1891.—Sess. II.

NEW ZEALAND.

GISBORNE HARBOUR-WORKS

(REPORT ON, BY MARINE ENGINEER, TOGETHER WITH COPIES OF DRAWINGS).

Presented to both Houses of the General Assembly by Command of His Excellency.

The Marine Engineer, to the Hon. the Minister having charge of the Marine Department.

Sir,— Marine Engineer's Office, Wellington, December, 1890.

In pursuance of your instructions, I have the honour to report on proposed harbour at Gisborne.

I inspected the works as now existing in August last, but the more immediate urgency of works actually in progress in other parts of the colony has prevented, until now, my devoting the amount of time and consideration to the Gisborne question that the difficulty and importance of the case required, before I could report upon it.

Sir John Coode's Design.

The works proposed by Sir John Coode, in December 1880, for a harbour at Gisborne, as indicated on map herewith in brown, consisted of a sea-mole with sheltering jetties, connected to a solid root on shore by an open iron viaduct; and were designed to commence about 50 yards to the east of Maori Point, and to run out from thence in a (magnetic) south-west direction for 2,460ft., thence curving into a direction west by south for a further length of 400ft. Total length of sea-mole, viaduct, and root, 2,860ft. The jetties were to project from either end of the sea-mole, and were each to be 430ft. in length.

Of the 2,860ft., a length, at shore end, of 550ft., reaching to low-water line, on the bare "papa" rock, and constituting the root of the structure, was to be solid work, composed of rubble and *débris* with masonry facing; the sea-mole, 900ft. in length, was also to be solid work, composed of concrete blocks; and the intervening viaduct was to have a length of 1,410ft., consisting of forty-seven spans of 30ft. each. The jetties were to be solid work, consisting of rubble and *débris* with timber-facing. The length of sheltered quay which this design provided for would have been 1,600ft., having a depth of 21ft. to 30ft. at low water of spring-tides. The estimated cost was as follows:—

			£	£
Root, of rubble and *débris*—Length,	550ft.	... ...	10,750	
Iron viaduct, "	1,410ft.	... ...	48,980	
Sea-mole, "	900ft.	... ...	135,180	
	2,860 ft.			194,910
Jetties (2) "	430ft. (each)	... ...	...	51,490
Total	... ...	...	...	246,400

As regards the undesirability of a continuously solid mole, Sir John Coode says:—

"Having regard to the great extent of sandy beach within the bay, extending, in fact, for several miles to the southward of the town and river-entrance, and also to aspect and exposure of the bay itself, *I am unable to recommend any solid structure between the shore and the line of 3 fathoms at low water*, feeling assured, as I do, that a serious amount of sanding-up, *on the inner or western side*, would inevitably follow, and to an extent that, to say the least, would be highly prejudicial to the present river entrance, and to the utilisation of the new work."

The reason for thus going into detail as regards Sir John Coode's design will be apparent further on.

Design as authorised.

The works authorised to be constructed in lieu of Sir John Coode's proposals, as indicated on map herewith in green, consist of—

(1.) A timber wharf and viaduct extending along river-side in a south-west direction from the blockyard to low-water line, length 1,580ft.

(2.) A solid concrete mole, in line of wharf and viaduct produced, from low-water line for a length of 1,900ft., and thence curving into a direction west by south for a further length of 250ft. Total length of concrete mole, 2,150ft.

(3.) A groin on west beach, length 400ft., in a direction due south; thus converging towards outer end of mole.

(4.) A bridge across the Turanganui River to get access to the town.

The depth below low-water spring-tides (as shown by soundings along proposed line) of the outer 600ft. or so of the mole thus provided for, was, and is still, from 16ft. to 26ft., but an additional depth of 3ft. or 4ft. was anticipated to be probable by river scouring away the sand. The estimated cost of these works was as follows:—

			£	£
Timber wharf and viaduct	Length, 1,580ft.	...	...	7,500
Railway to quarry, surveys, blockyard, buildings, and plant		...	35,200	
Sea-mole	„ 2,150ft.	...	123,300	
				158,500
Groin on west beach	„ 400ft.	...	...	4,000
Bridge over Turanganui River ...	...	...	...	5,000
Total		...	...	£175,000

Extent and Cost of Works constructed.

A loan of £200,000 was floated by the Harbour Board early in November, 1885, but by conditions of loan £25,000 of this amount is held by trustees towards a sinking fund, leaving only £175,000 really available for work. The existing design was finally adopted in December, 1885, and work commenced in April, 1886. The breakwater—concrete portion—however, was not started till June, 1887. It had reached to a distance of 400ft. in July, 1888, and was completed to extent of 1,100ft., as it now stands, and there terminated, in April, 1890.

The amount of loan actually available for works, as above mentioned, was originally £175,000, but, by Act of 1887, the Board was precluded from spending more than £65,000 of that amount. This £65,000 was subsequently, by Act of 1888, increased by £40,000, making in all £105,000. The remaining £70,000 is vested in trustees, and could not be made available for further works without the consent of Parliament and the ratepayers.

The following table shows extent and cost of works constructed, including, in each case, a due proportion of the cost (£4,400) of floating loan, and law-expenses:—

			£	£
Timber wharf and viaduct	Length, 1,580ft.	...	...	6,135
Railway to quarry, surveys, blockyard, buildings, and plant		...	36,283	
Sea-mole	„ 1,100ft.	...	48,821	
				85,104
Training-wall, in lieu of groin on west beach (only partially completed) ...	„ 530ft.	...	...	1,690
Total		...	...	£92,929

The wharf and viaduct above referred to, for the greater part of its length, is backed on east side by the natural bank of the river, or by a sand embankment formed against it, and, where not so, it is close-planked on east side, so that none of it is open for the sea to work through.

In addition to the cost of the works above described, there has been an expenditure of £6,851 on materials in hand, available for further works, making total expenditure £99,780. If to that amount there be added £5,220, cash in hand, it makes up the £105,000 authorised, as above mentioned, to be expended by the Board.

The 1,100ft. of concrete mole above described as completed, terminates at a point where there were soundings of from 12ft. to 14ft. at low water before mole was constructed, and there is still that depth of water at its extreme end, and at its east side, but a sandspit has been formed along its west or harbour side, which had reduced the depth available for navigation, in August last, to from 2ft. to 3ft. at low water. As against this, the normal depth on original bar, before works were commenced, is stated to have been from 3ft. to 4ft. at low water.

The works so far constructed seem, therefore, to have been rather detrimental than otherwise. They have had the effect of throwing the bar further out, and, consequently, into a heavier sea, with the additional danger of having to navigate a very narrow channel close to a solid mole; while, at the same time, the depth of water is rather less than it was originally. It is true, I believe, that the depth has been temporarily increased by freshes in the river since I have seen it; but this is a contingency of all such cases, works or no works, and is stated to have occurred similarly at Gisborne, before any works were constructed.

Remarks on Alteration of Design.

I think it is much to be regretted that, at any rate, the principle indicated in Sir John Coode's design was not adhered to—namely, an open viaduct reaching for some considerable distance from the shore-line, with a more or less enclosed basin at the end of it.

Briefly stated, this principle means simply taking a hint from nature.

A solid projection of any moderate length, reaching from a sand or shingle coast-line into the sea, where there is no large river or tidal basin to maintain deep water alongside it, has generally got a beach or shoal water at its sides and end; but a rocky island may exist, and frequently does exist, at a short distance from the shore, with deep water all round it.

The form of harbour most approved in modern engineering practice, for open sea coasts, in the absence of a large river or tidal basin, is therefore to construct what is practically a hollow island,

with vertical, or nearly vertical, sides—namely, in effect, a mole of rock or concrete, enclosing, or nearly enclosing, a space of more or less magnitude, connected with the mainland by a bridge of more or less length.

The size, location, and shape of such island, in relation to the length of the bridge and the direction of the preponderating winds and currents, are questions requiring the most careful study and consideration in each several case, no two sets of circumstances being quite alike, or, probably, even nearly alike; but, given a reasonably careful study of the circumstances, and a design conforming thereto, there is no reason why such a harbour as this should not succeed; while, on the other hand, the results from a solid wall running out from a sand or shingle beach, without, as before stated, a large river or estuary to maintain deep water alongside of it, are almost impossible to predicate.

The principal arguments used against Sir John Coode's design, and in support of the river-side alternative adopted in its stead, were, so far as I can gather from the various reports on the matter, as follows:—

(1.) That the site of Sir John Coode's design was further from the town, and consequently not so convenient as proposed site at river side.

(2.) That, as Sir John Coode's work for some distance out from low-water mark, was in the form of an open iron viaduct, affording no shelter to shipping, it could not be utilised "step by step" as it progressed, and would only become really efficient when carried out to nearly its full extent.

(3.) That the existence of a river at the proposed alternative site was a great advantage, as it would enable ships to get close up to the sheds, and also because deeper water (for a given expenditure) would be attained by the action of the river alongside the works, than could be expected to result without the aid of a river.

(4.) That the probable cost of Sir John Coode's design was beyond the resources at the disposal of the Board.

I do not think, however, that any of these contentions can stand the test of close examination.

As regards argument No. 1, which occurs very frequently in the various treatises on the subject, I cannot forbear from saying that I think too much importance altogether was given to that aspect of the question, and that, in view of the interests of the town itself, as well as those of the district as a whole, a mere difference of half a mile or so, either way, in the position of the root of the breakwater, was a matter of utter insignificance, in comparison with getting the most efficient harbour procurable for the available funds.

The same reasoning applies, to a great extent, to argument No. 2. All other things being equal, the mere temporary advantage of being able to utilise the work step by step, as it progressed, might properly, perhaps, have been allowed some little weight. Unless it could have been shown, however, that this advantage could be obtained without incurring *any* additional risk, and that, in fact, the design embodying it was as capable of meeting all the possible contingencies of the situation, and therefore just as likely in every way to continuously succeed as Sir John Coode's design, which did not embody this temporary advantage (a fact which has not been, and I do not think could possibly be, demonstrated) it must be evident that to risk anything in the way of ultimate success, for the mere temporary advantage of being able to utilise a work step by step as it advances, is somewhat shortsighted. That such a risk was incurred in this case, and that the obvious possibilities of this situation included a sand accumulation, which an open viaduct would probably have obviated, must, I think, be evident to any one acquainted with the locality, or glancing at the plans herewith; and it is scarcely necessary to say that such sand accumulation has duly ensued.

Argument No. 3 is a little catching at first sight, but, when carefully examined into, it seems to have really very little in it. Firstly, as regards the loading and unloading. The sheds for the receipt and delivery of goods would probably eventually be at whatever is found to be the most generally convenient place, wherever the harbour may be; and, as it is not possible that any large proportion of the goods could be delivered directly from the ships into these sheds, the majority having to be put into trucks, and run into the sheds on railway-lines, and *vice versâ*—that being, in fact, the almost universal practice in connection with breakwaters—it seems practically immaterial whether the ships load and unload within, say, ten chains of the sheds, or a few chains nearer or further. Then, secondly, as regards the deeper water alongside the works, anticipated from the action of the river, there is very little force in that either. The effect of the river, in fact, in the way of producing scour, seems to be scarcely, if at all, appreciable except in floods, and these occur so seldom as to be of but very little practical utility. Thus, for instance, the sandspit alongside of breakwater, which caused the entrance to be very shoal indeed, remained unaffected by the river from before August last till quite recently, and if intervals like that are to occur, during which no practical benefit is attained by river scour, it is scarcely worth considering the river as an element in the question at all. The insignificance, in fact, of this river, as an element in the question of harbour-works, can be easily appreciated from the following figures.

The Hokitika River, which is, I believe, the smallest of those dealt with in New Zealand, with any reasonable measure of success in connection with harbour-works, has a drainage-area of 382 square miles, with rainfall averaging 120in. per annum, and frequently reaching from 2in. to 4in. per day. This has been calculated by Sir John Coode to be likely to produce a discharge, in extreme floods, of 9,500,000 cubic feet per minute; in ordinary floods 5,000,000 cubic feet per minute; and at other times about 360,000 cubic feet per minute; and it should also be mentioned, that floods, of at least the ordinary type, occur very frequently.

As compared with this data, the figures for the Turanganui River, including all its tributaries, are as follows. Drainage-area, 116 square miles; average rainfall, 46in. per annum; extreme rainfall recorded in twenty-four hours, from 5·48in. in 1880 to 1·92in. in 1888; average

number of days per annum on which rainfall exceeded 1in. = 9¾ days. Calculated discharge in extreme floods (assuming rainfall at from 5·48in. to 1·92in. in twenty-four hours), say, from 650,000 to 230,000 cubic feet per minute; in ordinary floods (assuming 1in. of rainfall in twenty-four hours), say, 120,000 cubic feet per minute; and under normal conditions (taking average rainfall as 0·12 inches per diem), say, 15,000 cubic feet per minute.

There is also, of course, the discharge of tidal water, but this is likewise very insignificant in amount, when dealing with the question of navigation and scour through sandspits, being probably not more than about 40,000 cubic feet per minute even at high spring-tides.

Something might possibly be done to supplement the effect of the Turanganui River, by bringing into it a portion of the Waipaoa River (which has about seven times the drainage-area of the Turanganui, and, consequently, probably about seven times its discharge under the several conditions detailed above), but this was not, so far as I have seen, mentioned in connection with the project in question, and therefore, presumably, formed no part of it.

The whole brunt of supporting the contentions in favour of deviating from Sir John Coode's design, would therefore appear to devolve on argument No. 4, to the effect that the probable cost of Sir John Coode's design was beyond the resources of the Board, while the probable cost of the alternative design proposed was within those resources. This argument is not, however, I think, any more supportable than the other ones. It is quite true that Sir John Coode's estimate for his design was £246,400, while the estimate for the alternative design ultimately adopted (which does not go so far out to sea, or afford such facilities for future improvements) was £175,000, but there are several very important qualifications which have to be applied to this fact. In the first place, Sir John Coode's design and estimate provided for sheltering-arms or jetties at a cost of £51,490, which are entirely absent from the adopted design and estimate. Omitting these sheltering-arms from Sir John Coode's estimate, the cost of remainder of his design, taking his own figures, would be only £194,910. A further reduction which should then be made, in order to bring things more nearly on same basis, is in the estimate for the work between high- and low-water mark. This, Sir John Coode shows as masonry with rubble filling, and he estimates it accordingly at £10,750, while if constructed of timber, as in the adopted design, it would only cost about £2,750, leaving a saving there of fully £8,000. This would make total estimate only £186,910. A still further reduction is due to the amount which Sir John Coode has put down for his breakwater pier, 900ft. long, which he estimates at £135,180. This is based on a very high estimate for the concrete work, and if that item were put at same rate as in the estimate for the adopted design (including £35,000 for railway to quarry, blockyard, buildings, surveys, plant, and machinery, and without allowing anything for proceeds of sale of machinery, &c., when done with), which, moreover, has been found to be sufficient, it would come to quite £27,000 less. Thus it would appear, that putting both on same basis, the work on Sir John Coode's lines, while better situated, with much less risk of failure, and greater facilities for future improvements, would only have cost about £160,000, as compared with about £175,000 for the adopted plan. The argument that the probable cost of Sir John Coode's design was a bar to its adoption, would therefore appear to be untenable.

Another matter, which has struck me very forcibly, is the implication, in some of the reports on the subject of the best site for the harbour, that the scheme known as the harbour of refuge, indicated on the plan herewith in purple, and estimated to cost £450,000, was the only feasible alternative to the river plan. This, however, must surely have been merely hurriedly stated, without purporting to be exact. The site selected for the harbour-of-refuge plan has great advantages, and, is even, I think, superior to that selected by Sir John Coode for his works. It is in fact, I think, the best site in the vicinity, and, so far as the information I have got enables me to judge, I should recommend its adoption hereafter, in the event of a really efficient harbour for large vessels being undertaken at Gisborne in the future. In comparing it with the river scheme, however, the mistake appears to have been made of assuming, that if the harbour-of-refuge scheme were put in hand at all, it must be undertaken as a whole, whereas, as indicated on map herewith in blue, it is evident that a portion of it, with a slight modification in position, and adopting Sir John Coode's principle of an open viaduct from low-water mark to the 3-fathom line, could be carried out for a moderate cost, while having great advantages as regards depth of water. Thus the probable cost of the work indicated in blue on map herewith, would be, with the sheltering-arms complete, about £180,000, or without the sheltering-arms, about £130,000. This project, therefore, or at any rate a portion of it sufficient for immediate wants, came quite within the range of reasonable comparison with the other schemes in question, and it seems a pity that it should have been shut out of all practical consideration, by assuming it to be only approachable in the event of funds to extent of £450,000 being available.

In conclusion, as regards this phase of the subject, I may say again that I think it is much to be regretted that the main principle of Sir John Coode's design was departed from, and that, moreover, a distinctly less satisfactory site was adopted, whereas an even better site is probably available a few chains to the eastward. A sum of practically £93,000 has been expended (exclusive of value of materials in hand, and available for further works, £6,851), and even if the value of machinery in hand and available for sale—£11,390—be deducted from this, it leaves, say, £81,600 as the cost of constructed works, from which there is at present practically no return whatever. That these works can to some extent be utilised by a further expenditure of about £21,000, as hereinafter described, is probable; but I very much doubt if they could ever conveniently become part of any thoroughly satisfactory harbour for the accommodation of large vessels. The absence of an open viaduct for some distance out from low-water line is in fact, I think, fatal to the prospects of attaining any really satisfactory results on an extensive scale, by the present design, for a reasonable cost, there being no certainty, that I can see, that the sandspit would not make out considerably further if the mole were extended. It is needless to say, therefore, that I could not recommend any extension of the present works on the basis of the approved plan, and, although the results which may be obtainable from a further expenditure of £21,000, or so, in utilising the work

already done, would probably be more than value for that expenditure, it is scarcely probable that they would be commensurate with the total expenditure which would then have been incurred—namely, say, £102,600, if machinery is sold, or £114,000 if it is not sold. The constructed works being, however, practically useless as they stand, their cost—£81,600—may reasonably be left out of the question in considering the justifiableness, or otherwise, of expending a further sum to get some practical result.

Possibility, or otherwise, of utilising the existing Work, by Means of some Reasonable Expenditure on Further Works.

The fact that the existing works are practically useless, and likely, if left to themselves, to remain practically useless, being apparently evident, the question was: Could these works be in any way utilised by some reasonable expenditure on further works? and the vital point underlying this question was, as to whether or not there is at Gisborne what is generally known as "a sand-travel" from the westward.

I confess that when I first saw the spit at Gisborne, I thought it was the result of actual sand-travel, by which, I should explain, is meant not a mere local shifting of a limited quantity of sand, but a continuously progressive travel of sand in one direction, for a long distance, from a practically inexhaustible source. If this latter were the state of the case at Gisborne, the mischief would, I conceive, be incurable by any expenditure within reason. Under those circumstances, in fact, the sand would not alone be packed up against the mole, but would overlap and go completely round it, the volume of the Turanganui River being entirely insufficient to keep a clear passage of any considerable depth through even a very slight sand-travel.

Having devoted considerable time and care to investigating the question, however, I eventually came to the conclusion (to which Mr. Thomson and other engineers who had similarly examined into the question, had also come before me) that there was *not* an actual sand-travel from the westward. The principal facts which led me to this conclusion are as follows:—

(I.) The spit at west side, when I saw it, had made out almost to end of mole, but not quite to the end of it, and there was no sign of any appreciable quantity of sand having gone round the mole. I may here also mention that I was very anxious to be sure that this state of things continued for a lengthened period, the time during which it had continued, up to the date that I saw it, not being sufficiently long to render the evidence about it quite conclusive. This was especially so in view of the then coming summer months, when the opposing forces of the sea from the south-east would probably be at their minimum. A further reason therefore for failing to report on this question until now, in addition to the reason already stated, was in order to get fully satisfactory evidence on this point. Having kept myself informed on the subject in the meantime, I now find that the conclusions I came to on the ground are fully borne out by later evidence.

(II.) The total quantity of sand in the spit, taking the most extreme figures of all the various soundings, did not, when I saw it, exceed 70,000 cubic yards, and the measurements and soundings which I got taken in the immediate vicinity of the spit to the westward, when compared with measurements and soundings previously taken, showed that quite that quantity of sand, or more, had recently been removed from there. It was reasonable, therefore, to conclude that the spit was the result of merely local disturbance. It was also reasonable to conclude from these facts, and from observations of the set of the waves and currents in the vicinity, that this recent local disturbance, carrying the sand off the beach and forming it into a spit, was due, *inter alia*, to two causes—first, the inward curl of the waves on west side of breakwater, consequent upon the construction of the breakwater itself; and, second, the increased current in the sea along west beach in vicinity of entrance to river, caused by the tide having to get into the river entirely from one side, instead of from both sides, as formerly.

(III.) The evidence which I obtained, and the observations and measurements of currents, &c., which I made myself, all go to show that the preponderating force of the sea is distinctly from the south-east. This supplies the reason why the spit cannot travel round the breakwater. The forces from the west, being sheltered from the opposing south-easterly forces, are sufficient to pile it up against the mole on west face, but the south-easterly forces are apparently too strong to let it come round. This would point to there being a tendency to sand-travel from the south-east, which, in fact, is the case. Fortunately, however, there is practically no sand to come from that direction. A travel would only be practicable from Tuamotu Island, and between there and the breakwater the beach is practically bare of sand. There is also the fact that the promontory reaching from Gisborne to Tuamotu Island is a narrow ridge, having no considerable area of watershed on sea side, and, consequently, no room for any large stream to bring down *débris* into the sea. The results of this tendency to sand-travel from the south-east are therefore chiefly to be found on the other side of the bay, where the tendency is to make ground in the pocket or end of the bay, in the vicinity of the Waipaoa River. The same forces act on the sand coming out of the Waipaoa River itself, piling it on the shore in the vicinity of the river-mouth. This is further evidenced by information kindly furnished to me by Mr. Gold-Smith, Chief Surveyor of Gisborne, who is of opinion that the whole of the area coloured pink on map herewith (sheet 4) is sand-formation, and that a considerable portion of it has been made up by the sea, within, geologically speaking, a comparatively recent period.

Question as to whether the Funds at the disposal of the Board, are sufficient to enable the necessary Additional Works to be done.

The state of the case, as regards the possibility of improving the existing condition of things, being as above described, the next question was, as to whether the funds at the disposal of the Board would admit of the necessary additional work being done.

As already stated, the amount of loan originally authorised was £200,000, but of that sum £25,000 can never be available at all, being held in trust towards a sinking fund, and £70,000 of

the remainder, being locked up by Act of Parliament, could only be made available by a similar Act, and with the consent of the ratepayers. The total amount of loan-money made available for works to date, is consequently £105,000.

I was therefore given to understand, by the Board, that the only assets which could be counted on as at present available for construction works were as follows: (1) The unexpended balance of the £105,000, above mentioned, which is only £5,220; (2) materials in hand, available for further works, to the value of £6,851; and (3) plant and machinery, which would possibly fetch, if sold, about £11,390: Total, £23,461. The details of these items are shown in appendix herewith, marked A.

The length of the work required is 2,450ft., a considerable portion of which, at outer end, would necessarily be very much exposed.

The outer 1,100ft. of existing work cost £48,821, exclusive of £36,283 for plant and machinery. The inner work cost, as near as possible, £4 a foot. This for 1,350ft. comes to £5,400. Total, exclusive of plant and machinery, for a length of 2,450ft. (corresponding with the length of the work now required), £54,221.

It was therefore, of course, at once evident, that the assets above mentioned, amounting nominally to £23,461—even supposing that they can all be realised—are, in comparison with the cost of the existing work, relatively very inadequate for the work required; and that the task of designing structures which would be strong enough to act, while at the same time keeping within the funds stated to be available, must consequently be an exceedingly difficult one—something, in fact, of the character of endeavouring to make bricks without straw. It seemed just possible, however, that the actually necessary work could be done for the sum mentioned, so designs were taken in hand accordingly, and, being now completed, are enclosed herewith.

Extent and Character of Works now designed.

The works which I have now designed are outlined in red on drawing herewith, sheet 2, the details of the principal structures being shown on sheet 3. They commence at the intersection of Rangi Street with Customhouse Street, in the Town of Gisborne, and run out from thence in a direction about south-west by south, for a distance of 1,800ft., thence curving into a nearly due south direction for a further distance of 650ft. (total 2,450ft.), and terminating at a point, which, in view of the general direction of the heaviest seas, is calculated to be slightly outside the shelter of the existing concrete mole. Further details as to the character of the various structures, will be found in appendix herewith marked B.

I had contemplated using the soft rock known as "papa" for some of the cribwork filling, in order to save expense, but ultimately decided not to. The saving would not amount to much, and the rock from quarry is of course much preferable.

The small concrete blocks, indicated on drawing, are intended to be attained by blasting or splitting the concrete blocks now on hand, so far as they will go. After they are all used the balance required could be moulded to sizes indicated.

The total estimated cost of these works, including £2,000 for contingencies, is £21,000.

I should have preferred it if the work could have been kept more to the west, thus leaving more room within the harbour available for further shipping-accommodation in the future. This, however, would have entailed its being more exposed to the action of the sea, and would consequently have involved its being stronger and more costly, which the available funds would not admit of.

The underlying principle of the whole design is, of course, to get a wall on west side *projecting out beyond the shelter of the existing eastern mole.* I have assumed that a wall completely under the shelter of the existing work would do no good at all, as the sand would completely surround it, and still pile up against the existing mole as it does at present. *This is the great evil of the existing site, namely, that in order to get any useful result it involves two walls, the second of which must, for a considerable portion of its length, be nearly, if not quite, as strong as the first.* It is consequently a very expensive site to deal with, and hence, *inter alia,* my reason for saying above, that I could not recommend any extension of the existing works, as the cost would probably be excessive in view of the results which would be likely to be attained.

It is somewhat doubtful if the extreme outer portion of the work as designed is quite strong enough. If not, it will have to be supplemented with further concrete blocks. This is not directly provided for in estimate, but would probably be covered by the £2,000 included for contingencies.

Presuming that an eastern wall is carried out beyond the end of the western one, as now designed, it is anticipated that the south-easterly forces will prevail over the western ones at the end of it, as they do now at the end of the existing mole; and that, therefore, no sand will come into the harbour round the end of the new work.

If these anticipations are realised, there seems every reason to expect that a compact and convenient, though of course a small harbour, will result, with a depth at entrance of from 10ft. to 12ft. at low water, and 15ft. to 17ft. at high water.

Following on that, it is assumed, as indicated on drawing herewith sheet 2, that the channel between the letters N and M would be cleared to a depth of, say, about 10ft. to 12ft. below low-water level, throughout the extent defined by red hatching. This would probably be largely done by the river itself, when the harbour becomes protected from the western forces. The scouring action of the river, after harbour is enclosed, could also be considerably assisted by a row of piles, say, 3ft. to 6ft. apart centres, along the line indicated by strong red dots from I to J on same drawing. A timber wharf 650ft. in length (K to L), with swinging basin at lower end of it, which is likewise indicated on same drawing, would also probably be a desirable work to undertake in the future. Pending construction of wharf, a pile-facing from K to L, similar to that suggested from I to J, would be desirable, to assist the scouring action of the river. Such portions of the area indicated as the river will not scour out to the required depth would of course have to be dredged.

Recommendation.

I have had some hesitation in taking the responsibility of recommending any works to be undertaken, of such an economical character as were alone practicable for the funds stated to be available. Presuming, however, that no further funds can be obtained, and in view of the very deplorable state of things existing at present, and the great benefits which the additional works indicated on the drawings herewith are likely to produce, as compared with their estimated cost, I have decided to take the responsibility of recommending their being undertaken.

I now beg to recommend accordingly, for the approval of the Board, that the designs herewith enclosed be adopted; also that the works thereon indicated be put in hand as soon as practicable, in order to admit of their being carried out during the present summer weather. This is of course presuming that the Board can see its way to realise the amount required, from the assets hereinbefore described, or otherwise.

While making this recommendation, however, I would wish to strongly represent the necessity for great care and attention being given to the work during the course of its construction, and for some time afterwards. If the funds admitted of it, designs could of course readily be made (much more readily in fact, than designs of the character enclosed can be made) which would stand practically anything, and might consequently be carried out almost anyhow. The funds apparently available, however, will not admit of that, but they do admit of works being constructed which have a very reasonable prospect of succeeding, if due care is devoted to them. There seems to be no reason why such care should not be forthcoming, seeing that the saving in first cost, as compared with solid concrete work, or such like, is very large.

Conclusion.

In conclusion, I would wish to acknowledge, with thanks, the courtesy and assistance which I experienced at the hands of the Chairman, and members, and the Secretary of the Harbour Board, during the course of my investigations at Gisborne, extending over a period of a fortnight or thereabouts; and also to acknowledge, with many thanks, the very valuable assistance and information given to me by Mr. Gold-Smith, Chief Surveyor at Gisborne, and by his assistants, especially Mr. Armstrong, Assistant-Surveyor.

For the information given as to the rainfall in the Gisborne district, and the consequent discharge of the Turanganui River, I am indebted to the very valuable records, kept for many year past—as a labour of love—by the Venerable Archdeacon Williams.

I would wish also to remark, as my comments on adopted design may appear somewhat adverse, that I think it my duty to state that the actual construction of the work, as carried out under Mr. Thomson's supervision, has been, in my opinion, most excellently done. The arrangements and organization for carrying on the work were thoroughly able and efficient, and the machinery was as perfectly adapted to the requirements as it is possible for any machinery to be. The cost of the concrete work has consequently been abnormally cheap, sufficiently so indeed, as compared with the usual cost of such work, for the saving to have almost covered the depreciation in the value of the plant, machinery, and appliances up to date, and more than sufficient to have fully covered the whole cost of plant, machinery, and appliances, if the work had been carried to extent intended. I have therefore no adverse remarks whatever to make with regard to the execution of the work—in fact quite the contrary. The only thing which I have taken exception to, is its location.

I have, &c.,

C. Y. O'Connor,
Marine Engineer

The Hon. the Minister having charge of the Marine Department, Wellington.

List of Plans herewith.

Sheet 1.—General map showing the various schemes for harbour-works.
Sheet 2.—Ditto, showing works now recommended.
Sheet 3.—Details of works recommended.
Sheet 4.—Map of Poverty Bay, showing land believed to have been formed by the sea.

APPENDICES.

APPENDIX A.

Available Assets of the Gisborne Harbour Board towards continuing Construction Works, as stated by Mr. Bourke, Secretary to the Board, in August, 1890.

Summary.

Description.	Amount.
	£
Cash in hand	5,220
Materials on hand, value	6,851*
Plant on hand, saleable value	11,390*
Total	23,461

* *Vide* details attached.

MATERIALS ON HAND.

[All these can be utilised towards the Construction of the Work now recommended.]

Description.	Item.	Quantity.	Price.	Value.
			£ s. d.	£
Blocks (224)	c.y.	2,610	1 10 0	3,915
Cement	casks	1,300	0 17 8¼	1,250
Timber	CBM	720	1 0 0	720
Fascines	value	...	..	15
Jute sacking	"	...	...	190
Iron rails	tons	31¼	4 0 0	125
Tools, including 4 anvils, 9 hydraulic jacks, 4 winches, monkey, &c.	value	...	...	636
Total	...	...	...	6,851

PLANT ON HAND.

Description.	Saleable Value.
	£
Hercules and grab	4,310
Goliath	1,418
Concrete-mixer	562
Sand-pump	608
Locomotive	452
Trucks and trollies	1,393
Crane and grab	460
Block-moulds	766
Bag-box	287
Diver's gear	408
Stone-crushers	400
Skips and Lewis bars	82
Boats	87
Tank	84
Weighbridge	73
Total	11,390

APPENDIX B.

DETAIL DESCRIPTION OF WORKS HEREIN RECOMMENDED.

For a distance of 726ft., from A to B, at outer end, the work consists of a timber viaduct, spans 12ft. centres, with cribwork at both sides, and having filling and slopes of rubble, protected at both sides by concrete blocks of from 2 to 5 tons each.

The next 460ft., B to C, consists of a similar timber viaduct, but with cribwork at one side only, and rubble mound without concrete facing.

The next 218ft., C to D, has been designed for the present as a timber viaduct only, spans 12ft. centres. No special form of filling is indicated, as it is hoped that such filling-in as may be required, may be done with fascines or rough timber work of some very inexpensive character.

The next 363ft., D to E, which is intended to terminate at edge of present sand-cliff, above high-water mark, is a sand-embankment, faced on both sides with fascines, and sufficient rubble stone to protect the sand from the wash of the sea.

The remainder of the work provided for, which is merely indicated as a means of getting access to the outer work above described, is as follows:—

304ft., E to F, is an ordinary sand embankment, with fascine protection on slope adjoining the Waikanae Creek.

108ft., F to G, is a timber bridge, spans 12ft. centres, over the Waikanae Creek.

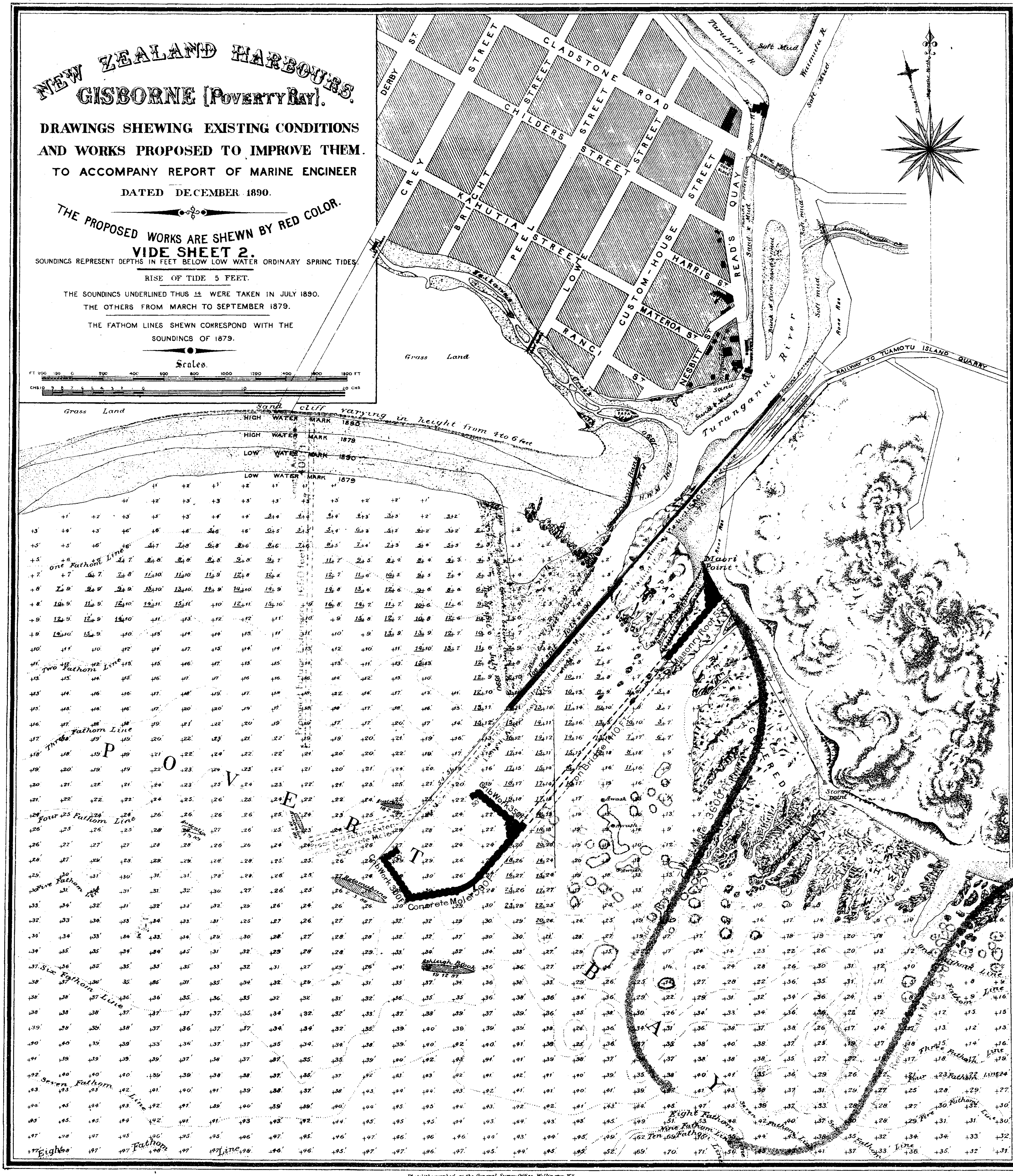
271ft., G to H, is an ordinary sand-embankment, protected with fascines on Waikanae Creek slope.

The total length of the work recommended is thus 2,450ft.

A single line of rails, gauge 3ft. 6in., with sleepers 2ft. 8in. from centre to centre, is provided for throughout the entire distance; and a footway, consisting of planks 12in. by 2in., laid on the sleepers, is shown continuously throughout the whole of the viaduct and bridge work.

[*Approximate Cost of Paper.*—Preparation, nil; printing (1,300 copies), £5 7s.]

By Authority: GEORGE DIDSBURY, Government Printer, Wellington.—1891.


NEW ZEALAND HARBOURS.
GISBORNE [POVERTY BAY].
DRAWINGS SHEWING EXISTING CONDITIONS
AND WORKS PROPOSED TO IMPROVE THEM.
TO ACCOMPANY REPORT OF MARINE ENCINEER
DATED DECEMBER 1890.
THE PROPOSED WORKS ARE SHEWN BY RED COLOR.
VIDE SHEET 2.
SOUNDINCS REPRESENT DEPTHS IN FEET BELOW LOW WATER ORDINARY SPRINC TIDES.
RISE OF TIDE 5 FEET.
THE SOUNDINCS UNDERLINED THUS 14 WERE TAKEN IN JULY 1890.
THE OTHERS FROM MARCH TO SEPTEMBER 1879.
THE FATHOM LINES SHEWN CORRESPOND WITH THE
SOUNDINCS OF 1879.
Scales.
FT 200 100 0 200 400 600 800 1000 1200 1400 1600 1800 FT
CHS 10 9 8 7 6 5 4 3 2 1 0 10 20 CHS
DERBY ST.
GREY STREET
CLADSTONE ROAD
CHILDERS STREET
BRIGHT STREET
KAHUTIA STREET
PEEL STREET
LOWE STREET
CUSTOM-HOUSE STREET
HARRIS ST
MATEROA ST
NESBITT ST
RANCI ST
READ'S QUAY
SWINC BRIDGE
Soft Mud
Sand & Mud
Turanganui River
RAILWAY TO TUAMOTU ISLAND QUARRY
Grass Land
Sand cliff varying in height from 4 to 6 feet
HIGH WATER MARK 1890
HIGH WATER MARK 1879
LOW WATER MARK 1890
LOW WATER MARK 1879
One Fathom Line
Two Fathom Line
Three Fathom Line
Four Fathom Line
Five Fathom Line
Six Fathom Line
Seven Fathom Line
Eight Fathom Line
Nine Fathom Line
Ten Fathom Line
POVERTY BAY
Maori Point
Stoney point
Masonry Root 550 FT
Crib Work 350 FT
Crib Work 300 FT
Concrete Mole 500 FT
Australia
Rotomahana
Ashleigh Brook
Awash

Sir John Coode's Design .... Brown

Photolithographed at the General Survey Office, Wellington, N.Z.

The outlines of ships show places where ships of various tonnages have anchored. "Australia," steamer, 459 tons; "Rotomahana," steamer, 1,727 tons; "Ashleigh Brook," steamer, 2,863 tons.

COPY OF M.D.1626

NEW ZEALAND HARBOURS.

GISBORNE [POVERTY BAY].

DRAWINGS SHEWING EXISTING CONDITIONS AND WORKS PROPOSED TO IMPROVE THEM.

TO ACCOMPANY REPORT OF MARINE ENGINEER

DATED DECEMBER 1890.

THE PROPOSED WORKS ARE SHEWN BY RED COLOR.

SOUNDINGS REPRESENT DEPTHS IN FEET BELOW LOW WATER ORDINARY SPRING TIDES.

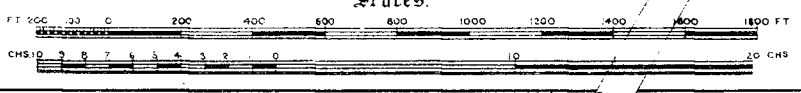
RISE OF TIDE 5 FEET.

THE SOUNDINGS UNDERLINED THUS 12 WERE TAKEN IN JULY 1890.

THE OTHERS FROM MARCH TO SEPTEMBER 1879.

THE FATHOM LINES SHEWN CORRESPOND WITH THE SOUNDINGS OF 1879.

Scales.



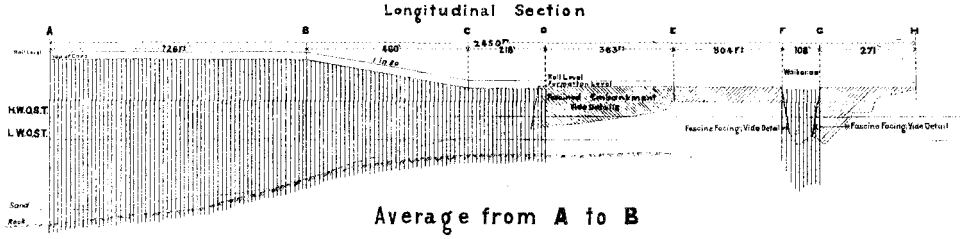
Photolithographed at the General Survey Office Wellington N.Z.

THE outlines of ships show places where ships of various tonnage have anchored. "Australia," steamer, 469 tons; "Retomahana," steamer, 1,777 tons; "Ashleigh Brook," steamer, 2,863 tons.

GISBORNE HARBOUR WORKS.—DRAWINGS to accompany Report of Marine Engineer, dated December 1890 — SHEET 3.

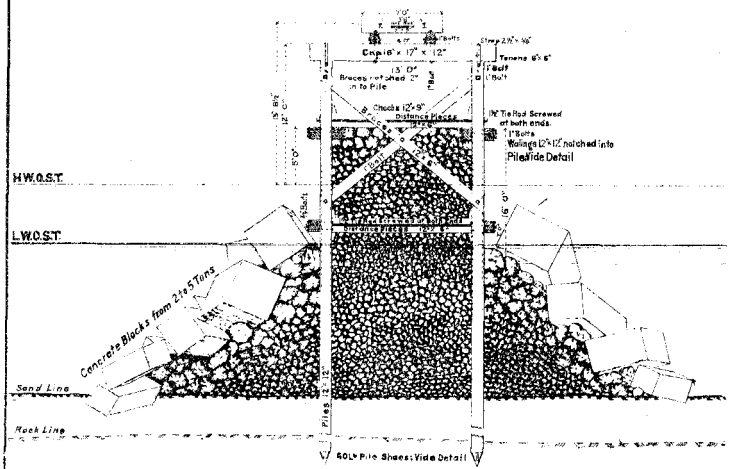
— WORKS COLOURED RED: VIDE SHEET 2. —

Longitudinal Section

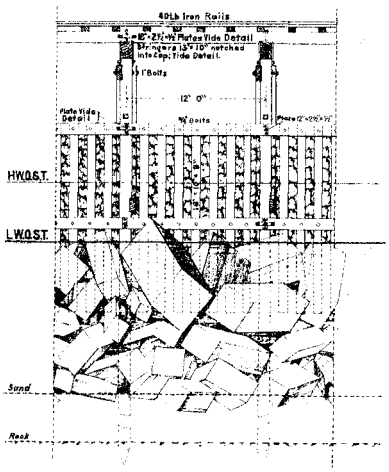


Average from A to B

Cross Section

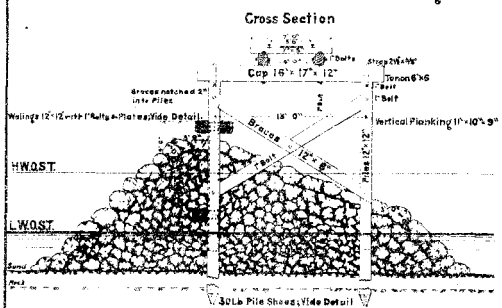


Side Elevation

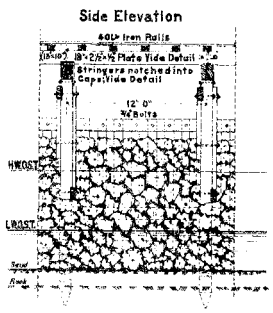


Average from B to C

Cross Section

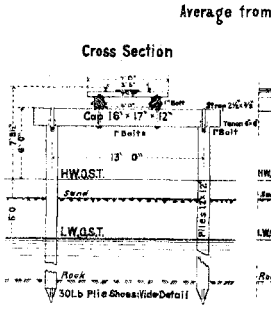


Side Elevation

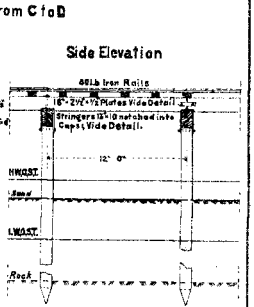


Average from C to D

Cross Section

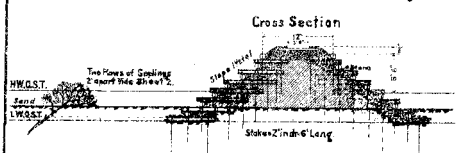


Side Elevation

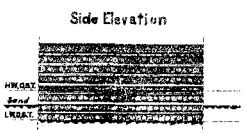


Average from D to E

Cross Section

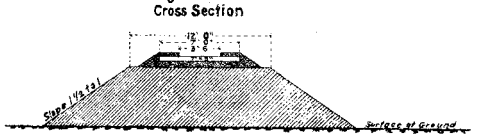


Side Elevation



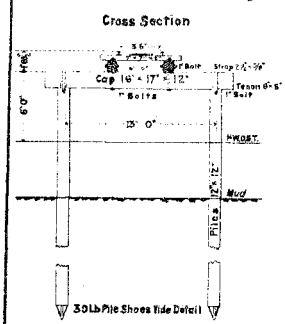
Average from E to F

Cross Section

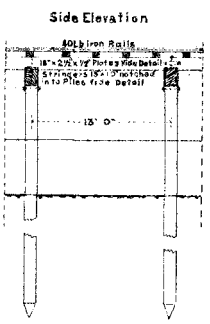


Average from F to G

Cross Section

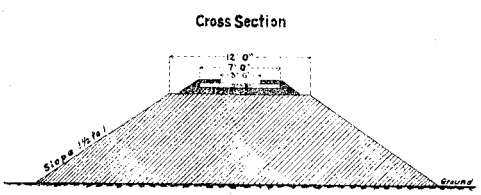


Side Elevation

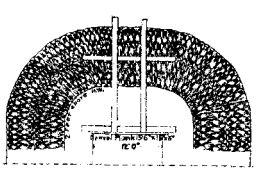


Average from G to H

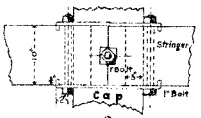
Cross Section

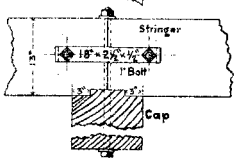


Plan of Fascine Work at F & G

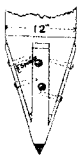


Joint of Stringers & Plates

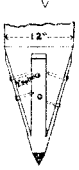




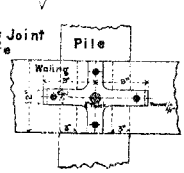
40 Lb Pile Shoe



30 Lb Pile Shoe



Waling Joint & Plate



— SCALES —

— Longitudinal Section —

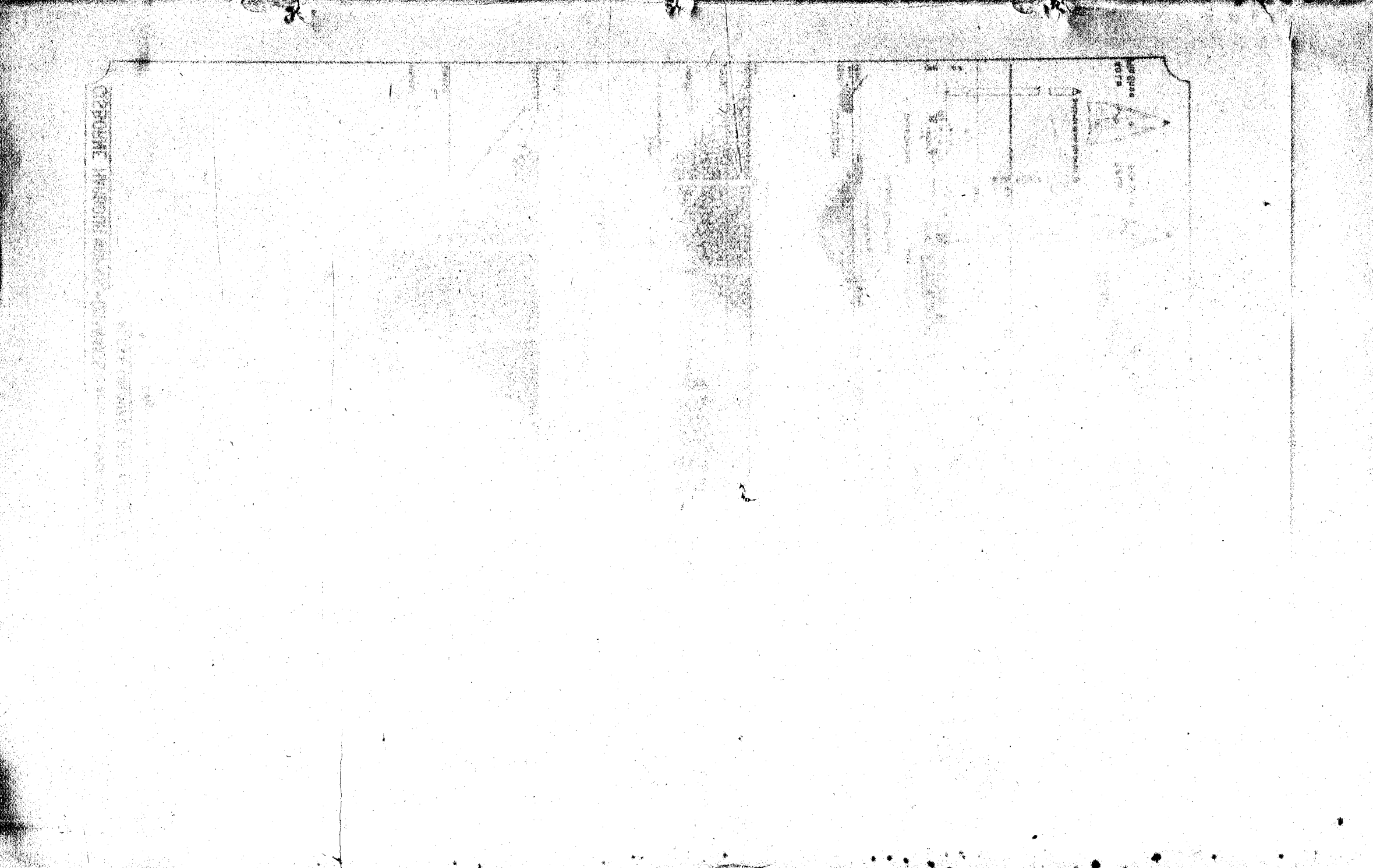
— Horizontal

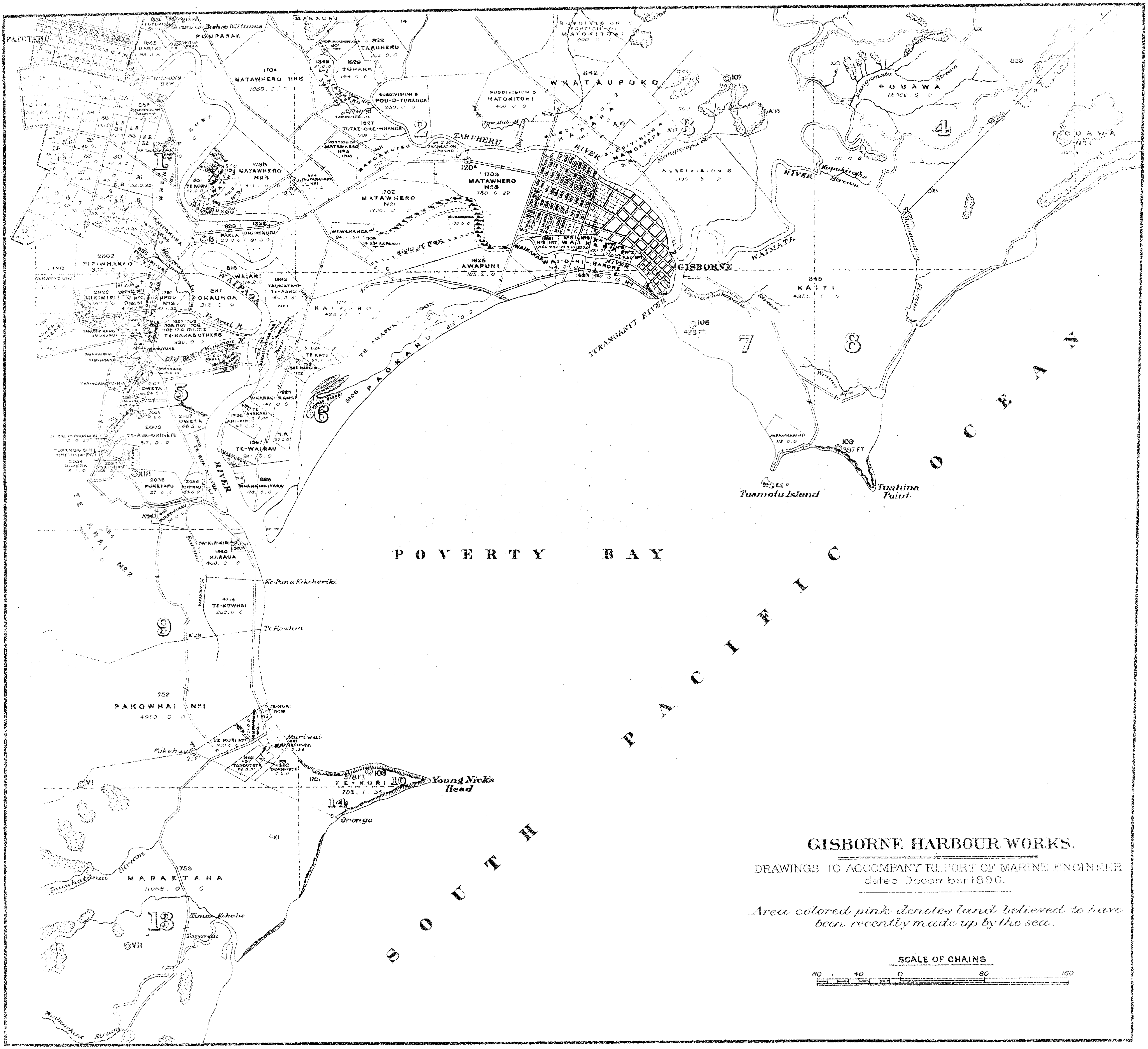
— Vertical

— Average Sections &c. —

— Fascine Work —

— Details —




GISBORNE HARBOUR WORKS.
DRAWINGS TO ACCOMPANY REPORT OF MARINE ENGINEER dated December 1890.
Area colored pink denotes land believed to have been recently made up by the sea.
SCALE OF CHAINS
80 40 0 80 160
POVERTY BAY
SOUTH PACIFIC OCEAN
GISBORNE
TURANGANUI RIVER
TARUHERU RIVER
WAIMATA RIVER
WAIPAOA RIVER
WHATAUPOKO
KAITI
POUAWA
MATAWHERO Nº1
MATAWHERO Nº3
MATAWHERO Nº4
MATAWHERO Nº6
AWAPUNI
PAOKAHU
PAKOWHAI Nº1
MARAETAHA
TE-KURI
TE-KOWHAI
KARAUA
TE-WAIRAU
OWETA
PUKETAPU
WAIARI
KOKAUNGA
PIPIWHAKAO
HIRIMIRI
TOHAKA
TARUHERU
TAUMATA-O-TE-RANGI
WHARAU-RANGI
Young Nick's Head
Tuahine Point
Tuamotu Island
Muriwai
Pukehau
Orongo
Te Kowhai
PATUTAHI
1
2
3
4
5
6
7
8
9
10
13
14