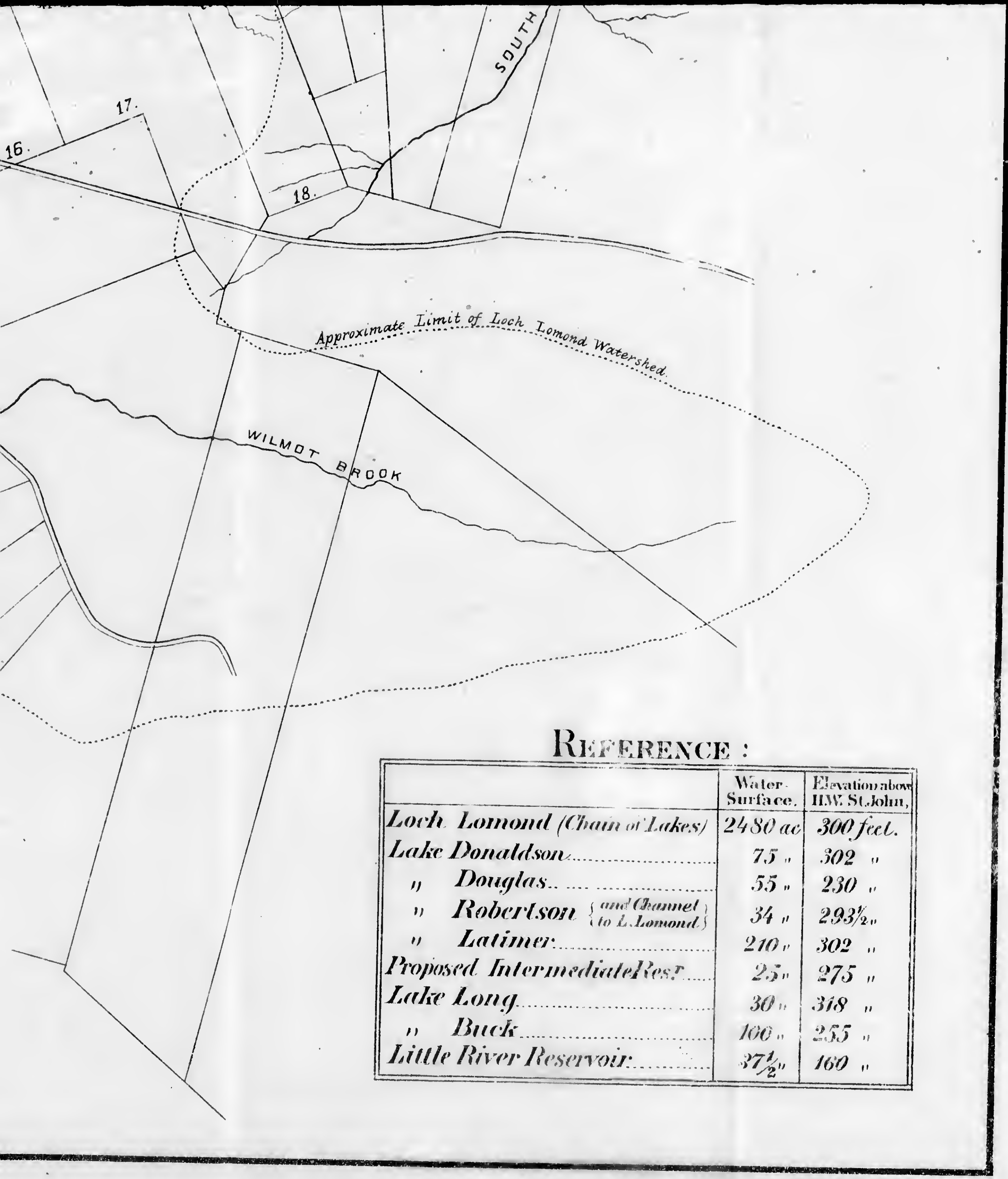
LILY LAKE
MARSH
INTERCOLONIAL
2 M.
RURAL CEMETERY
LINES OF PIPES CONVEYING WATER TO R.C. INDUSTRIAL SCHOOL
NEW ROMAN CATHOLIC CEMETERY
Jardine
Jardine
Gilbert
1 M.
1 M.
Wilson.
Clark
Shaw
3 M
2 M.
Pub. School
Creighton
Calkin.
Shillington
Shillington
McSween
4 M
OF ST. JOHN & TOWN OF
Miles
J. Arthurs
CITY OF SAINT JOHN
HARBOUR
COURTENAY BAY
CROUCHVILLE
Alms House
Brick Yard
Little River
Brick Yard.
Jas. Lee.
FORT DUFFERIN
RED HEAD


Approximate Limit of Little River Watershed
Approximate Limit of Little River Watershed
LAKE LATIMER
LAKE BUCK
LAKE FITZ GERALD (to drained)
LAKE DOUGLAS
RESERVOIR
PROPOSED PIPE LINE
ALTERNATIVE PIPE LINE
PROPOSED AQUEDUCT
PROPOSED DAM.
Proposed Dyke
INTERMEDIATE RESERVOIR
Little River
ROUTES A E
ROUTE No
SCHOOL.
4 M.
5 M.
6 M.
7 M.
8 M.
9 M.
EDMUNDS BROOK
MISPECK RIVER
H.W. Crookshanks
Mc Sweeny.
J. Arthurs.
Miles.
Harrison.
Armstrong.
Davidson.
Ryan.
Brayden.
E. Nelson
B. Nelson
John Nelson
Jas. Nelson
Boyle.
Bustin
O'Connell.
Mrs Chas. Hazen.
Est. C.D. Hazen.
Desmond.
G.S. Smith.
W. Murdoch.
Thomson.
Abbott.
Cox.
Caplas.
Mrs C. Hazen
Thomas Caplas
F.L. Lewin.
Murphy.
Hill.
Chittick
W.W. Douglas
Risk
DAM
Almon.
Heney.
Moore.
Drury.
Mc Guire.
Mc Manus.



Wootton.
LOWER LOCH LOMOND
13.M.
12.M.
Bunker.
Commissioners of S. & Water Supply
F.L.Lewin.
McAffee.
Brayden.
Johnston.
Sentell.
Sentell.
Brown.
Church.
Murphy.
Wootton.
Robertson
Robertson
THE DONALDSON
9.M.
10.M.
11.M.
Raymond's Hotel
Cody.
Jordan.
Mrs C.Hazen
Hill.
Thomas Caplas
Leetch
Darrow
ROBERTSON L.
11.M.
Cody.
3.
4.
5.
Approximate Limit of Loch Lomond Watershed
Approximate Limit of Little River Watershed
Val. Waters.
Chittick
9 M
W.W.Douglas
Robert B. Douglas.
PROPOSED DAM
PROPOSED AQUEDUCT
Risk
W.W.Douglas
12.M.
A.
C.L.Darrow.
Bell.
1.
2.
3.
McGuire.
McManus.
Woollen Mill.
13.M.
WILLOW GR
BLACK RIVER
14.M.
Church.
MISPECK RIVER

OMOND
15 M.
16+M.
Sherwood
Hurley
Hurley.
Hagerty
Robertson
17.
16.
15.
14.
13.
12.
11.
10.
9.
8.
7.
6.
5.
14.M.
Sherwood.
Armstrong.
Ratcliff.
Johnston.
Brayden.
Gilmour
Saw Mill.
WILMOT BROOK.
J.Baxter.
OTTER LAKE
TAYLOR LAKE
DAM
GROVE
.M.
15+M.
BLACK RIVER



Reference:

	Water-Surface.	Elevation above H.W. St John,
Loch Lomond (Chain of Lakes)	*2480 ac*	*300 feet.*
Lake Donaldson	*75 "*	*302 "*
" Douglas	*55 "*	*230 "*
" Robertson (and Channel to L. Lomond)	*34 "*	*293½ "*
" Latimer	*210 "*	*302 "*
Proposed Intermediate Res.r	*25 "*	*275 "*
Lake Long	*30 "*	*318 "*
" Buck	*100 "*	*255 "*
Little River Reservoir	*37½ "*	*160 "*