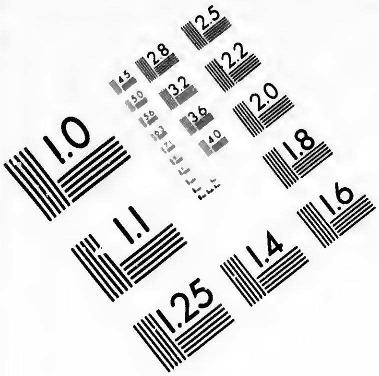
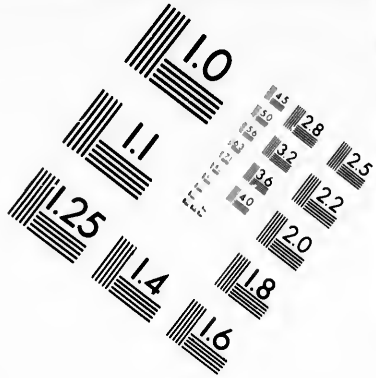

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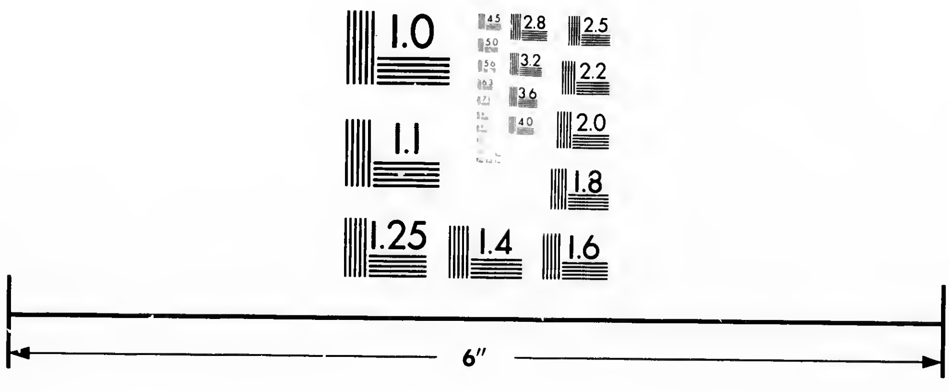

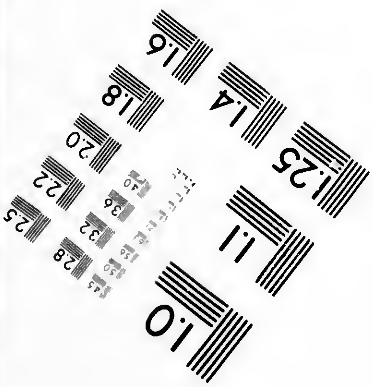
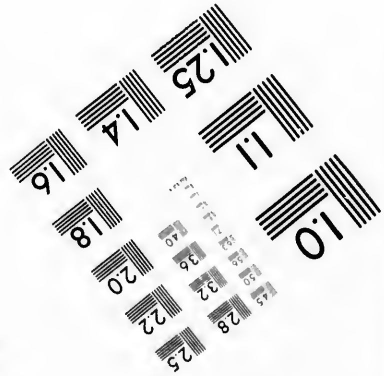

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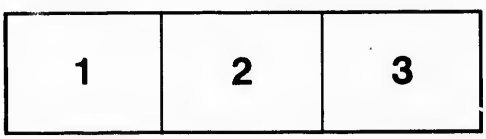
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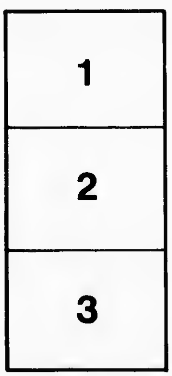
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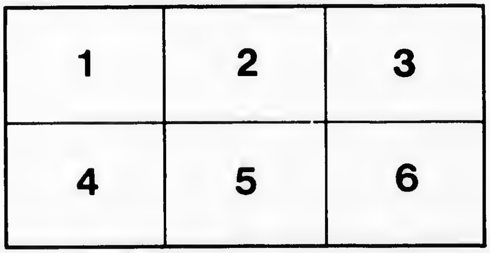
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A SCHEME OF SEWERAGE

FOR THE

CITY OF HALIFAX, NOVA SCOTIA,

PREPARED BY

THE CITY ENGINEER,

BY ORDER OF THE BOARD OF WORKS,

UNDER THE AUTHORITY OF THE CITY COUNCIL.

1876.

HALIFAX, N. S.,
BLACKADAR BROS., STEAM PRINTERS.
1876.

A SCHEME OF SEWERAGE FOR THE CITY OF HALIFAX, N. S.

TO THE BOARD OF COMMISSIONERS OF CITY WORKS:

Gentlemen,—

In conformity with your instructions received in July last, I have gone very carefully into the consideration of the whole of the matters appertaining to the construction of a thorough system of sewerage for this city; and I submit herewith a plan (marked No. 4 A), upon which is shewn a system of sewers—in my opinion—not only suitable for our present requirements, but which will be sufficient when the whole district under consideration is thickly built upon. Instructions. Proposed Scheme.

The surveys were commenced on the 27th of July, 1875, at which date an assistant engineer was engaged, at a salary of $100 per month, whose whole time has since been taken up in surveying, levelling, and plan drawing in connection with this scheme. Surveys.

The amount of money granted by the City Council to prepare the plan referred to, was $1,500, and the entire cost has been $1,281.66. Expenses.

The following is a list of the plans which it has been found necessary to prepare, and which are submitted with this report. Plans prepared.

No. 1 A. An accurate plan of the whole city on a scale of 400 ft. to the inch, with the elevations above city datum marked at all intersections of streets, at all changes of grade and undulations in the streets and roads.

No. 2 A. A plan of the whole city, scale 600 ft. to 1 in., shewing all existing water courses and the water-sheds.

No. 3 A. A plan, scale 600 ft. to 1 in., shewing all existing sewers, their approximate sizes and depths.

No. 4 A. A copy of No. 1 A. (without the elevations), shewing the proposed new system of sewers, together with the old sewers.

No. 5 A. A tracing, scale 400 ft. to 1 in., shewing the drainage areas of all the proposed sewers and the quantities of combined rain water and sewage which they are calculated to discharge when running half or two-thirds full according to the nature of the district.

Also—Sections or profiles of all the streets and roads, plotted on profile paper to a scale of 100 ft. horizontal to 30 ft. vertical.

Chief Matters for consideration.

In designing a system of sewerage, the principal matters requisite to be taken into consideration are—

1st. The area to be drained.
2nd. The rainfall.
3rd. The topography of the district.
4th. The population both present and prospective.
5th. The water supply.
6th Existing sewers.
7th. Ventilation.
8th. The difficulties in the way ot carrying out the proposed scheme.
9th. The probable cost.

Object in preparing Scheme.

It must be borne in mind that it is not now proposed to construct the whole of the sewers laid down upon the plan. The chief object in preparing this scheme being that in all new constructions a system might be adhered to which would be adapted to our prospective wants.

AREA.

Area of City.

Area to be drained.

The area of the whole city is 4,363 acres. The total area which will ultimately be drained by the proposed system of sewers is 2,236 acres. This may be termed the city proper, as it includes the whole of that portion of the peninsula of Halifax which has been laid off into streets, besides a large suburban district.

Sewers at present unrequired.

Nearly half of the sewers shewn on the plan are not now, nor will they be, required for many years to come. For this reason I have thought it advisable to again sub-divide—what I have termed—the city proper, into two divisions, shewn on the plan by the tinted purple line.

Sewers now required.

Within the purple line the streets are mostly built upon, and the town may be considered as growing rapidly inside of this limit. New sewers are therefore more required inside of this sub-division than beyond it, and a separate estimate is given of the cost of constructing these, nearly all of which are now required for the health of the town. The construction of the others may be deferred until they are wanted.

RAINFALL.

For statistics of the rainfall I am indebted to Mr. Frederick Allison, M. A., Chief Meteorological agent to the Dominion Government.

Statistics.

The amount of rain which fell during the past year ending 31st December, 1875, was 42·493 inches. The depth of snow was 87·81 inches, and the total precipitation, or the combined rainfall and melted snow, was 51·48 inches.

The average for the last 13 years was as follows: Rain, 43·367 ins. Snow, 82·26 ins. Total precipitation, 52·172 ins.

It is not, however, so much with annual or mean annual results we have to deal in questions of sewerage, as with maximum falls within a limited period of time.

Heaviest rainfall

The heaviest rainfall in a short time—of which I have any information—occurred on the 19th June, 1872, when 0·183 of an inch fell in half an hour.

Other heavy rainfalls.

On the	20th Dec., 1869 — 1·024	In. fell in	5.6	hours	=	0·221	In. per hour
"	28th Aug., 1871 — 0·888	"	3·7	"	=	0·240	"
"	19th Feb., " — 1·100	"	4·5	"	=	0·267	"
"	29th June, 1872 — 0·448	"	1·3	"	=	0·345	"
"	17th Aug., " — 1·285	"	4·7	"	=	0·274	"
"	14th Oct., " — 1·090	"	4·5	"	=	0·242	"
"	13th Nov., 1873 — 1·520	"	5·5	"	=	0·276	"
"	9th Jan., 1874 — 1·040	"	4·1	"	=	0·256	"

Statements of Mr. Allison.

Mr. Allison remarks, "it is probable that these rains did "not fall equally hour by hour; but where they persist, as "these did, for four or five hours falling heavily, the want "of proportion is not so great as an inexperienced person "would imagine; and if, for instance we allow ·37 to one "hour of the fall of 13th November, 1873, leaving 1·15 to "the remaining 4·5 hours, I think we will be within the "limits of disproportion; for remarkably heavy showers, as "that of 19th June, 1872, never last long."

Heavy rainfalls in 1875.

Two very heavy rain storms occurred here during the past year, occasioning much damage to the streets and roads especially in the steep hill districts, and flooding a few cellars—see my annual report for 1875. The first took place on the 10th October, when 4·406 inches fell in 18 hours. This is the greatest fall recorded in 18 hours since 1859, or for a period of 17 years. The second occurred on the 10th and 11th November, when 2·418 inches fell in 17½ hours, and for violence at the time of its greatest height this exceeded the former. The gauges were observed every three hours, the result being that during the storm of 10th October the greatest fall was 0.996 inch from 9 a. m. to noon, while in the storm of 11th November 1.003 inch fell from 6 a. m. to 9 a. m.

Gaugings of Freshwater Brook

Gaugings of Freshwater brook were taken in the Public Gardens during both of these storms, when it was found that the greatest flow occurred about 40 minutes after the heaviest fall on 11th November, at which time 3,500 cubic feet of combined sewage and rain-water were running per minute over the weir, from an area of 373 acres, mostly suburban. This would be at the rate of 9.38 cubic feet per minute per acre.

Capacity of the new Sewers.

All the new sewers are arranged to carry off the combined sewage and rainfall, and in order to reduce their size, and consequently the cost as much as possible, storm overflows are introduced wherever practicable on all the long lines, by which means the storm waters will be discharged directly into the harbour at the nearest point.

Overflows.

Method of calculating size of Sewers.

The calculations of the required discharges and sizes of the sewers were prepared in the following manner.

Provision being made for a rainfall of 0.38 inch per hour, (a quantity which has been nearly though never quite reached, as far as I can ascertain) the yield per acre would be 1379 cubic feet. Allowing half of this quantity to flow directly into the sewers=11·5 cubic feet per minute per acre. Providing for a population of 50 persons to the acre and allowing seven cubic feet of sewage per day for each person, one-half of which is found from observation to pass off in from six to eight hours=0.50 cubic feet per minute per acre, or a total of 12 cubic feet to the acre per minute in the time our greatest rain storms.

Provision for extraordinary storms.

In order to provide against the liability of the sewers being gorged during heavy rains, when the surface may be covered with large quantities of melting snow, they are made large enough to discharge the above quantity when running two-thirds full in comparatively flat districts, and half full in the steep hill districts of the town.

London Sewers.

The new sewers of London are calculated to discharge only one quarter of an inch rainfall in 24 hours, in addition to the sewage.

Experiments on London Sewers.

In Neville's work on hydraulics—containing probably the most reliable data relative to the flow of water in pipes and sewers in the English language, *the following is stated in reference to some experiments made in the London sewers to ascertain the proportion between the rainfall and the actual discharge of sewers.

" In a town district, such as that drained by the Savoy and " Northumberland—street sewers, the quantity running off " into sewers, within six hours after the fall, varies from 10 " to 60 per cent of the quantity fallen. Of the rain during " the storm of the 20th June, 1857, nearly one inch and a " quarter in an hour, 65 per cent, ran off within 15 hours of " the fall, viz :—

*A writer to " Engineering"—whose article is copied into " Van Nostrand's Magazine (April No., 1876)—throws some doubt upon this statement, and even goes so far as to hint that there is no reliable work on hydraulics to be found in the English language.

"46 per cent in 45 minutes after the rain ceased.
"14 " in the next 6¾ hours.
" 5 " in the next 7½ hours."

Assuming these deductions as applicable here, the result would be that our sewers should be large enough to discharge a rain fall of 14·10 cubic feet per minute per acre in addition to the sewage or in all 14·60 cubic feet per acre, which they are quite capable of doing even when not nearly full.

TOPOGRAPHY.

The physical outline of the town favorable to the construction of Sewers

The topography or configuration of the town is highly favorable to the construction of sewers. The deepest excavation will not exceed 16 feet, and the average will be about 9½ feet.

Necessity for Ventilation

Owing to the steep gradients of many of the streets, sewers of comparatively small size will answer; but this renders it the more imperative to take special precautions for ventilation, as the more rapid the descent of a sewer the quicker will the foul sewer—gases, generated, ascend to the higher localities.

POPULATION AND WATER SUPPLY.

Sewage small when compared with rain-waters

In a scheme of drainage such as this now proposed, where the sewers are adapted to discharge heavy rainfalls, the consideration of the population and water-supply, becomes a matter of minor importance; as the amount of house-drainage-water, or sewage, as it is termed, is extremely small, when compared with the storm waters which the sewers will—at times—have to carry off. In fact where the sewers are proportioned—as is here the case—as rarely being taxed to more than two-thirds of their capacity, the element of sewage, could, without much danger, be entirely omitted from the calculations.

Population provided for.

Water supply provided for

For the purposes of this report, however, it has been deemed amply sufficient to provide for a population of 50 persons to the acre, over the whole area which it is proposed to drain, and to allow to each person a water supply of 50 gallons per day.

Population in the heart of the town.

As a matter of information it may be interesting to know, that in the heart of the town, the population is 86 to the acre; the portion taken, being the populated parts of wards 3 and 4, or that lying between the Citadel Hill on the west and the harbour on the east, Sackville street on the south and Jacob street on the north, not including the wharves and H. M. Ordnance Yard. The area of this district is 65¼ acres, and the population is 5,608, according to the report of the Secretary of Statistics for 1871. There is probably no material difference in the population now. This district is all on steep side-hill ground, and the proposed sewers are of sufficient capacity to discharge the storm waters and sewage combined, when running less than two-thirds full.

EXISTING SEWERS.

Old sewers retained where practicable.

One of the chief points borne in mind in preparing this scheme, was, to design the new works in such a manner as to utilize as many of the existing sewers as possible, where they were deemed efficient, or that they could be made so.

Length of existing sewers.

There are now known to be 18·66 miles of public sewers in use, besides a number of stone-box-drains of doubtful utility which may, or may not, have been constructed at the public expense.

Character of existing sewers.

Of these 18·66 miles, 3·71 miles are built of brickwork; 10·77 miles are common stone sewers, and 4·16 miles are earthenware pipes.

Many of these sewers are wretched constructions, and totally unfitted for the work they are supposed to do; causing endless trouble and expense in cleaning, continually choking up, and frequently flooding the cellars in the vicinity.

Necessary to abandon some of the existing sewers.

In carrying out the proposed system, it will be necessary to abandon 6.44 miles of the existing sewers. The remaining 12·44 miles may, I think—to a large extent—be utilized. Probably some of the latter, on being opened and examined, will be found unsuitable to be retained.

Stone drains should be abandoned.

As a rule, the ordinary stone-box-drain, or sewer—as here constructed—should be abolished; the only places where they can safely be allowed to remain, being, where they exist in a soil not already, or likely to become "excrement sodden," or soaked with sewage matter, where they are of sufficient capacity and depth; and where they have a constant and sufficient flow through them to keep clear of deposits.

VENTILATION.

That all sewers should be ventilated is an axiom which will scarcely be controverted.

Dangers of unventilated sewers.

It has been stated—and with much truth—that unventilated sewers are far more dangerous than steam-boilers without safety-valves.

The following is quoted from Latham's work on Sanitary Engineering:

"It is a remarkable fact, but nevertheless true, that from those towns in which no proper provision is made for the ventilation of the sewers, a certain type of disease (typhoid fever) is seldom absent. The normal condition of the generality of houses has an important bearing on the necessity for the ventilation of sewers and drains. The superior temperature of the air of houses, and the draught caused by chimneys, have the effect of causing the various traps that are used to seal the drains to be relieved from pressure. Consequently, as there is less atmospheric pressure upon the traps within houses than upon external traps, and, moreover, as many of the traps used within a house have far less seal than those usually employed out of doors when no ventilations is provided, gases are sure to escape into houses as the point of least resistance. The evil effects of the want of ventilation were conclusively shown in the early sewerage works of Croydon, in which place, no sooner were the works of drainage drawing towards completion, than the town was visited by an epidemic of typhoid fever, which was traced entirely to the absence of ventilation in the system of sewers. The mortality of Croydon at this period rose from 18·53 per thousand in 1851 to 28·57 per thousand in 1853. These early sewer works were designed on the principle that all matters were to be so rapidly discharged from the sewers, and the sewers flushed with such a copious supply of water, that decomposition could not take place, and therefore it was thought that sewer-gas would never be present; but in practice this theory was not found to be borne out, and it is a remarkable coincidence as to the cause of the frequent outbreaks of fever in Croydon, which took place at certain intervals until the year 1866, when the sewers were thoroughly ventilated, that diseases which formerly made their haunt in the low-lying districts were transferred, after the completion of the drainage works, to the highest or best portions of the town, thereby establishing the fact that the presence of the disease in the high localities was due to something carried in the air of the sewers, which, in obedience to a natural law, accumulated in the highest part of the district."

Necessity for Ventilation.

Effect of temperature of houses.

Effect of non-ventilation of sewers at Croydon.

Early sewer works of Croydon.

Transfer of disease from lower to higher distric

* * * * * *

"With regard to the results that have arisen where ventilation of sewers has been adopted, the case of Croydon shows clearly that proper ventilation has been attended with very beneficial results. Since the introduction of systematic ventilation there have been no periodical outbreaks of fever, and the general rate of mortality has so declined, that in a district having a population of nearly sixty thou-

Result of sewer ventilation;

sand persons the rate of mortality rarely exceeds eighteen in the thousand, which is a standard of health unparalleled in the history of sanitary science, for a district having so large a population. The case of London affords another striking example as to the influence of sewer ventilation. Here the sewers are ventilated, though no general plan is adopted for dealing with the noxious effluvium escaping from the ventilators, and yet London stands at the head of all large towns by reason of its small death-rate, which has been ascribed by more than one eminent authority to the somewhat rude ventilation provided for the sewers."

Different plans of ventilation.

Numerous have been the plans proposed at different times for the ventilation of sewers. One, which has found many advocates, is to utilize for this purpose the "down-spouts" or rain-water-conductors from buildings, by connecting them, untrapped, with the sewers. This method has many objections, the principal of which are, that the down-spouts are seldom made with tight joints, so that the sewer-gas may escape freely in its upward course and find its way into the house through loose or open windows; or even supposing it to be carried safely to the eaves-gutter, it will then gain easy access to the houses through the dormer windows. If, as a rule, all down-spouts were made perfectly tight throughout their whole length, were connected with the crown of the sewer, and could be carried up to the highest part of the house, this expedient would not then be objectionable, presuming that other conditions were also complied with. But the down-spout would then cease to act as a rain-water conductor and would be solely a sewer ventilator of a very expensive kind, if applied to all or any large number of buildings. The practical way, however, usually adopted in this case, is to connect the rain-water-spout with the house drain at some convenient point, which drain invariably enters the sewer at about a foot or so above the invert, so that when the sewer is running partially full and the ventilator is much, if not most, needed, its mouth will be closed, and so of necessity it must entirely cease to act in that capacity.

Objections to ventilation by means of down-spouts.

Proposed method of ventilation.

The method of ventilation proposed in this scheme is by means of the man-holes in the centre of the streets—placed at frequent intervals, seldom exceeding 300 feet apart—and at the head or upper end of all branch sewers. At each man-hole where sufficient fall for the sewer can be obtained without going to much extra expense, a step, or drop in the invert, is made for the purpose of breaking the ascent of the sewer-gas, which otherwise is found to have a tendency to leap over the opening and to pass upwards along the sewer. This arrangement has also the additional advantage of enabling the sewers to be constructed in straight lines from man-hole to man-hole, thereby affording a better opportunity for inspection and to keep the whole system entirely under control, without the necessity of digging up the streets.

It is scarcely within the limits of this report to enter upon the subjects of house drainage and the trapping and ventilating of private drains, but this I think it incumbent upon me to say, that—for the future sanitary condition of the town, and to realize the benefits which should result from the expenditure of such a large sum of money as is now contemplated—these are matters of the utmost importance; in fact, without proper attention being paid to these details, it is questionable if it would not be better to have no sewers at all. I would strongly advise all householders to act entirely on the defensive principle, *i.e.*, to assume that the sewers have no other means of ventilation than into the houses in which they dwell. In this case they are pretty sure to adopt measures which will exclude sewer-gas from their dwellings.

Necessity for trapping and ventilating private drains

Advice to householders

SEWERS.

The lengths and sizes of the different sewers are given in the estimates of cost.

Earthenware pipes.

There are a few places where earthenware pipes of nine inches in diameter may—I think—be used with advantage, but generally brick sewers are in my opinion preferable, and I do not hesitate to recommend their use to the exclusion of pipes above that size. My reasons for arriving at this conclusion are:

Objections to the general use of Earthenware pipes.

1st. That in my experience, where large crock pipes have been laid and there has been occasion to lift or examine them, it is quite the exception to find them perfect. Usually they are found to be so broken as to render it necessary to put in new ones.

2nd. That there is practically a good deal of difficulty in getting pipes properly laid, especially in rock excavations which, with us, are the rule. To be well laid a groove should be cut in the bottom of the trench to receive each socket end, and each pipe should be carefully placed in true line, on a perfectly even bed, or, when the pipes are laid to bear upon the sockets, they should be very carefully packed beneath. It is found, however, almost impossible to get these conditions properly attended to—even simple as they are—especially in contract works.

3rd. That when junctions with private drains require to be made, a very common practice is to break the pipe sewer and insert the end of the pipe drain, instead of going to the trouble and expense of providing a proper junction, the difficulty of which is very much increased where the pipes are cemented together. Cases of stoppage in pipe sewers and the consequent flooding of cellars in the vicinity have arisen from this practice.

4th. That in the case of pipes of twelve inches in diameter and upwards, it is cheaper to build brick sewers of equal or larger diameters. According to my estimates, a barrel drain of brick 14 inches in diameter costs about the same as a 12 inch pipe, and one of brick 24 inches the same as a 15 inch pipe.

Places where it is proposed to use pipes.

The only places where it is now proposed to lay earthenware pipes are in a few small courts and lanes, where nine inch pipes will be amply large enough. It will be seen from the schedule that there will also be required about 415 feet of 12 inch and 40 feet of 15 inch pipes; these, however, are only for the purpose of continuing existing pipe sewers—that can be utilized—a little further along the streets in which they are laid.

Description of brick sewers.

With the above exceptions all the proposed sewers will be built of brickwork laid in Portland cement mortar. Most of these will be egg shape,—with the smaller end down—but in some places where the flow will be continuous and always comparatively large, it has been thought better to provide circular sewers. The smallest brick sewer will be 18″ × 12″, egg shaped, and the largest one of the same kind, 42″ × 28″. The smallest circular brick sewer is 24″, and the largest 48″ in diameter.

No small bricks to be used.

It is proposed to use no small bricks or bricks of the ordinary size in the construction of these works, but in all cases to employ large and specially made bricks for the purpose. The large bricks will be of the standard English size, with a certain proportion of radiated bricks.

Thickness of Sewers.

The sewers up to 30 inches in diameter and those 24″ × 36″ will be mostly half a brick or 4½″ thick. For sewers above these sizes and up to 45″ in diameter—in order to save the expense of double work—it is proposed to use a still larger description of brick, or one 6 inches in width or depth. All larger sewers will be double ring work or 9 inches thick. There may arise exceptional cases where it will be necessary or advisable to depart from the above rules.

Sizes of small bricks.

Among the ordinary bricks which come to this market, the largest I have seen, measure 7¾″ in length 3¾″ in width and 2¼″ in thickness, though such are rarely to be met with.

The usual size is about 7½" long, 3½" wide and 2" thick, while some are even smaller. My reasons for not recommending these to be used are:—1st. That even though the cost per thousand is considerably less than that of the proposed bricks, they are a more expensive article. In my judgment it would be economy to pay nearly double the price per thousand for the larger bricks on account of the very much larger quantity of work which they will lay. 2nd. That although the smaller article is no doubt amply sufficient for the smallest description of sewers of half a brick in thickness, yet for a sewer of 2′–0″ or 2′–6″ in diameter it would scarcely be safe to construct the work less than one brick thick, thereby adding very largely to the cost.

Objections to the use of small bricks.

It is proposed to use none but the very hardest burned bricks in the inverts, especially where the inclinations are at all rapid; and in those places where they are very steep—or where for other reasons it would appear desirable—the inverts will be of double thickness.

Hard burnt bricks to be used in inverts of sewers.

In this scheme the town is divided into eleven sewerage districts (see plan No. 5) each having a distinct and complete system of sewers within itself, with the exception of district No. 5, the storm waters from which will overflow and pass through portions of districts Nos. 6, 7 and 9, and from thence into the harbour. These districts may be briefly described as follows:

Description of proposed plan.

District No. 1.

In the south end of the town, lying to the south of South Street and Victoria Road; drains an area of 180½ acres and discharges into the harbour through the public water lot to the North of Laidlaw's wharf.

District No. 2.

Includes the whole water shed of Freshwater brook, an area of 764½ acres and discharges at Freshwater.

District No. 3.

Lies to the south of Spring Garden Road and to the east of Queen Street, having an area of 39 acres and discharging the greater portion of the sewage in dry weather, through the outlet of No. 4 district, but in wet weather the whole will be discharged through H. M. Lumber Yard into the harbour, by means of a self acting gate at the intersection of Hollis and Morris Streets. This arrangement is made for the purpose of maintaining a constant flow—in dry weather—through the Water Street sewer between Bishop Street and

Prince Street, as the inclination of the sewer there is very small; while during heavy rain-storms this sewer will, at times, be tide-locked and it is then desirable to exclude from it as much as possible.

District No. 4.

Lies to the South and East of the Citadel Hill and has an area of 93¾ acres. This district is thickly populated. The outlet will be into the harbour, at the foot of Prince Street.

District No. 5.

Includes a large part of the thickly settled sections of the town. This may be termed an intercepting district, as its design is to cut off from the low-lying portions of the town the sewage from those parts which are at a higher level. The area is 325½ acres and the dry weather outlet will be through the new sewer constructed last summer at the foot of Bell's Lane. During heavy rain storms a self closing gate—at the intersection of Proctor's Lane and Lockman Street—will shut off the great bulk of the sewage from going in that direction, when it will be discharged through the outlet for district No. 6. This latter arrangement is necessary on account of the new sewers in Lockman Street Extension being too small to discharge all the waters which would then be brought to them.

District No. 6.

Is a small district extending northwardly along Water Street from the foot of Jacob Street and including old Lockman Street as far north as Gray's Lane. The area is 18¼ acres and the discharge is through the city water lot near the foot of Hurd's Lane.

District No. 7.

This is a small district lying to the north of No. 6, and including portions of Water Street and Lockman Street. The area is 40¼ acres and the outlet is into the harbour through the North Slip lot.

District No. 8.

Lies to the west of District No. 2. It is all suburban and none of the sewers are at present much required. The area is 315¼ acres and the outlet is into the North-West Arm at the foot of Coburg Street.

District No. 9.

Is situated to the north and east of District No. 5, and extends northwardly to Duffus Street. This district is nearly all suburban. The area is 244 acres, and the outlet will be by means of the brook through the railway grounds at Richmond Depot.

District No. 10.

Lies to the north of District No. 9, and includes the greater portion of the Glebe lands of St. Paul's Church, recently laid out into Streets. The area is 118 acres, and the outlet will be into the harbour through private property, and the Railway grounds. The right of way through the private property (which has already been offered to the City) should be acquired at once, and I have no doubt but that the government could be induced to construct a culvert through the railway grounds, at their own expense, as it is even now much required for railway purposes.

District No. 11.

Is a small district of 44½ acres, including that portion of the town recently laid out into streets and built upon by Colonel Hornsby. This district may be almost indefinitely increased when required, and the outlet will ultimately be into Bedford Basin. At present there is no suitable outlet for the sewage from this district, unless it be applied to the lands in the vicinity and the storm waters be turned into the natural water-courses.

In order that any sewer may not become a "sewer-of-deposit," it is essential that it should have a certain rate of inclination, which must be determined by the size of the sewer and the ordinary quantity of sewage which it will have to discharge. For this reason, small sewers—up to 12 inches in diameter require a velocity of about three feet per second; from 12 inches to 24 inches in diameter a velocity of not less than two and a half feet per second, and above 24 inches in diameter a velocity of—at least—two feet per second. The proposed sewers are all designed with due regard to these circumstances, and the gradients vary from about 1 in 10 to 1 in 600. Few of the small sewers will have an inclination of less than 1 in 250. This inclination, for a sewer 18″ × 12″, (which is the smallest egg-shaped sewer proposed) will give a velocity of 2·85 feet per second when running one-third full. In places where the flow will on ordinary occasions be small, the inclination is increased as much as possible. But as an additional precaution, and in order to provide against accidental deposits, all the man-

Gradients of sewers.

Provision made for flushing.

holes will be so constructed that by the insertion of a temporary flushing board or gate the sewage may be dammed up until a large volume is collected, when, by raising the gate the whole quantity so dammed back will be at once discharged, the effect being to flush the sewers. The manholes require to be arranged in this manner particularly at the heads of all branch sewers, but, for the purposes of flushing, water from the nearest hydrant will have to be used.

Sewer junctions with pipe drains.

For the purpose of making connections between pipe drains and the public sewers, it is proposed to use specially made junction-blocks which will be formed to correspond in thickness, and with the internal figure of the brick sewer.

Owing to the expense of providing junctions in the sewers (as has been the practice for the last three years) for all buildings, lots, and purposes; the uncertainty of placing them in their proper positions, and the fact that large numbers must unavoidably be built in, where in all probability they will never be used, or—at least—not required for very many years; I would recommend—in ordinary cases—providing them only at points where they are now required and where they are wanted by the owners of property. As regards breaking into a sewer for the purpose of inserting a junction, it may be done without much fear of damaging the sewer when junction-blocks of the proper form are employed, and ordinary care is used by the person doing the work. It would be a wise precaution, however, to allow no persons to tap the sewers but such as hold a license from the City for that purpose.

Objections to contract system.

There is another matter to which I would draw attention, and that is, the great difficulty which exists in getting sewer works—which are let out to contract—constructed in a satisfactory manner. For this reason I would recommend that the proposed sewers be built by "days work" in preference to the contract system. In my judgment this course will not only result in a large saving of money, but in the works being executed in a thorough and superior manner.

Difficulties in the way of carrying out the work.

No serious difficulties.

There are no serious difficulties in the way of carrying out the projected system of sewers, and certainly none of any kind which would not be common to any scheme that might be proposed.

Chief causes of trouble to be anticipated.

The chief causes of trouble and expense will be:—

1st. The large amount of rock to be encountered in almost every section of the town.

2nd. The gas and water pipes which lie at depths varying from 4 feet to 8½ feet. Cases may arise in which it would be necessary, or advisable, to alter the proposed gradients of some of the sewers on account of these pipes, or for other reasons. Should such occur, plan No. 5A will be found of service in determining the corresponding changes which should be made in the sizes of the sewers. Gas and Water pipes.

3rd. The Street Railway will be found a constant source of trouble, danger, and heavy expense in prosecuting the works, on account of the narrowness of some of the streets in which it is constructed and the double line of rails which must be constantly kept open to traffic, well shored up and carefully guarded, combined with the fact that the charter held by the company is so one-sided on some points and so extremely vague on others, that the Managers claim to have rights over our streets superior to those of the city. Street Railway

In order to carry out the proposed system in its entirety it will be necessary to open a few new streets, which in all cases it is advisable should be done whether this scheme is adopted or not. Necessary to open new streets.

The streets requiring to be opened are the following: Atlantic St.

1st. Atlantic Street, to be extended eastwardly from Bland Street to Pleasant Street. This extension will be an expensive one on account of the large amount of rock cutting which will have to be made. To grade the new street properly the amount of rock excavation will be about 8,000 cubic yards and earth about 3,000 cubic yards. The stone, however, taken out will be valuable for building purposes and if sold—will reduce the cost of the work very considerably. Should it be decided not to make this extension, it will be necessary to lift about 900 feet of 15 inch earthenware pipes now laid in Inglis Street and to build a new sewer of about 30 inches in diameter in the same place.

2nd. Neal Street to be extended from Summer Street to Tower Road. The eastern end of this extention is already partially opened and it only requires a small piece of land to be taken to make the connection. The land through which this extension passes is City property held under lease. Neal St.

3rd. Louisburg Street to be extended northwardly to Allen Street. This extension is rendered necessary by the contemplated large additional area which it is proposed to drain into the valley of Freshwater brook. Louisburg St.

4th. Clifton Street to be extended southwardly to come out on Robie Street at the west end of West street. This extension, although not absolutely necessary, is considered advisable as it will follow the lowest ground to be found in Clifton St that locality and as it will avoid the necessity—which otherwise would exist—for making very deep excavations in North Street and Robie Street.

5th. *————Street to be extended northwardly from Duncan Street to Chebucto Road, a distance of of about 200 feet only.

King St.

6th. King Street to be extended southwardly from Paris Street to Chebucto Road. The only portion of this extension which is necessary to be provided for at present is that part lying between North Street and Chebucto Road.

Maitland St.

There is another Street extension shewn upon the plan, viz:—that of Maitland Street northwardly to North Street, which—although not required for the purposes of this scheme—is a desirable one to be executed.

TIDES.

Tide gauge established.

On the 6th of September last a tide-gauge was set up at Corbett's Wharf and has been regularly observed. The following are the results for the seven months ending 31st March:

Extreme tides.

The highest tide observed occurred Feb. 2nd, 1876=6'-6" above city datum (strong S. wind).
The lowest tide observed occurred Feb. 3rd, 1876=2'-7" below city datum (strong N. W. wind.)
Difference between extreme high and low tide=9'-1"

Ordinary tides.

Mean high tide..............................=3'-8" above city datum.
Mean low tide..............................=0'-10" below city datum.
Difference between mean high and low tide...=4'-6"

The Saxby tide.

During the great storm of October 4th, 1869, which was accompanied by a tidal wave—commonly known as "the Saxby tide"—the greatest height to which the tide rose was eight feet above city datum, or only one foot and a half above the tide of 2nd Feb. of this year.

Cellars in Water St.

Many of the cellars along Water Street are about the same level as ordinary high water mark, the lowest being about 3 ft. 9 in. above datum.

Effect of high tides.

The sewers in Water Street will in most cases be deep enough to drain the deepest cellars, it must, however, be expected when tides rise to the same or to a higher level than the bottom of a cellar, that it will be flooded, unless the walls and bottom are impervious to water and proper precautions are adopted to keep out the waters of the sewer. The sole risk must in such cases be with the owner, it would clearly be preposterous to hold the city liable.

Deepest outlet

The deepest outlet will not be below the level of ordinary low tides.

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* This street has no name to my knowledge.

ESTIMATES.

It has already been stated that most of the sewers within the purple line on the plan are now required, while without that line, few of them can be considered of urgent necessity; in fact many in the latter district are in streets not yet opened.

Practically therefore we have now only to consider the probable cost of carrying out this scheme so far as it is contained within the limits of the purple line; the great bulk of the remaining portion of the scheme will not—in all probability—be required for many years to come.

Uncertainty as to rock work.

Owing to the large quantities of rock in most parts of the town, its extreme irregularity and the uncertainty that exists as to the amount that will be encountered, it has been thought prudent to allow one half of the excavations to be rockwork. This allowance is deemed to be somewhat in excess of what may be expected and consequently the estimates may be considered as very liberal.

Estimates considered fu

Estimate of the Cost of Constructing the Sewers inside of the Purple Line,

Allowing half of the excavations to be in rock and the average depth to top of brick invert to be nine feet.

Size of Sewer.	Length.	Average cost per lineal foot.	Total cost.	Remarks.
Inches.	Feet.	$	$	
9	1900	2·75	5225	Earthenware pipe.
12	415	3·00	1245	" "
15	40	3·50	140	" "
18 × 12	54100	3·00	162300	4½ inch brickwork.
21 × 14	7600	3·10	23560	" "
24 × 16	9000	3·20	28800	" "
27 × 18	2400	3·30	7920	" "
30 × 20	9200	3·40	31280	" "
33 × 22	5000	3·50	17500	" "
36 × 24	3000	3·60	10800	" "
39 × 26	1000	5·50	5500	6 inch "
24	700	3·40	2380	4½ inch "
30	400	3·60	1440	" "
33	1100	5·50	6050	6 inch "
36	700	5·80	4060	" "
45	1300	7·00	9100	" "
48	400	8·50	3400	9 inch "
48 × 36	300	8·00	2400	" "
Total length	98,555	feet . . . =	$323,100	

80 Man-holes in existing sewers at $60 each.........	4,800
420 ditto in new sewers at $50	21,000
Extra works at outlets and overflows.........................	5,000
Contingencies 10 per ct. (nearly)	35,100
Total probable cost	$389,000
Less amount to be collected for 132,000 feet frontage of assessble property at $1.25.	165,000
Total cost to the city..........	$224,000

The above estimate includes—besides the earthenware pipes there mentioned—3 millions of 4½ inch bricks in the sewers and 300,000 six inch bricks. 800,000 four-and-a half inch bricks in the man-holes, 60,000 cubic yards of rock excavation and 60,000 cubic yards of earth, besides tide gates, flushing doors and other necessary works. If the cost of constructing street gullies is to be charged to sewerage the estimate must be increased by 8,000.

Estimate of the Cost of the remaining portion of the system, or that lying beyond the Purple Line.

Size of Sewer.	Length.	Average Cost per lineal foot.	Total Cost.	Remarks.
Inches.	Feet.	$	$	
18 x 12	53100	3.00	159300	4½ inch brick-work.
21 x 14	12400	3.10	38440	" " "
24 x 16	6600	3.20	21120	" " "
27 x 18	4200	3.30	13860	" " "
30 x 20	3200	3.40	10880	" " "
33 x 22	1700	3.50	5950	" " "
36 x 24	3100	3.60	11160	" " "
42 x 28	820	5.40	4428	6 inch " "
30	1000	3.60	3600	4½ inch " "
33	700	3.70	2590	" " "
36	6200	5.80	35960	6 inch " "
45	100	7.05	705	" " "
40 x 36	700	6.00	4200	" " "

Total length 93,770 feet. = $312,193
300 man-holes at $50 each.... 15,000
Contingencies, 10 per cent, (nearly)........ 32,807

Total probable cost............$360,000
Less amount to be collected for 125,000 feet frontage of assessable property at $1.25 per foot............... 156,250
Total cost to the city.... ......$203,750

I have the honor to be,
Your obedient servant,
E. H. KEATING,
City Engineer.

City Engineer's office,
20th April, 1876.