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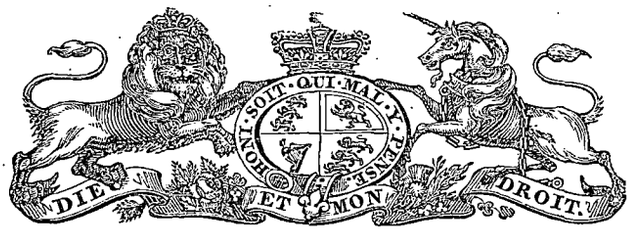

1896.

SESSION II.

PARLIAMENT OF TASMANIA.

REPORT ON THE SEWERAGE AND DRAINAGE OF THE CITY OF HOBART:

REPORT BY MR. C. NAPIER BELL, M. INST. C.E.

Presented to both Houses of Parliament by His Excellency's Command.

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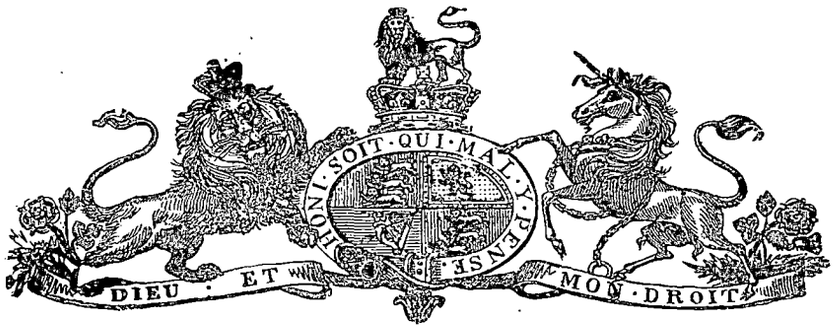


REPORT ON THE SEWERAGE AND DRAINAGE OF THE CITY OF HOBART.

To the Chairman of the Metropolitan Drainage Board.

SIR,

ACTING under your instructions, conveyed to me through your Secretary by letter dated 14 September, 1895, requesting me to make such examination of your Engineer's plans and report and of the locality as would enable me to give my opinion upon the scheme with respect to the sufficiency of the proposed collecting sewers and works connected therewith ; of the estimates of probable cost ; of the best method of disposal of the sewage ; and with regard to any other matters connected with the subject that I might think it necessary to enter upon, I have the honour to report as follows.

I arrived here on the 29th October, and at once put myself in communication with your Engineer, Mr. A. Mault. In company with him I made a thorough inspection of the city, the drains, creeks, and the shores of the harbour. We also made a series of observations of the direction of currents from Macquarie and Battery Points. We inspected Queenborough, New Town, and the site proposed for its outfall sewer, and examined the land which is suitable for a sewage farm. I also examined the plans and estimates prepared by your Engineer for the sewerage of Queenborough, Hobart, and New Town, and took note that at present Queenborough and New Town are excluded from the drainage scheme.

Present condition of drainage.

The position of Hobart, situated on slopes and ridges rising from the shore of the harbour to heights of over 350 feet, is peculiarly favourable for good and easy drainage ; and any difficulty that presents itself affects the disposal of the sewage when it reaches the lowest levels round the shores of the harbour.

The town is crossed by several valleys between high ridges. These valleys, some having permanent streams and others dry except in wet weather, take their rise in the hills above the city, and fall to three principal rivulets or creeks—Wellington Creek, which bounds the city on the south, Hobart Creek, which runs through the city, and Park Creek bounds it on the north. Hobart Creek receives much the largest part of the drainage of the city, Park Creek receives a considerable part, and Wellington Creek much the least, but the latter receives part of the drainage of the suburb of Queenborough in addition to what it receives from the city of Hobart.

The valleys which have streams in wet weather and are used as storm-water channels and sewers, flow as follows :—One to Hobart Creek at Elizabeth-street, with branches at Melville-street, Patrick-street, and Warwick-street, and one at Chapel Road. Park Creek receives one at Trinity Lane, with two branches, and one at Clare-street. There are sewers carrying storm-water discharging to the harbour at Constitution Dock ; at the foot of Murray-street ; at Salamanca Place ; two at the New Wharf, and one at Secheron Road.

Condition of water-courses.

The Hobart Rivulet is by law a common sewer ; the smaller streams, with the valleys and depressions in which drains are situated, are by use kept as common drains and storm-water channels. The condition of these drains is fully described by the Inspection Committee in their Report of 10 May, 1895, which is to the effect that they are in as bad a state as is possible ; they receive house-drains coming from every property ; many carry water-closet sewage ; many have outlets on the land at some distance from the water, instead of being taken into it ; parts of the

sewers are built of rough stone, with earth or paved bottoms ; parts are brick barrel-drains ; parts are earth ditches covered with boards. When they pass through gardens they are sometimes open ditches, in other places covered with rotten planks, and when they arrive at the higher parts they are in their natural condition, but arched over when streets cross them. The open parts are the receptacles of every sort of rubbish and garbage, which on the occurrence of heavy rain gets swept into the covered parts, occasionally blocking the drains and causing them to overflow. These drains also vary in size as well as construction : some are too large ; some too small ; some are new ; some old and ruinous. There are no records of these drains and sewers, which have been built at various times, from 60 years ago till lately, and where they are underground their position is often unknown ; neither are there are any records of the house-drains which connect to them.

In the steeper parts of the town the greater part of the house drainage discharges into the street side-channels, which are generally paved with cobble-stones, but some are merely ditches. Where the ground of the streets slope crossways, houses on the upper side drain to side-channels, while those on the lower side drain to creeks or ditches in the adjacent valleys. The drainage of houses to the side-channels is very offensive in hot weather, and is the more objectionable as the vile smells from them pervade the streets and enter every house.

Soil under drains saturated with sewage.

From the age and the neglected condition of the numerous rubble drains, pipes, and timber-covered ditches, which receive the sewage of the town and convey it to the principal creeks or to the harbour, there can be little doubt that the soil under and around them is saturated with sewage, and any unhealthiness in this city which is correctly attributed to defective drainage must have its origin in the condition of the street and house drainage as more fully described in the above-mentioned Report of the Inspection Committee. I saw one of these sewers opened for repairs, and the bad construction, the broken-down condition, and the filth which half filled it and saturated the soil for some distance on either side, I infer to be a sample of the condition of most of these underground drains. A large part of at least the lower levels of the town must therefore stand upon soil saturated with sewage from the leakage of both house and street drains, and this condition of things is liable to cause periodical outbreaks of disease. If, however, one were to assume from the filthy and neglected condition of the drainage that Hobart was an unhealthy city one would be mistaken, for, in spite of occasional outbreaks of typhoid and other zymotic diseases, the town, judging by the death-rate, is very healthy,—indeed, the death-rate is about the same as Christchurch which has a very effective system of sewerage.

Creeks used for drainage.

Park Creek in dry weather carries a small stream of sewage mixed with some fresh water from the soakage of the hills, but in heavy rain it is a considerable stream.

The Hobart Creek rises in Mount Wellington, and in dry weather has still much water which is very turbid with sewage ; in floods it brings down an immense volume of water flowing about 50 feet wide and 8 or 10 feet deep.

Wellington Creek is a small stream of filthy water in dry weather, but in floods it carries a good stream. All of these creeks contain garbage and rubbish, and have pools and hollows where the sewage stagnates until the next flood cleans them out.

Drains discharging into them.

At present a pressing necessity exists to purify and keep clean the numerous drains of all kinds which flow into these creeks or into the harbour ; but as they were constructed to carry the rain of the greatest storms they are too large for the sewage in dry weather, and the question arises whether these drains should be rebuilt in a proper manner and made to take rain and sewage together ; or whether they should be left as they are to serve as storm-water outlets, and sewers be provided for sewage only.

The storm-water.

The town being situated on very steep ground, the side channels of the streets are amply sufficient to carry off the rain, except in the lowest parts where the accumulation becomes great ; here the drains are mostly underground, and by short lengths of sewer the rainfall is taken to the creeks. The hollows of the valleys and the watercourses in the bottoms of them are most convenient for receiving and conveying the rain of heavy storms, and if these had been reserved for the purpose, as the Hobart Creek has been, everything in this respect would have been satisfactory.

Watercourses, private property.

Unfortunately the watercourses in the bottom of the valleys have not been reserved, and now pass entirely through private property. The consequence is that every one treats the watercourses which pass through his land as he likes ; some provide pipes altogether too small, some wall them up with old timber and cover them with planks, some build rough rubble drains and cover them over with earth, some leave them as they are.

Storm-water sewers provided in other towns.

In many other towns during the progress of improvements the storm-water is taken out of the original watercourses and passed through sewers under the streets ; in most parts of Hobart, from the depth of the valleys and the steepness of the streets, this method of treating the storm-water drainage is impracticable, and it must always pass along the bottom of the valleys. For this reason some action should be taken to secure legal rights over the watercourses, to prevent owners

of properties dealing with them in an unsuitable manner; in fact, anything which private owners may desire to do with these watercourses should be under the sanction and supervision of the Municipal authorities. In this way the city would secure sufficient drainage for the storm-water without the cost of large sewers, and if the city could acquire the right to reserve and fence in the watercourses they could be greatly improved and kept clear of rubbish.

Creeks and valleys should be kept as storm-water channels.

Where these watercourses descend to the lower and more directly inhabited parts of the town, they require to be covered in, as they are at present. If sewage were kept out of them they would give no further trouble except for necessary repairs. It does not matter for rain water, and how they are built, so long as they are large enough and do not tumble in. In the matter of provision for storm water, Hobart has not spent much money if it be compared with Dunedin and Christchurch; in the latter city I had to build about 11 miles of sewers in order that the storm-water might be taken out of creeks and ditches, and placed underground.

Touching the question of using the storm watercourses to carry the sewage as well, one difficulty at once arises, which is, that unless the present creeks are to be retained as the places for discharging the sewage, additional sewers must be provided to divert the sewage from the creeks; and if storm-water and sewage are to go together these additional sewers must be of great size; but sewers of a size sufficient to carry the storm-water are far too large for the sewage in dry weather, which then stagnates and flows very sluggishly; the sewers are continually choked with sediment in dry weather, and they are so large that it is difficult if not impossible to properly flush them. Also the storm-water drains and watercourses receive the mud and sand from the roads, and many of them being open at the top end and terminating in the slopes of the hills; receive everything that comes into them during rain storms, such as rubbish, gravel, sand, and earth. To have the sewers receiving and carrying such matters is highly objectionable, the stones and sand rapidly wear out the pipes, and the brick and concrete of the inverts; in the flatter gradients, sand, mud, and sewage deposits in the sewers in dry weather, and these cause intolerable nuisance and expense.

Shall sewage and storm water go together?

These and other considerations should be sufficient to convince any one that the sewage should have a system of its own, and then the storm-water can flow off as it does at present. Even if it becomes necessary in the future to build considerable extensions of the existing storm-water drains, to take more of the open channels underground, I believe it will still be found more economical to have separate systems for sewage and storm-water.

Separate systems for sewage and storm water desirable.

From reading the report of the Inspection Committee mentioned above, and from inspection of plans of some of the house drains shown me by the City Surveyor, I infer that these are in as discordant and neglected condition as the main drains; that is, that they are of all sorts and sizes, mostly too large, generally badly laid, with all sorts of gradients, without flushing arrangements, probably mostly untrapped and leaking, and in many cases it will perhaps be found that the material as well as the construction is defective.

Existing house-drains defective.

To connect such defective drainage arrangements to a new system of sewers is a difficulty that can only be tolerated on account of the great expense that the people would be put to if your Board insisted on every house connection being relaid with the latest improvements, and it may be anticipated that if the old defective house drains are to be left untouched, the new sewerage system will not give its best results in the form of cleanliness and improved sanitation; also, if the new sewers are made small so as to carry a limited portion of the rainfall, a condition essential to economy in construction, then the old house connections which take all rain that falls must have some overflowing arrangements to limit the quantity delivered in wet weather to the new sewers, which is unsatisfactory, to say the least.

Connection of old house-drains with new sewers.

This difficulty is inherent in the sewerage of most towns, and must be dealt with in the best way that circumstances will allow; time should be given to owners to make necessary improvements, which, if urgent, can be accelerated by pressure from the sanitary authorities. Your Engineer estimates that to entirely renew the house drains will cost about £29,000, and the drainage system will not be perfect until these are renewed.

There are about 700 water-closets in the city, 400 of which drain to Hobart Creek; the pan system is in use for the remainder of the town.

The pan system, without earth or ashes to deodorize it, is a dirty and unhealthy method of scavenging a town; the fumes from thousands of open pans are carried by the wind into every dwelling, and in times of epidemic sickness they carry infection directly to people, as well as infecting meat, milk, and other provisions.

A great deal has been said about earth and ashes closets, and if well and carefully attended to they are very satisfactory; this, however, is the theory of them; in practice they never are and never will be carefully attended to, and become foul and filthy. In a large town it is impossible to

Night soil to the sewers.

Water closets best.

supply the people with dry earth, and ashes will not be saved and used as they require to be. The water closet is by far the best and cheapest way of getting rid of fæcal matters, and to make sewers and exclude the nightsoil from them, as a few towns persist in doing, is illogical and highly uneconomical. It has been repeatedly shown and proved that the night soil does not add to the impurity of sewage by any test that can be appreciated; it has also been proved that nightsoil does not pollute the sewer gases to any appreciable extent, because it is found that sewer gas is more free from floating bacteria than the open air of the streets, a result that common sense would have inferred, because the germs that are in the sewage cannot become dry and float in the sewer air, and the sides of the sewers are so damp that germs adhering to them remain there till they die. It is also not true that the water of the harbour will be rendered offensive by the solid *dejecta* of water closets, which, in its passage through the sewers is reduced to a state of solution, and disseminated through the volume of dirty water.

Plans prepared by the Engineer.

The above is a description of the drainage of Hobart as its exists. To remedy its acknowledged defects, and to dispose of the sewage in such manner as to obviate as far as possible any nuisance which it causes, or which is ascribed to it, is the object of the plans which your Engineer has under your instructions prepared.

These plans consist in an excellent survey of the city and suburbs, with a complete set of outline plans of each building block, which only require the interiors to be filled in to be ready for all the purposes of setting out the back drainage of houses. A complete set of levels has been taken, from which contour lines 10 feet apart are drawn over the whole of the city and the suburb of Queenborough, and bench-marks are fixed all over the city. On the plan the whole of the drainage is shown by lines of sewers in every street. Part of the drainage is shown to have its outlet at Battery Point, and the greater part at Macquarie Point. A pretty large area is shown as requiring to be pumped. I have gone carefully over your Engineer's estimates for the cost of the drainage systems which he proposes, and I find them to be correct so far as I can judge from the preliminary condition of the plans, which are not yet in such detail as to enable one to make a close estimate. There are some details, however, on which my views would incline me to increase your Engineer's estimate for the reticulation by 10 per cent., which I do accordingly herein.

I have carefully inspected these plans for the general drainage of the City, excluding, as they do, the suburbs of New Town and Sandy Bay.

Size of city in the future.

The plans are designed on the basis of the present city population of 27,000 being increased in the future by 67 per cent., giving a future number of 44,000. I think this is a reasonable and sufficient provision, as I see no reason to suppose that Hobart has such a position or command of country that should raise its population over, say, 44,000. The water supply is taken at 40 gallons per head, excluding what is used to water streets or gardens, which does not come into the sewers.

Water supply.

The plans.

The plans for the general drainage show a main sewer up every valley, also one up Elizabeth-street, and one from Battery Point up Montpelier Retreat. These main sewers are, I think, well placed, as they cannot be in better positions than the bottoms of the valleys, and, given the position of the main sewers, the reticulation of the streets is easily arranged where the streets are as steep as they are in Hobart.

Quantity of sewage.

For the sizes of sewers and pipes your Engineer has made out a preliminary list, which may require to be revised when the longitudinal sections of streets are plotted. The quantity of sewage which your Engineer takes is 40 gallons per head in 24 hours, and he allows $\frac{1}{7}$ of the whole to flow in one hour of the busy part of the day. As a more usual allowance is $\frac{1}{2}$ of the whole in six hours, it is seen that he has made a liberal allowance for the size of sewers.

Quantity of rain.

Respecting the rainfall to be admitted to the sewers, I am inclined to think that the allowance made by your Engineer is too liberal, but to what extent this affects the size of the pipes and sewers I cannot make out until more details are prepared. Apart from the saving in the size of sewers, the quantity of rain admitted to the sewers is of no consequence if the sewage is neither to be pumped nor submitted to chemical treatment and precipitation.

Your Engineer allows rain to enter the sewers to the extent of two inches of rainfall in 24 hours on 180 square feet of yards or roof for every head of persons. For the city of Parramatta, New South Wales, the Chief Engineer, Mr. R. Hickson, allowed 1 inch in 24 hours on 200 square feet per head; but this was a case where all the sewage had to be pumped. In Wellington, 100 square feet of yards or roof is allowed per head, with a rainfall of 0·8 inch per 24 hours. In this case two-thirds of the total city area goes to its outlet by gravitation, and one-third of the area is pumped.

Of course it is understood that the quantity of rain to be admitted to the sewers is regulated as nearly as may be in the house connection, and any excess that unavoidably reaches the sewers is disposed of by overflow to the nearest storm-water sewer.

As these are preliminary plans and estimates, your Engineer's allowance for rain and sewage is on the safe side, and can easily be reduced if necessary when detail plans are prepared.

I have attempted to check the calculations for the sizes of the sewers in one or two places, and they appear too large; this is also on the safe side for preliminary estimates, and can be reduced to the correct size when detail plans are prepared; but seeing that your Engineer's allowances for both sewage and rain are large, I think it advisable not to make further allowances by increasing the sizes of the sewers over the stated allowance of $\frac{1}{7}$ of 40 gallons of sewage, together with 2 inches of rain and 180 square feet of yards or roof per head of people.

Extra sewers.

In the plans are shown a number of extra sewers besides those in every street. This is caused by the necessity of having a pipe to drain houses on the lower side of street where the land falls crossways. These extra pipes add considerably to the cost, but it cannot be avoided, as it would require too deep an excavation in the streets to set the pipes down to levels that would drain houses on the lower sites as well as those on the upper.

Dead-ends objectionable.

I notice on the plans about 200 dead-ends of pipes, and it appears as if a large number of them can be joined up to man-holes. Dead-ends are a nuisance and should be avoided as much as possible, as each requires a separate flushing arrangement, whereas if joined up to man-holes the same flush can be diverted at will from street to street and so on to the outlet; the sewage itself being principally used for the purpose.

Dead-ends must be flushed.

It is essential that all dead-ends be flushed, and for this purpose a flush-tank should be provided holding enough water to fill several hundred feet of the pipe to be flushed; thus a 9-inch to be filled for say 400 feet requires about 1120 gallons, and the flush-tank should hold about that quantity; this flush, along with the sewage, can at man-holes be diverted to any street by means of hinged flaps on the mouths of outgoing pipes, an overflow pipe being provided to prevent the pipes being injured by jamming up the flush too high.

How shall sewage be disposed of.

Before any scheme of drainage can be studied in detail, it is necessary to determine in what manner the sewage is to be disposed of; that is, 1st, whether it shall be discharged into the harbour in its raw state; 2nd, whether it shall be purified before discharging into the harbour; and 3rd, whether it shall be taken to irrigate a sewage farm.

After a vast deal of experience it is now generally agreed among sanitary engineers that where there is no chance of a nuisance arising the best way is to discharge the sewage into the sea. For many years strenuous efforts were made to prove that sewage could be profitably disposed of by land irrigation, or by precipitation and purification and making the sludge into manure.

Sewage farming.

Where the discharge to the sea is not practicable, sewage-farming is undoubtedly the best way of disposing of sewage; it is quite innocuous, entirely purifies the sewage, and often gives some return in the shape of food for men and beasts. The working, however, is very costly, and much more so if the sewage has to be pumped, and I am not aware of any sewage-farm which pays its expenses, not even in Europe where farm products sell well; but in the Colonies there is still less chance of a sewage-farm paying.

Sewage precipitation and purification before discharge into the sea, rivers, or harbour is generally the last resource when other methods are not available, and I consider it to be the most objectionable of all: the constant attendance required, the cost of chemicals necessary to precipitate the sewage, the detention of great volumes of sewage in settling-tanks, and the nuisance arising from the accumulation of the precipitated sludge is intolerable if any other method is open for selection. The precipitation of solids from the sewage by the use of chemicals does not remove the putrescible organic matter which is in solution; this can only be effected by subsequent filtration through earth, sand, or special filters, and the effectual filtration of large volumes of sewage is by no means easy. If, however, it is not filtered, but merely precipitated, then the clarified effluent sewage still contains organic matter in solution which is at any time liable to what is called secondary putrefaction, that is, it gets a fresh growth of bacteria from the air and water which again sets up putrefaction. Of course if the volume of water into which the clarified sewage is discharged be very large putrefaction is not set up, and the putrefying organisms die. In the case of salt-water they are very soon killed by the salt, the sunlight, and the air in the water.

In spite of repeated assertions of the patentees of different chemical precipitants, that the precipitated sludge can be profitably used for manure, it is found in England that there is the greatest difficulty in disposing of it even if given away. After many trials it is now agreed that it has a very low manurial value, so low indeed that it is sometimes the practice to enrich the sludge with other chemicals before farmers can be induced to use it. This might be inferred, as the sludge is little else than carbonaceous matter, which is not a manure at all; it is what the sewage holds in solution and which precipitation cannot remove that has manurial value. In the case of Hobart it would be hopeless to try and dispose of the sludge, consequently endless expense would be incurred in burying it or taking it to be thrown into deep water.

Electricity and sewage.

It has been proposed in Europe to sterilise the sewage by electrolized sea-water; but whatever value there may be in this process for particular circumstances, it is useless near the sea, as the harmful bacteria are soon killed in salt water. Putrescible matter is not permanently changed by this process; and for adoption on a large scale I consider it as a costly toy.

In the disposal of sewage every town should be considered under its own special circumstances, and the methods adopted which appear best suited to it. And, in this case, to my mind the only two methods that deserve consideration are a sewage farm, or discharging the sewage in its raw state into the harbour.

A sewage farm.

Sewage must be pumped to farm.

For a sewage farm there is a very suitable area of land situated about 4 miles from Hobart. The soil is sandy and very suitable; the land lies in even slopes with good facilities for drainage, and it lies about 60 feet above the sea. The distance and intervening low land would prevent any but a very small part of the town from receiving the benefit of draining to this place by gravitation, so that much the greater part, if not all, the sewage would have to be pumped to the farm. To pump the sewage of a high-lying town like Hobart requires strong reasons to urge its adoption, and I do not in this case consider them to be strong enough.

A sewage farm at such a distance would be very costly, from the great length and size of iron pumping main required, as well as from the size and cost of the pumping engines, which of course must be in duplicate. The Shone system of pumping by compressed air would in this case be far from economical, if not altogether inadmissible, from the great lift required to overcome both the height of the land and the friction head in the pipes. A large tank or tank sewer must be constructed to collect the sewage when the pumps are not working, otherwise it must run into the harbour at such times. The sewage collected in the tank during the night throws more work on pumps and engines during the day, which is increased if some rain is admitted to the sewers. But if the rain is to be entirely excluded, as in this case it should be, then either the whole of the house connections must be relaid about as soon as the pumps are set to work, or the sewers must be allowed to overflow into the harbour during wet weather, so as to reduce the work on the pumps. The running of the pumping engines and the attendance at the farm will be a continual expense, which the profits of the farm will do little to reduce.

By your Engineer's calculations the total cost of works necessary for a sewage farm for Hobart, excluding New Town, would be about £61,500; the interest on this at 5 per cent. would be £3075, and the working expenses, including repairs, stores, wages, and administration, would be about £3200, making an annual cost of about £6275. A sinking fund may in time extinguish the capital and its annual interest, but the working expenses, amounting as above to £3200, can never be extinguished, and is equivalent to paying interest for all time on £64,000.

From above figures it is evident to me that a sewage farm is almost impracticable for Hobart; the expense would be an intolerable burden, and instead of increasing the value of property by the convenience and sanitary result, the heavy rate charges would have the tendency to lower the values of city property.

Sewage discharged into harbour.

Under these circumstances it is now necessary to consider the question of discharging the sewage in its raw state into the harbour.

I find, in the first place, that it is usual to call the harbour a river, and people in thinking about discharging the sewage into the River Derwent, as they call it, forget that this is not a river at all. It is a saltwater estuary, 3400 feet wide at and above Macquarie Point, nearly 3 miles wide below Macquarie Point, and over 60 feet deep. The River Derwent proper is about 20 miles from Hobart.

Your Engineer has prepared plans showing the outlets for the sewers to be—one at Macquarie Point, and one at Battery Point. In order to form an idea of the probable effect of discharging the sewage at these points, it appeared to me that as the whole of the sewage of the town at present, and ever since the establishment of the town, is discharged at the mouth of the Hobart Rivulet, at several sewers discharging among the docks and wharves, and at the mouth of the Wellington Creek, there ought to be some evidence of the effect of discharging sewage at these places for about three quarters of a century. I therefore carefully examined the whole of the shore from the Cattle Wharves at Macquarie Point to One Tree Point, beyond Sandy Bay, and I found no signs of sewage pollution.

Are shores polluted by existing sewers?

No evidence of pollution.

The beach at the mouth of Hobart Creek, and both north and south of it, is perfectly clean, both above low-water mark and under water as far out as can be seen; the rocks between high water and low water, and under the water are covered with seaweed, mussels, and whilks, which is a sufficiently delicate test of the absence of sewage pollution; the water is as clear as sea water, and I could see no effect of the outflow of the filthy water of Hobart Creek close by. The great bank of sand at the mouth of Hobart Creek has a thin coating of black stinking mud for a short distance out;

for some distance on each side of this the sand is slightly dirty and blackened, but all round a very limited space, the bottom in front of the outlet of the rivulet is quite clean. At the wharves and docks the stone and piles are covered with seaweed and mussels, and the water appears just like ordinary sea water. At the corner of the wharf in Lower Murray-street a considerable sewer discharges underneath the wharf; the dirty water from it slightly colours the sea water for about 40 or 50 feet out, beyond which the effect cannot be distinguished. I am told that this sewer deposits a bank of black mud and sand at its outlet, which is occasionally dredged, and is very offensive when disturbed; that is quite likely, but I could discover no sign of offensiveness at the time I examined it.

At the New Wharf a sewer discharges under the wharf, from which I could discover no effects on the sea water a few feet away from the point where it enters the water; very likely, however, it has deposited dirty mud on the bottom, which may smell offensively when disturbed, though its presence is not evident from the surface.

The whole of the shore, the rocks, and the bottom, as far under water as can be seen from the New Wharf to the mouth of Wellington Creek, are as clear as the shores of the sea, and covered with seaweed and shellfish; at high-water mark is collected some evidence of the presence of a town in drift rubbish of various kinds.

At Wellington Creek the sand of the beach is blackened below the surface from the effect partly of the sewage of the creek, but chiefly from the rotten seaweed which is cast ashore there in great quantities from the shallow water of Sandy Bay. This blackened sand, containing a little mud, is found for two or three chains from the mouth of the creek, beyond which it does not appear.

From Wellington Creek all round Sandy Bay as far as One-Tree Point the shores are as clean as they are on the sea beach, and although sewers of small size enter the water at several places they have scarcely had any effect on the purity of the shores. All along this part at high water there is the evidence of the presence of the city in collections of drift rubbish, but they are so small in quantity as to be insignificant; here and there are a few apples, some apple pealings from Risby's apple-curing place, drift stalks of cabbage, a dead dog, some straw, an old mattrass, drift-wood, shavings, turnip-tops, old bags, &c. Not all of this rubbish named has drifted in from the harbour; a part has been thrown into the sea from adjacent houses.

Shores not polluted since foundation of Hobart.

The present population of Hobart and suburbs is about 32,000; in 1845 it is said to have been 10,000, therefore the sewage from the mean of the two numbers, say 20,000 people, has had no perceptible effect in polluting the shores of the city in 50 years. Your Engineer in his plans provides for a future population of 53,000, and I have no reason to suppose that that number in 50 years will pollute the shores of the city any more than they are now polluted.

Shores seldom polluted by sewage.

A great deal of exaggeration and nonsense is talked about sewage polluting shores, and one hears more about it than is to be found in reality. A large number of the pleasantest towns in England discharge their sewage into the sea or the harbour in front of the town without any ill effect; and Edinburgh has just built two very large sewers to carry the sewage of 260,000 people, the mouths of which are at low water on the sea beach of Portobello, the most favourite watering-place in Scotland. Auckland and Wellington discharge their sewage directly into the harbour in front of the towns, and I never perceived any ill effects from it. It is true that Auckland intercepts the deposits in a large tank, and where sewers bring down sand and mud from the streets the sand and mud gets black and filthy, and settles at the mouth of the sewers. When, however, the sewers carry nothing but sewage this becomes mixed with a million times its own bulk of sea water, and the effect of the sewage on the water is such as would be produced by pouring a thimble full of sewage into a 400-gallon tank of salt water.

Sewage sludge does not readily subside. Fish eat it.

The sewage sludge is so light that it requires chemicals to precipitate it; it therefore drifts away great distances before it settles to the bottom, but not before a great part of it is devoured by fish and animalcules of the sea-water. In Wellington an incredible number of fish of all sizes swarm round the mouths of the sewers, the very small ones devouring particles of the sewage or animalcules which live on the sewage, and the larger fish devouring the smaller. At Bondi, in Sydney, a very large sewer discharges into the sea, and great flocks of birds hover continually over the mouth of the sewer, preying on the shoals of fish which feed on the sewage. These facts show that the sewage at the mouth of the sewers is so diluted that it does not hurt the fish, and also that the solid particles of the sewage are food for fish and other living things in the sea.

Currents tested by floats.

To test the effect of the currents in the harbour in front of the town, we put a large number of floats about six feet deep into the water at both Macquarie and Battery Points, and on both rising and falling tide, the winds being either W., N.W., or N.N.E.

From Battery Point with falling tide the floats drift round Sandy Bay and One-Tree Point. With rising tide they drift outwards until the tide turns, then drift down the harbour.

From Macquarie Point with falling tide floats drift past Sullivan's Cove usually about 800 feet from the end of Dunn-street Wharf, then past Battery Point, after which they follow nearly the course of floats from Battery Point. When the tide is three-quarters ebb and getting slack water we found floats from Macquarie Point come past the cove at 600 or 800 feet off Dunn-street Wharf, then double round at the New Wharf, passing it at 350 feet, then go northward at 400 feet from the Dunn-street Wharf, then up to the lower black buoy, then out into the stream, and very slowly towards One Tree Point.

At rising tide floats deposited at Macquarie Point drift down to near the upper black buoy, then out into the stream towards Kangaroo Point, then turn round and drift very slowly upstream as far as the cattle wharf, then down stream with the turn of the tide. At rising tide floats deposited at Battery Point drift slowly outwards towards Kangaroo Point, then down stream with the turning tide.

What the floats indicate.

Summarising these results, it appears there is very little up-stream drift in the floats, which generally make their way, at some distance from the beach, round the curve of the shores towards One Tree Point. Close into Sullivan's Cove there is nearly still water, or a very slight eddy upwards at some time of tide. At other times the drift is round the shore towards Battery Point. There are the currents close in shore, and of the water near the surface; but when the tide is rising, though a 5 feet float may be drifting down stream, a 30 feet float is drifting slowly up stream. The *flood stream* therefore runs up underneath, while the surface water runs down or is nearly stationary. The *ebb stream* is always down.

Floating matter drifts with wind; but water does not drift.

In strong N. or N.E. winds anything floating on the surface of the harbour is drifted to the shores at Sullivan's Cove, Battery Point, or Sandy Bay. The water itself is not drifted by the wind, but keeps on its course according to the set of tides; but during strong N. and N.E. winds the surface is very rough, which would have the effect of thorougly mixing the sewage discharged into the harbour.

Currents set to One-Tree Point, with little intermission from flood stream.

From these observations, it seems evident that the sewage discharged into the harbour at Macquarie Point would, in about 24 hours drift as far as One Tree Point, notwithstanding that it might be stationary, or set upwards for a short distance at the rising tide; that part of the sewage would form an eddy and pass close in to Sullivan's Cove at particular times of tide, but setting out again and down stream like the rest of it; that the sewage which passed Sullivan's Cove would, by the time it reached there, be diluted with a vast quantity of sea water, and that this dilution would increase the farther the sewage travelled with the tides; that the sewage sludge being extremely light would be carried great distances before it settled on the bottom, and consequently would be distributed over a large area, so large that one can hardly imagine the thinness of the layer of it that would come to rest on the bottom; that sewage which carries road grit, sand, and earth form banks of filthy mud at their outlets, but sewage from which the heavy materials are excluded is very different and has little tendency to form such deposits.

From observations of the effect of over 50 years' discharge of the Hobart sewage into the harbour, I cannot form any other conclusion but that the discharge of the sewage at Macquarie Point would have no effect in polluting the shores, or defiling the water of the harbour, especially if the storm water is kept separate from the sewage.

Outlets concentrated at Macquarie Point.

I think it is important to have only one outlet for the sewage, and I think Macquarie Point is better for the purpose than Battery Point. The reason for this preference is that there is deep water from Macquarie Point all the way to the end of the New Wharf, with the exception of the part from Macquarie Point to Hobart Creek mouth; but when the long breastwork is finished there will be deep water all the way, that is to say, there are no sloping beaches in this distance, and the deep water of this part must have the effect of increasing the dilution of as much of the sewage as can get close to the wharves and docks. By the time the sewage has reached opposite Battery Point and Sandy Bay it would be so diluted with sea-water that it is useless to consider the question of pollution from it.

Pumping obviated by intercepting-sewer.

I am also in favour of doing away with pumping as far as possible, and with the object of concentrating the whole of the discharge at Macquarie Point and abolishing the necessity for pumping, I have prepared a longitudinal section of an intercepting-sewer which, commencing at Lord-street in Queenborough, and passing through Queenborough and round close to the water's edge at Battery Point, will end in a manhole at Runnymede-street; from which place to the main sewer of Mr. Mault's plan on the north side of Hobart Creek the sewage collected by this intercepting-sewer would pass under the low land which intervenes by 65 chains of pressure pipe, and discharge into the main sewer at the north end of Macquarie-street.

Pressure pipe.

A pressure pipe of this kind is like a siphon crossing a valley, and is useful to catch the drainage off higher ground, and convey it across intervening flats. The pressure pipe will catch all drainage which lies above a straight line drawn from its inlet to its outlet, commonly called its hydraulic gradient. Wherever a street has to be drained to the pressure pipe, a pressure branch

must be carried from the pipe up the street to the height of the hydraulic gradient, at which point the drainage of the street by ordinary sewers drops into the pressure branch at what is called a "swallow," and passes into the pressure pipe and on to its outlet. This system is used in many places. It is part of the plan for the drainage of Wellington, and was recommended by the two experts and myself in the plans selected for the drainage of Dunedin.

It will be seen by the plan which I submit herewith, showing area required to be pumped by your Engineer's plans, and those to be pumped by the intercepting sewer now proposed, that the area in the city excluded from drainage by the pressure pipe is so small that I am of opinion it might be left to drain into the harbour, while the intercepting sewer above the pressure pipe leaves no drainage out, except the part of Queenborough which lies below the level of about 30 feet above high water-mark, and this can be pumped into the intercepting sewer if and whenever it is thought desirable to do so. This intercepting sewer and pressure pipe carries all drainage to Macquarie Point, and does away with a very large area of pumping, as may be seen by inspection of the areas coloured on plan herewith.

Outlet at One-tree Point.

The outlet at Macquarie Point has probably no objection that can be maintained conclusively against it; it is a good outlet, and I do not believe that any bad results would arise from its adoption. There is, however, a popular feeling against it, which may be difficult to allay.

If I had to select an outlet I think I would naturally choose to place it at One-tree Point.

Abolishes some of the pumping.

Probably some objections will be raised to the outlet of the sewers wherever they may be placed, but I cannot see that any good objections can be maintained against an outlet at One-tree Point except the extra cost. From the various plans which I have prepared, I find that some little pumping cannot be avoided. The outlet at Macquarie Point, with an intercepting sewer as shown herewith, leaves the least pumping to be done, and that is chiefly at Queenborough. The outlet at One-tree Point abolishes pumping at Queenborough, but leaves an area near the north-east corner of the town which must be pumped, as shown by hatched lines on plan herewith. This area is about the same as your Engineer's plan required for the same neighbourhood with his outlet at Macquarie Point; but it does away with all pumping elsewhere, and it has the advantage of draining all properties along the Sandy Bay Road, which must, from its favourable situation and beautiful aspect, become a favourite villa site.

Plan and Section of it.

I have accordingly prepared a plan and section of an intercepting sewer, beginning at Park Rivulet, running through the lower part of the town, as shown on plan herewith, skirting the shore round Battery Point, passing through the lower part of Queenborough, and on to the Sandy Bay Road, following this road to Manning's Creek, then passing through lower ground on the brow of the bluffs past the Red Chapel, and on to the low flats, which it follows till it reaches the low bluffs at One-tree Point, skirting round these above high-water level till it reaches the far part of this rocky point, where just under the battery it discharges at high-water mark into the harbour.

The section for this intercepting sewer has correct lengths taken from the plans, and within the city and Queenborough the heights are taken from your Engineer's contour levels; but all along the road the heights are estimated above high water, consequently this part is an approximation, but it will be found fairly correct; a number of sketch cross-sections herewith assist in locating the position, and defining the amount of excavation to be done. I have shown the sewer terminating by a cast-iron pipe about 400 feet out in 12 feet of water; this is a costly termination, which may be modified if 400 feet out is not thought necessary. The extension out into the water is shown standing on an embankment of stone, the pipe and slopes of the embankment being protected from the waves by heavy rock. I would recommend the sewer to be terminated at low-water mark at first, and until it is seen whether there be any necessity to carry it out further.

Terminates in deep water.

The flattest gradient for this sewer is 1 in 1200, which is a good gradient for a sewer of the size. The long outlet sewer in Christchurch, of about the same size, has a gradient of 1 in 1760, and has kept clean and free of deposit for 12 years. The sewer discharging at high water can never be tide-locked.

As I have already remarked, any position of outlet leaves some part of the city to be pumped, and an inspection of the plans with hatched-line areas herewith shows how they all stand in this respect. They show that the One-tree Point outlet has more area to be pumped than an outlet at Macquarie Point, though less than the original plans showed; but it commands the drainage by gravitation of the greater part of the city as well as all Queenborough, whether the latter chooses to take advantage of it or not.

The sewer along the Sandy Bay road crosses two very low parts of the road where the invert of the sewer would be on a level with the road. The method of getting over this difficulty is shown by the sketch cross sections herewith (page 2). The sewage is carried in a steel pipe coated inside and out with asphalt tar; the present retaining wall of the road is to be taken down and rebuilt

outside the pipe and the space being filled with gravel, the pipe will rest on this. The outside wall is to be built as high as the top of the pipe; a small dwarf wall is built on the site of the present retaining wall, and between these walls the pipe is to be covered with earth or gravel; it will thus form a parapet 4 feet 6 inches high above the road, which will serve to keep children from falling into the sea.

After entering the town the sewer would pass through two high ridges, one at Hadley's Hotel and the other at Bathurst and Argyle streets. These must be tunnelled, but the strata being sandstone this is neither difficult nor costly, and I have avoided all tunnelling in the basalt, which would be very costly. The part of the sewer round Battery Point is all basalt, but here the ground must be carefully contoured at the gradient of the sewer so as to place the sewer just below the surface, and in this way very little of the hard basalt will have to be excavated. The sewer would cross over Wellington Creek in a pipe, under the Slip by siphon, also by siphon over the low land between Runnymede street and Salamanca Place, under Hobart rivulet, and end at the level of the bottom of Park Creek at north end of Brisbane street. The cost of this intercepting sewer, which is about 4 miles and a half long, is estimated at £38,000, including 15 per cent for contingencies and compensation.

It will be observed that this outlet for the sewage of Hobart entirely discards any idea of sewage farming in the future. I would have no hesitation about taking such a step, as I cannot imagine that any idea would be entertained of pumping the sewage to a farm four miles away when it can be taken four miles by gravitation in the opposite direction and got rid of in the open estuary without expense except the maintenance of the sewer itself, and if well and carefully built there will be no maintenance expenses at all.

There is, however, the area that requires to be pumped to take into consideration as affecting the current expenses. Mr. Mault has estimated these works at £3828, and the current expenses of pumping at about £365 per annum.

We can now compare the costs of the different systems which have been discussed.

1st. Discharge without treatment at Macquarie and Battery Points, as per Engineer's original plans and estimates—

	£
Total reticulation and outfalls	50,000
Total cost of pumping plant	6149
Total cost of system	£56,149

Annual Cost—	£
Interest, at 5 per cent. on £56,149	2807
Repairs and maintenance, 1 per cent. on ditto	511
Sewer men	500
Water for flushing	350
Pumping	600
Administration	600
Total yearly cost	£5368

2nd. Outlet at Macquarie Point only, with intercepting sewer from Queenborough and Wellington Rivulet, and no pumping—

	£
Total reticulation and outfalls	50,000
Less sewers cut out	842
Total	£49,158
Add intercepting sewer	9075*
Total cost of system, without pumping	£58,233

Yearly Cost—	£
Interest, 5 per cent. on £58,233	2917
Maintenance, say 1 per cent.	582
Water for flushing, say	200
Sewer men as above	500
Administration, say	360
Total yearly cost	£4559

* Of this sum £1240 is expended in Queenborough.

3rd. Outlet at One Tree Point—	£	£
Total reticulation and outlets	50,000	
Less sewers and pipes cut out	3761	
		46,239
Add intercepting sewer	...	38,600
Add pumping plant	...	3828
Total cost of system		£88,667

Yearly Cost—	£
Interest, at 5 per cent. on £88,667	4433
Maintenance, say 1 per cent. on ditto	886
Water for flushing, say	300
Sewer men as above	500
Pumping	365
Administration as above	600
Total yearly cost	£7084

The case for consideration is now reduced to two issues; that is—First, to discharge the sewage at Macquarie Point, with an intercepting sewer from Queenborough to Hobart Creek, whereby the area excluded from drainage is so small that it may safely be allowed to drain to the Harbour, and so avoid all pumping. The cost of this system being about £58,233, and the yearly cost £4559. 2nd, to discharge the sewage at One-tree Point, leaving a part of the city at the north-east corner of it to be pumped; the cost of this system being about £88,667, and the yearly cost £7084. Having asserted that I do not believe the outlet at Macquarie Point would have any tendency to foul the shores or pollute the waters of the harbour, the choice between these two outlets seems to be decided in favour of the cheapest, from a purely financial point of view. Nevertheless, it seems to me that there are a few advantages in the One-tree Point outlet that are worth consideration. By it the whole of Queenborough, as well as the whole length of the Sandy Bay Road, finds an outlet by gravitation to the main sewer. This extensive District is beautifully situated for future villa residences, and in time will probably be so occupied; there is a pleasant beach all along it, which is the delight of children in summer, and the main sewer would remove all necessity for adjacent dwellings to foul the beach by their drainage; for, although a sewer taken out to a prominent point would probably not foul distant beaches, yet a number of sewers discharging on the beach in a hollow bay probably would do so.

The temptation to economise and choose the cheapest system is no doubt great. I think, however, something is due to the popular feeling, which I am inclined to think would rather that the sewage were carried away as far as possible. Many cities have acted on this feeling, such as Wellington, Dunedin, Sydney, Melbourne; others, as I mentioned above, have boldly discharged their sewage in front of the town, probably because no reasonable sum would take it farther away.

Having now considered the question in all its aspects, and discussed all the circumstances of the case, I hope I have been able to place them before you in the clearest light, so that you can form your own judgment on the subject. My advice is that the sewage be taken to One-tree Point, which I am pretty sure will, in the long run, be found to be most satisfactory to the citizens of Hobart.

Drainage of suburbs—Sandy Bay. New Town.

Respecting the drainage of the two suburbs of Queenborough and New Town, that of Queenborough is disposed of by the construction of the sewer above recommended. In the case of New Town I recommend that no pumping be provided; the village lies so high on sloping ground that there can be no good grounds for adopting the troublesome and expensive work of pumping. The expense of taking a long outfall sewer to the extreme end of the point north of the Cemetery would not equal the cost of pumping plant, and the sewage would then be discharged at a prominent point exposed to the full force of the currents.

If sand and road grit is kept out of the sewers, a 15-inch or an 18-inch pipe can be laid as the main outfall at a gradient of one in 1000. The distance from the Risdon Road at *Maypole Hotel* to the end of the point is about 85 chains, and the rise of the outlet sewer at one in 1000 (the outlet being at high water) would for this distance be about 6 feet above high water, at which height every part of New Town would be commanded by gravitation. At this level the long outlet main sewer can be so connected with the rivulet that a full head of water can occasionally be turned into it for flushing.

The street pipes can be allowed to receive as much rain-water as a due regard to their sizes will permit, as a storm can be easily overflowed into the rivulet before the street pipes join the long outlet pipe.

The disposal of storm-water presents no difficulty in New Town, provided the watercourses in the low valleys be reserved for that purpose; the streets are all so steep that the side channels can take all rain. It is probable that water for flushing is scarce at New Town, so that it should be economised by having few dead-ends to pipes, and making one flush go through as many streets as possible.

I have not investigated detail plans nor estimates for New Town, as the levels are not yet taken.

With this Report are submitted the following plans :—

Plan of outlet sewer to One-tree Point showing area that is excluded from drainage; area excluded that is common to this and to Mr. Mault's original plans; and area included in this, but excluded in the originals.

Plan of outlet sewers concentrated at Macquarie Point by means of intercepting sewer and pressure pipe from Queenborough to Hobart Creek, whereby pumping is obviated in the city, but an area is shown which has to be pumped in Queenborough.

Longitudinal Section of One-tree Point sewer.

Longitudinal Section of intercepting sewer and pressure pipe from Queenborough to Hobart Creek.

Cross Sections of One-tree Point outlet sewer, showing manner of placing steel pipes on the road.

Specimen map of invert levels as necessary for correctly laying down pipes in the streets.

I have great pleasure in acknowledging the cordial assistance which I have received during these investigations from your Engineer, Mr. A. Mault, as well as from the Secretary, Mr. T. C. Just.

I have the honour to be,
Your obedient Servant,

C. NAPIER BELL, *M. Inst. C.E.*

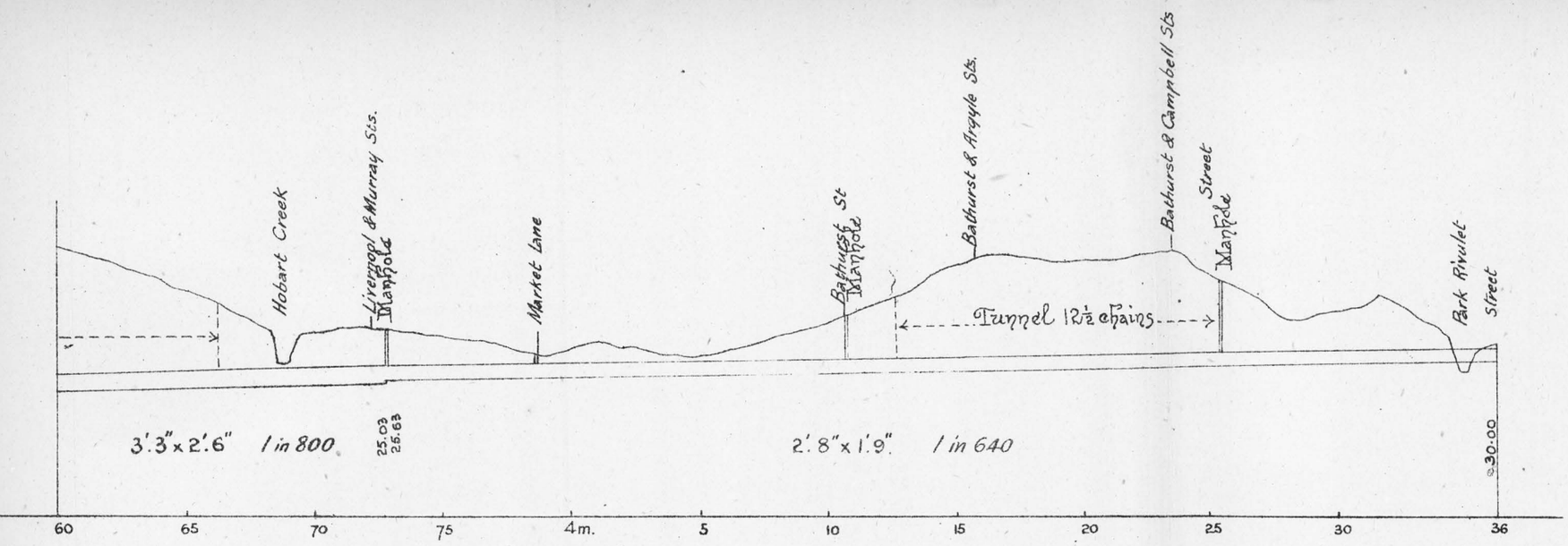
Hobart, 29*th November*, 1895.

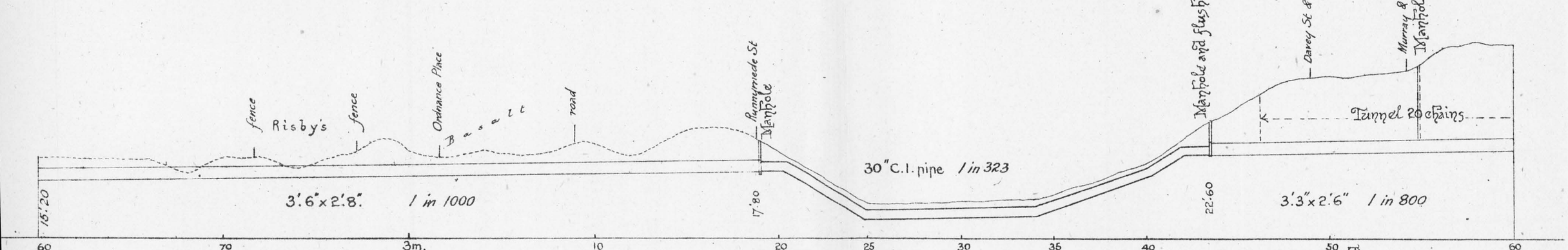
WILLIAM GRAHAME, JUN.,
GOVERNMENT PRINTER, TASMANIA.

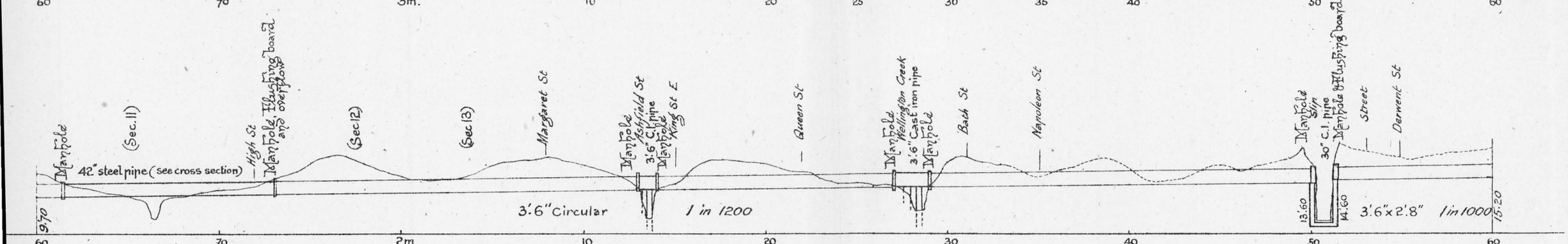

SHEET 1
SULLIVAN'S COVE
SANDY BAY
BATTERY POINT
MACQUARIE POINT
DUNALEY'S POINT
SANDY BAY POINT
ONE TREE POINT
INTERCEPTING SEWER
TO
ONE TREE POINT
Area excluded from Drainage or pumped to One Tree Point
Area common to outlets at One Tree or Macquarie Points
Area pumped to outlets at Macquarie & Battery Points

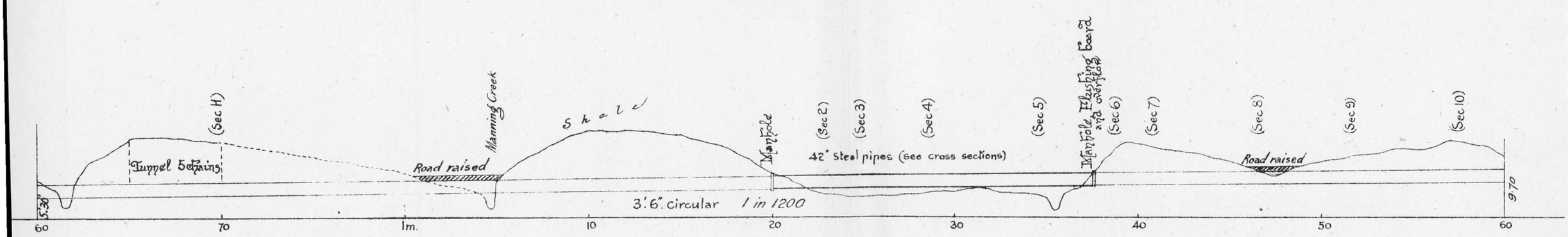
Section of Intercepting Sewer
Park Creek to One Tree Point—

Scales
Horizontal — Six Chains to an Inch
Vertical — Thirty Feet " " "







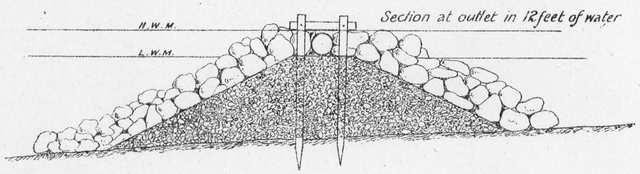


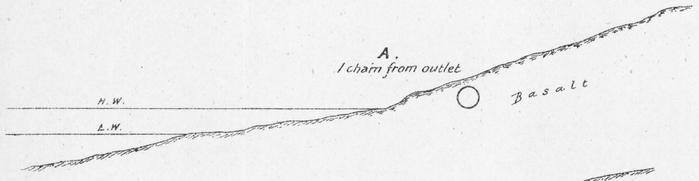
Chas. Kell
29 Nov 1895

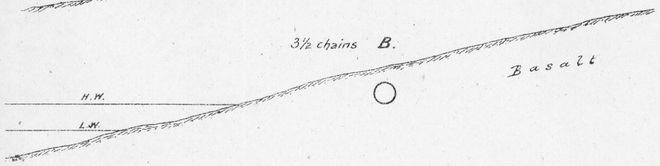
SECTIONS OF OUTLET SEWER AT ONE TREE POINT

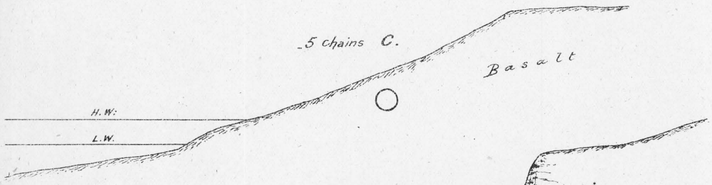
SHEET 3.

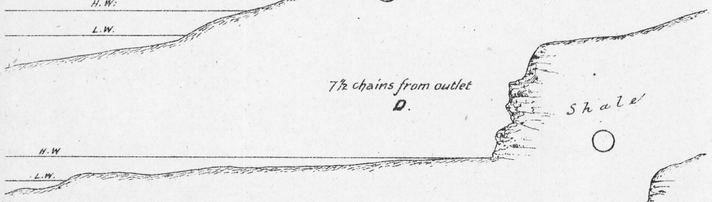
Scale 16 Feet to 1 inch

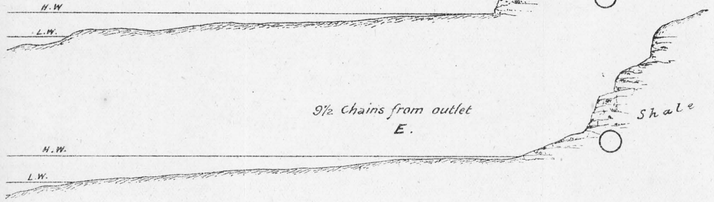


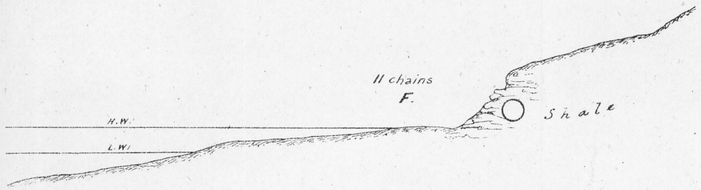


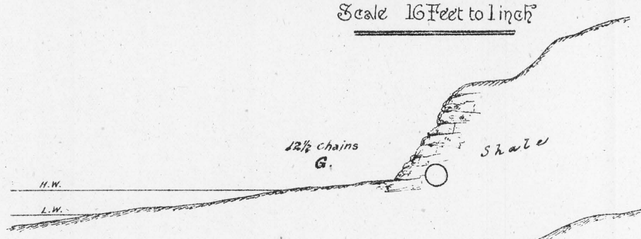


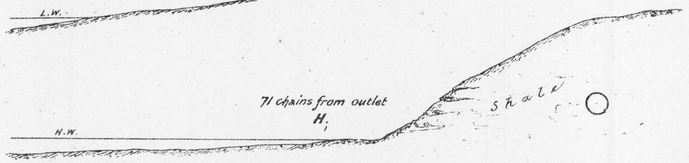


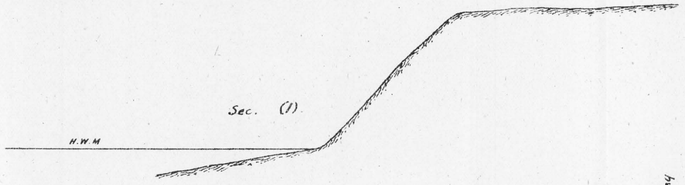


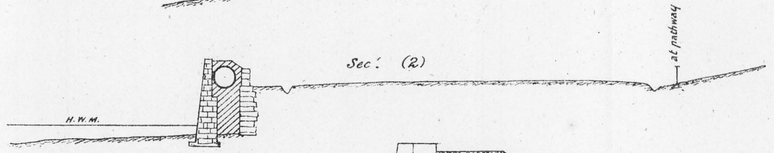


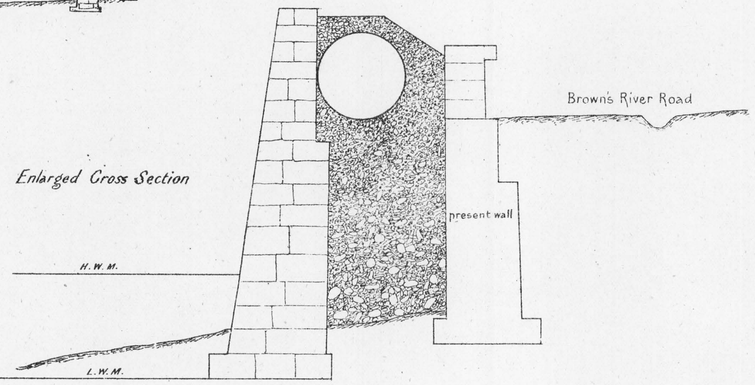


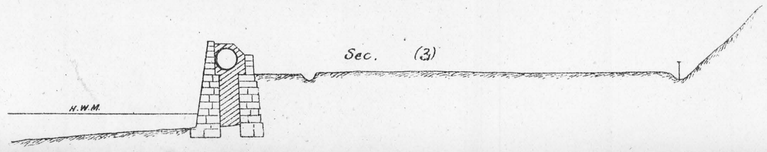


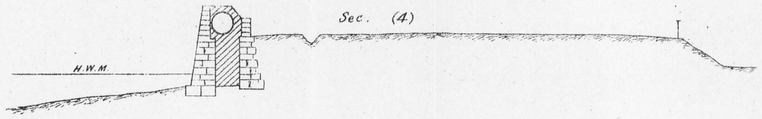


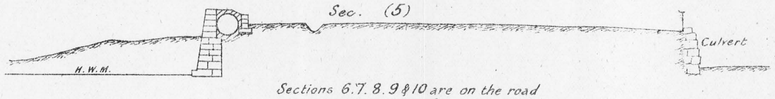




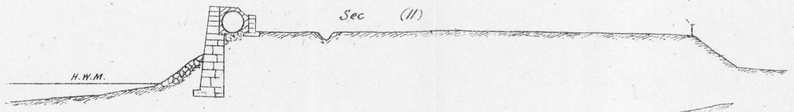


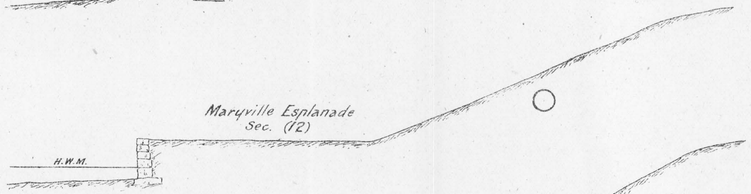


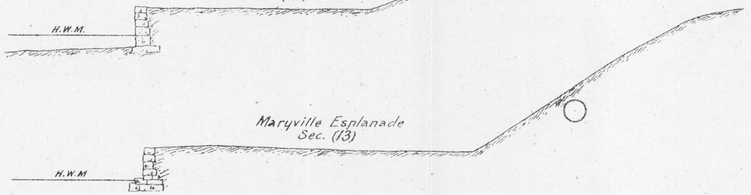




Sections 6.7.8.9 & 10 are on the road







Chas Hall
23 Nov 1895

OUTLET AT MACQUARIE POINT ONLY
with
INTERCEPTING SEWER
FROM
ASHFIELD CREEK to HOBART CREEK

Excluded from Drainage or pumped to Intercepting Sewer

Excluded or pumped on both Systems

Pumped if outlets are at Macquarie Point and Battery Point

SULLIVAN'S COVE

SANDY BAY

MACQUARIE POINT

MULGRAVE POINT

BATTERY POINT

PROPOSED SITE OUTFALL WORKS

CAST IRON PIPE SEWER

Chapman Hall
29 Nov 1895

To accompany Report

Scale of Links

Section of

INTERCEPTING SEWER

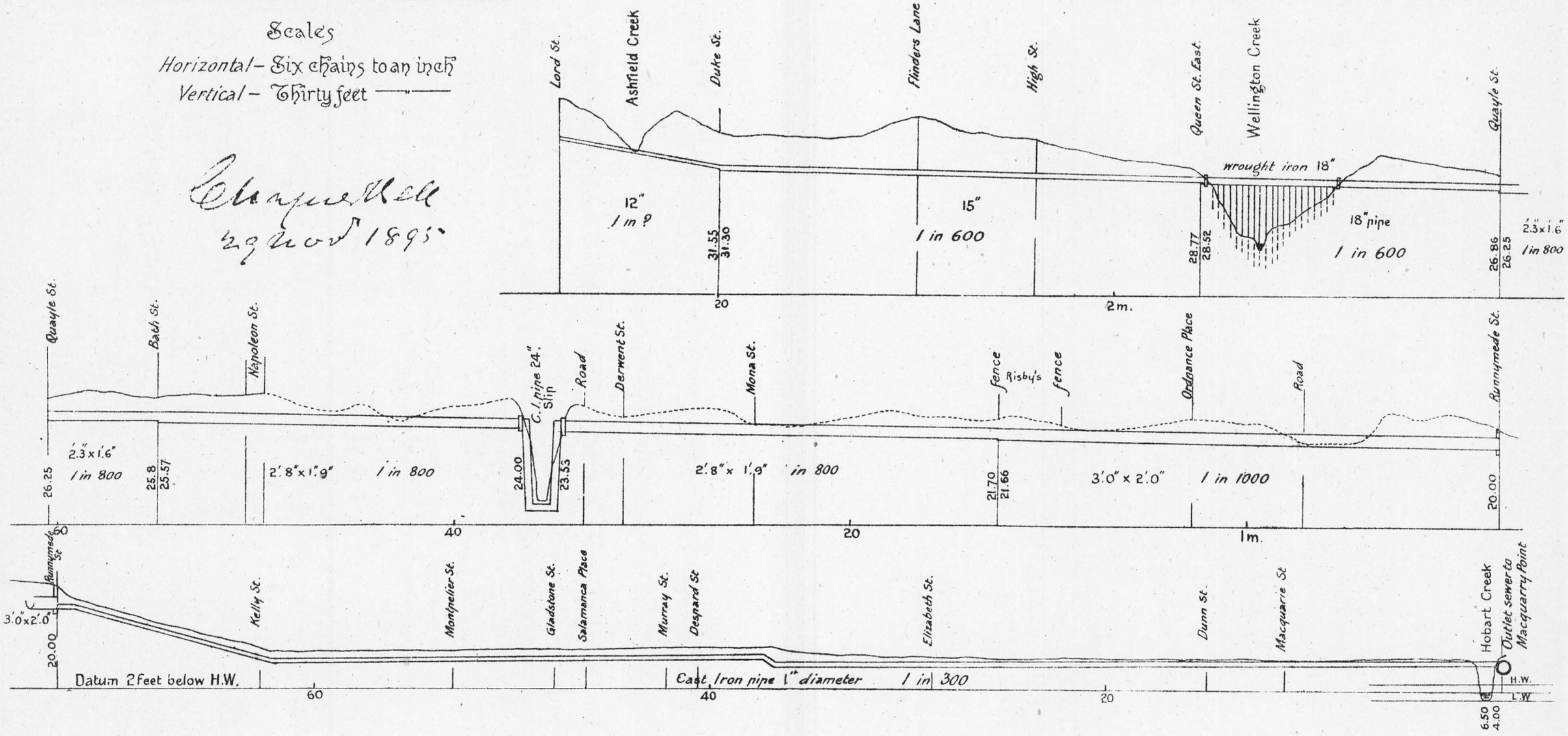
ASHFIELD CREEK TO HOBART CREEK

Scales

Horizontal – Six chains to an inch

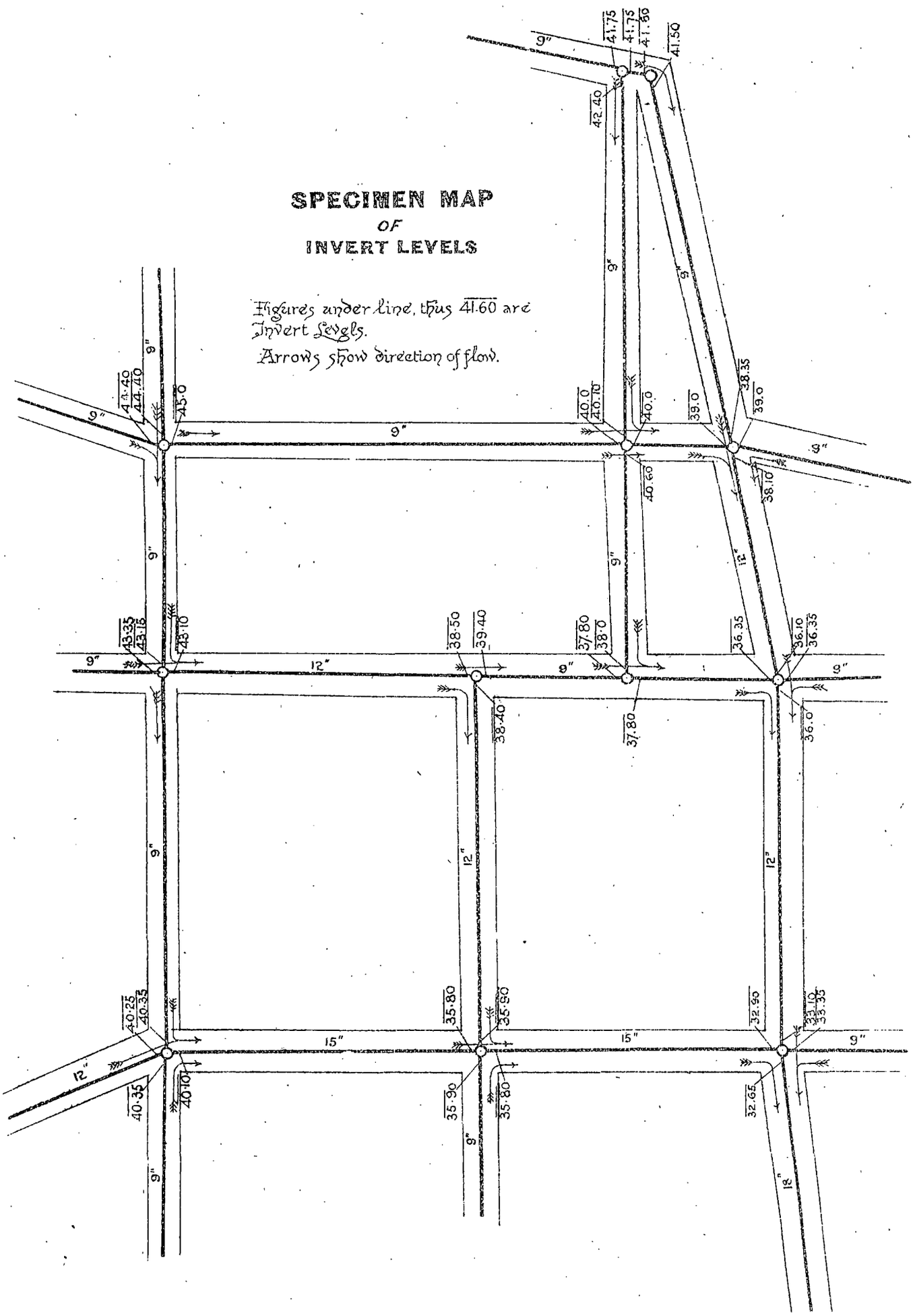
Vertical – Thirty feet

Chas Bell
29 Nov 1895



SPECIMEN MAP
OF
INVERT LEVELS

Figures under line, thus 41.60 are Invert Levels.
Arrows show direction of flow.



Chas Campbell
29 Nov 1895