1892.

NEW ZEALAND

HARBOUR-WORKS, GREYMOUTH AND WESTPORT

(REPORTS AND CORRESPONDENCE RESPECTING).

Returns to orders of the House of Representatives dated 18th August and 16th September, 1892.

Ordered, "That there be laid before this House copies of any recent reports made by Mr. C. N Bell, either to the Harbour Boards or the Government, upon the harbour-works of Greymouth and Westport, together with copies of any plans or soundings accompanying such reports, and any correspondence relating thereto."—(Mr. WRIGHT.)

Ordered, "That there be laid before this House the report of Mr. Reynolds on the Westport Harbour."—(Mr. WRIGHT.)

THE GREYMOUTH HARBOUR WORKS

(CORRESPONDENCE RELATING TO MR. C. NAPIER BELL'S REPORT).

No. 1.

C. Napier Bell, Esq., Wellington. Greymouth, 14th May, 1892.

GREYMOUTH Harbour Board would be glad if you would kindly report on dredging operations in Grey River, and on necessity for completing training-banks. Will you kindly wire whether you can do so. Also amount of your fee for report.

A. R. GUINNESS, Chairman.

No. 2.

A. R. Guinness, Esq., M.H.R., Greymouth. Dunedin, 20th May, 1892.

WILL make same charge as for Westport—that is, fifty pounds and actual expenses. Address, Christchurch.

C. NAPIER BELL.

No. 3.

C. Napier Bell, Esq., Christchurch. Greymouth, 21st May, 1892.

TELEGRAM received. Board agrees to your terms.

A. R. GUINNESS, Chairman.

No. 4.

DEAR SIR,— Christchurch, 22nd May, 1892.

Having received your telegram accepting my offer to report on the Greymouth dredging and training-walls, I shall, without delay, proceed to Westport, where I have to make a report, and after that I shall come to Greymouth to receive your instructions.

I am, &c.,

A. R. Guinness, Esq., M.H.R. C. NAPIER BELL.

No. 5.

SIR,— Greymouth, 6th June, 1892.

I have come to Greymouth from Westport to get some information here which I require for Westport, and intend to return to Westport to-morrow After being four or five days in Westport I intend to come back to Greymouth and devote myself to the business you require of me.

Meantime, would you be good enough to write my instructions on the subjects which you wish me to attend to. I am, &c.,

The Chairman of the Greymouth Harbour Board. C. Napier Bell.

No. 6.

Sir,— Greymouth Harbour Board, Greymouth, 6th June, 1892.

In reply to your letter asking for written instructions on the subjects which the Board wishes you to attend to, I am directed to inform you that the Board wishes you to report on the following subjects, namely (1) On the dredging operations in river now in progress and lately completed, (2) on the advisability or otherwise of completing the training-banks, or of either of them, (3) generally on works in progress, (4) in respect of any work on which you may have suggestions to make, or which you may consider to be advisable for the Board to undertake for the improvement of the harbour. I have, &c.,

C. Napier Bell, Esq., Civil Engineer, Greymouth. Thomas Allen, Secretary

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No. 7

Sir,— Greymouth, 9th July, 1892.

Herewith please receive my report on the training-walls, dredging, and harbour-works generally, as required in my instructions from your Chairman.

The report is accompanied by a sheet of cross-sections of the river, the object and use of which is explained in the report. Also a plan of the harbour, on which is shown contour-lines of depths, soundings at sea, and proposed works.

I shall leave by the first boat for Christchurch, where I shall be glad to receive any further orders from your Board at any time. I am, &c.,

The Secretary of the Harbour Board. C. Napier Bell.

Enclosure in No. 7

Report on Training-walls, Dredging, and Works generally.

Sir, Greymouth, 6th July, 1892.

Acting under your instructions to report to you on the effect of the training-walls, the dredging, and the works generally I have had a number of cross-sections of the river taken, also a set of soundings outside the breakwaters, with observations on the velocities and direction of ground-floats, which are useful to enable an opinion to be formed of the effect of the works both inside the river and in the sea outside the breakwaters.

Comparison of Depths.—On the sections across the river I have shown the depths of the water in June, 1892, and, for comparison, the depth just after the great flood of the 6th July, 1887, also, the depth in November, 1888, before the training-walls were built, and the depths in November, 1890, after they were built.

Effects of Jubilee Flood.—The effect of the great flood appears to have shoaled the upper part of the river, from the bridge to just above the sheds, but from the sheds to the signal-station there was a great deepening of the water as the result of the floods. From the date of that flood to the present time the depths in different parts of the river have varied considerably, and, although the excessive scouring caused by the flood near the wharf has filled up, yet, on the whole course of the river, from Tainui Street to the signal-station, the deepening produced by the flood has been preserved to this time, and in some places the present water is deeper than that produced by the flood.

Effect of Training-walls.—Before the training-walls were erected the river was narrower than it is now, and, although there are constant variations in depth as fresh gravel is brought down by the floods, there appears to be a progressive increase in depth, taking the river as a whole—that is to say, since the walls were erected some parts are shoaler on one side and deeper on the other than they were before the walls were erected, but, generally, the river is deeper now than it was then. I do not think the current in the river is capable of maintaining a uniform depth between the walls, unless these were narrowed to an inconvenient extent. As it is at present there is good water close beside the wharves, and shallow water towards the centre of the river, but at the part of the wharf near the cranes there is sufficient depth right across to allow of vessels swinging, and the depth from the lower end of the wharf down the river is always ample for all purposes. As the shingle travels down the river the depths vary, but no serious shoaling has occurred, and I am of opinion that the river will always preserve about the average depth found at present, although irregularities of depth, caused by floods, may require some dredging to be done from time to time.

Training-walls.—The training-walls which have been built to guide and regulate the current and its scour have apparently had a somewhat uncertain effect, probably due to the material of the river-bed being rough heavy shingle, which is shifted down by floods in an irregular manner, and afterwards slowly sorted out to a more regular bed.

Effect of Tainui Street Wall.—In the lower parts of the river—that is, from the lagoon mouth to the bar—there is good water right across the river, and the tendency is to get deeper An inspection of the soundings shows that the erection of the Tainui Street training-wall has produced a considerable deepening of the river opposite and below it, as far as Boundary Street, but the sharp curve in the root of the wall has the effect of concentrating too much of the scour of the wharf, causing the river to shoal on the right side, from the end of the wall downward. In order, if possible, to correct to some extent this irregularity of the scour, it is necessary to prevent the current from

striking against the curved root of Tainui Street wall, and forcing the water too suddenly across the river to the bend in the wharf at Boundary Street. This can be done, and a more direct and uniform current produced, by extending the Coal Creek training-wall as shown on the plan which accompanies this report, and I recommend this extension to be done, as I believe it will secure a more uniform depth across the river just where it is most wanted, and probably obviate the necessity for much dredging. This extension will also hasten the scouring-away of the shingle-bank below the bridge, which is continually wasting away, and the more it is removed the better will be the direction of the current.

Middle Training-wall.—I do not think there is any necessity at present to extend the middle training-wall, although, if the wharf should ever be extended to the lagoon, the extension of the middle training-wall might improve the channel, and make the depth more uniform. At present, from Chapman Street to the lagoon-mouth, the right side is very shallow

Effect of Floods and Shingle.—The floods and heavy shingle moved down the river by them are no doubt the cause of the very irregular depths which are found in the navigable part of the river This irregularity is clearly shown on the contour-lines of the depths which I have laid down on the plan herewith. I do not think the training-walls can always regulate the depth, and that from time to time shoals will be found after floods in unexpected positions. If left alone for some time such shoals gradually disperse, and the average depth is restored but, as navigation cannot wait on natural causes, it is more than likely that dredging must be resorted to, and to what extent this will be required it is not possible, without long experience, to foresee. The heavy shingle which composes the river-bottom can only be removed during floods, but, in the lower part of the river the bottom is softer, and the bar is composed of gravel and sand. When the river is low the currents are feeble, and it is important to secure all the scouring-power that can be got. The scouring-currents are derived partly from the river-water, and partly from the tide which flows in and out of the river, and into a number of small lagoons.

Channel to Karoro Lagoon.—I consider it to be of sufficient importance, with the view of securing a greater quantity of tidal water, to incur the expense of dredging the channel referred to in Sir John Coode's report, to the Karoro Lagoon, and I recommend the Board to undertake this work at its earliest convenience. The channel should be 100ft. wide at bottom, and should be 3ft. 6in below low-water spring-tides. This will enable the lagoons to fill up to the level of the tide in the river itself, and will secure a material addition to the scouring-force of the river The cost would be about £4,180.

Dredging.—A large quantity of dredging has been done to secure the existing depth of water along the wharves. Dredging commenced under the Public Works Department, and, from 1879 to 1882, 295,548 tons were dredged along the wharves from Wereta Street downwards, at a cost of £14,311, the average per ton being 11½d. From 1885 the Harbour Board has done a considerable quantity of dredging at various times until this year, amounting to 92,771 tons, at a cost of £5,117, the cost per ton varying from 1s. to 1s. 6d. and 1s. 8¾d. per ton. The total quantity of dredging that has been done to improve the berthage and give room for swinging is 388,319 tons, costing £19,428. The average cost is 1s. per ton.

Necessity for it.—The necessity for so much dredging has arisen largely from the deepening of the bar by the construction of the works, which has allowed vessels of deeper draught to seek the port. The berthages have now a depth of about 12ft. at the upper wharf, and 15ft., 18ft., and 21ft. at its lower parts, below low-water spring-tides, and for a width of about 75ft. from the wharf.

Permanence of Dredging.—I have not been able to entirely satisfy myself as to whether the depths gained by dredging are silted up to any extent after floods the evidence, so far as it goes, appears to show that the depths are maintained by natural scour I believe the dredging has had a useful effect, and, with occasional exceptions from floods causing partial deposits, I think the good results will be fairly maintained. Where dredging has been done, quantities of snags and heavy limestone rocks, slipped out from the pitching underneath the wharf, have been raised.

Nature of Bottom.—The dredgings show that coarse shingle, with boulders up to 1cwt., cover the surface, and below that the shingle is finer and contains more sand. These snags and heavy stones have no doubt taken centuries to creep down the river, and when once removed it will perhaps take centuries to replace them by floods. The removal of snags, limestone rocks, and heavy shingle by dredging would therefore leave the bottom covered with finer shingle and sand, which is much more under the influence of the ordinary scouring-power of the river The only dredging which is contemplated is that necessary to give good berthage for ships along the wharf, and to secure turning-room at the lower wharf, and to maintain the depth so gained.

Dredger.—The dredger employed is a very effective machine for its size it is capable of raising from 100 to 125 tons an hour The difficulty of disposing of the shingle, which has to be lifted up to the wharf and carried away in trucks, limits the output, and increases the cost. At present about 260 tons per day is raised, at a cost of 1s. 6d. per ton, or 2s. 3d. per cublic yard, but the greater part of the previous dredging cost about 1s. 1d. per ton.

Stones slipping into Fairway.—In dredging alongside the old part of the wharf some trouble will occur from the very steep slope of the stone pitching which covers the bank under the wharf, and which, as the bottom is deepened by dredging, keeps slipping into the fairway The wharf cannot keep the stones up, as the piles are 12ft. apart, and it may be found necessary, if deeper water is wanted at this part of the wharf, to drive piles 1ft. apart all along it, and secure their heads by walings to the present piles. If this is not done, and deep dredging is carried on along the old wharf, the whole of the pitching may slip down, and let down the street at the back of the woodwork.

Velocity of Currents.—I took a few observations on the velocity of the current in the river, with the object of ascertaining the variations in speed at different parts, variations which the floods will also be subject to when they occur The following list shows the velocities on two different days, the river being very low and the sea smooth ;—

TABLE showing Velocity of Grey River between Cobden Bridge and Ends of Breakwater on the 5th July, 1892.

[Float was put in under centre of Cobden Bridge at 9.25 a.m. Depth of float was 8ft. Strong easterly breeze. High water, 6.30 a.m.; low water, 12.30 p.m.]

Time.	Position of Float.	Distance.	Velocity in Feet per Minute.	Remarks.
9.25	Cobden Bridge to—	Feet.		
9.30	Opposite railway-station	884	177	Centre of bridge second quarter ebb.
9.38	End of quay-wall	1,043	130	Float 100ft. from wharf.
9.41	Centre Street	406	135	" 60ft. "
9.43	Hammond's Hotel, corner Boundary Street	244	122	" 40ft. "
9.48	Upper corner	693	139	" 20ft. "
9.50	Lower corner	350	175	" 20ft. "
9.50½	End of wharf	175	116	" 20ft. "
9.59	Cattle wharf	838	112	" 10ft. "
10.03	Lagoon Point	363	91	Third quarter ebb.
10.18	Signal-station	1,518	101	"
10.31	North tip	1,162	89	"
10.37	South tip ..	581	97	"
10.55	500yds. straight out, in line with south breakwater	1,500	83	Approximate only

TABLE showing Velocity of Grey River between End of Wharf and Ends of Breakwaters.

[Float was put down 100ft. out in stream from end of wharf. Depth of float, 13ft. High water, 5.30 a.m. low water, 11.30 p.m. 6th July 1892.]

Time.	Position of Float.	Distances.	Velocity in Feet per Minute.	Remarks.
10.32¼	End of wharf to—	Feet.		
10.37½	Cattle wharf	832	158	Second quarter ebb.
10.44	Signal dwelling-house	819	126	"
10.50¾	Peg 20 on wall	792	117	"
10.55⅔	Peg 30 on wall	660	134	"
11.1¾	North tip	766	151	Third quarter ebb.
11.6⅕	South tip	581	131	"

These are the least velocities of the ebb tide a very small fresh greatly increases them, and in a high flood the velocity of the river is about ten miles an hour

Direction of Ground-floats.—On the plan herewith is shown the direction taken by ground-floats drifting out of the river over the bar, the wind being east with a slight westerly swell. These show the prevailing northerly set of the shore-currents of the sea. With a rising tide the floats drift out to sea with a small set to the north, but the blue arrows on the plan show that the surface river-water sets slightly to the southward, while the bottom sea-water sets to the northward. With a falling tide the ground-float sets much more to the north, and finally comes ashore on the beach. With a strong west or south-west wind and heavy southerly swell the shore-current sets very strongly to the north, and south-west wind and southerly swell is the prevailing weather here.

Contours of Depths.—The contour-lines of soundings on the plan herewith show the influence of the current in forming a great bank with shallow water to the north of the river-mouth, while to the south deep water is much nearer the beach. The sand travelling along the south beach crosses the river-mouth, and the strong current out of the river disperses it in an extensive shoal on the north side, while all sand brought out of the river is added to the shoals on the north, and seldom passes south of the river

Shoaling outside Breakwater.—There were very few soundings taken in 1878 outside the lines of the breakwaters, but from the few that there are, compared with the soundings taken by myself, it appears that, as in the case of Westport, there is a general shoaling of the water all round and outside of the ends of the breakwaters. Thus, on the line of south breakwater, produced seaward 11 chains out and 8 chains to the south, the old depths appear to have been 23ft., while the present depth is 15ft. at 18 chains out, and 5 chains south, old depth 26ft., present depth 15ft., at 7 chains out in line of south breakwater the old depth was 15ft., the present depth 15ft. At 11 chains out, and 15 chains north, old depth 15ft., present depth 13ft.; 15 chains out, and 18 chains north, old depth 18ft., present depth 14ft., below low-water spring-tides. There not being enough soundings taken in 1878, it is not now possible to accurately compare two sections out to sea between the pier-heads—one to show the depth then, and the other to show the depth now—but I think there is sufficient evidence that the effect of the construction of the breakwater has been to extend the shoal water all round them and seaward.

Overlap of Breakwater.—Sir John Coode intended that the south breakwater should overlap the north one by 120ft. only The overlap at present is 500ft., and the Board has decided to increase it to 1,000ft. Sir John Coode intended the width between the breakwaters to be 400ft., they are constructed at 450ft. at low-water line, and are found to be dangerously narrow for steamers coming in with a heavy swell. The great overlap of the south over the north end of the breakwaters was suggested by shipmasters as a remedy for the difficulties of entering the river in rough weather I should not have thought that this overlap would improve the depth on the bar, and I shall watch the result with much interest, if, however, it causes any serious shoaling of the entrance, the north breakwater must also be extended, and the entrance will then be in a better position than it is now, as the further seaward the breakwaters are the greater will be the average depth of the entrance. One effect of the projection of the south breakwater beyond the north one is seen in the considerably greater depth which the section taken across from wall to wall at the end of north wall has over the section taken from the end of south wall square across towards the north. The contour-lines I have drawn from my soundings show these effects very plainly, and I think it would be useful as a guide in future operations if a thorough marine survey were made from time to time of the water all round outside the breakwaters.

Depth of Bar.—In spite of the long absence of floods, I find that the depth of water on the bar not only holds its own, but continually improves. The following table shows that in 1881 the usual depths were from 10ft. to 13ft.; in 1891, the usual depths were 16ft. to 23ft. at low-water spring-tides, and 1891–92 shows a slight improvement over 1890–91.

TABLE showing the Number of Days each Year the Available Depths for Navigation at High-water Spring-tides over the Greymouth Bar have been as under for Twelve Years ending the 31st March, 1892.

	1880–1	1881–2	1882–3	1883–4	1884–5	1885–6	1886–7	1887–8	1888–9	1889–90	1890–1	1891–2
Under 10ft.	165	130	16	27	13	14			..			
10ft., under 12ft.	140	143	78	85	44	75	5					
12ft., „ 14ft.	57	90	230	134	144	91	57	6	1	..		
14ft., „ 16ft.	3	2	40	100	124	119	230	108	11	44	20	13
16ft., „ 18ft.			1	30	40	64	65	105	60	92	59	51
18ft., „ 20ft.						2	8	119	146	133	94	123
20ft., „ 22ft.								28	99	69	88	112
22ft., „ 24ft.			..						33	27	80	49
24ft. and over.									15		24	18

Cost of Works.—The expenditure on the Greymouth Harbour works is so mixed up with the expenditure by the Public Works Department that it is difficult to ascertain the total cost of the works. The cost incurred by the Harbour Board on account of harbour-works from 1884 to 1892 is as follows:—

	£
North breakwater	45,719
South breakwaker	56,236
Training-walls	21,575
Wharves	26,931
Dredging ..	6,570
Raising flood-wall ..	1,232
Plant ..	11,989
Brunner Railway and rolling-stock	20,773
Cobden Bridge	1,079
Land	2,242
Office and furniture ..	2,227
Sundries	1,550
	£198,123

Work still to be done.—The works remaining to be done consist of extending the south breakwater 500ft., the extension of the Coal Creek training-wall which I have recommended, dredging to an uncertain amount, but as may be necessary from time to time, a cradle to repair the dredging-plant, and the cost of supervision. Sir John Coode's plan shows extension of the training-bank above the bridge, but the construction of the bridge has entirely altered the circumstances under which his plan was designed, and I do not see the necessity for any works above the bridge.

List of works yet to be done—	£
Extension of south breakwater (500ft.)	26,532
Extension of Coal Creek training-wall	4,200
Dredging (say)	4,000
Dredging in channel to Karoro Lagoon	4,180
Cradle for repairing plant	300
Supervision and contingencies	1,758
	£40,970

The total cost of the works when completed will therefore be £239,093. From this must be deducted the sum paid towards improvements and extra rolling-stock on the Brunner Railway,

amounting to £20,773, leaving the cost of harbour-works £218,320 when fully completed. The above expenditure will be paid for as follows:—

	£
Already expended and paid for out of loans	165,664
" " revenue	11,686
To be expended and paid for out of loans	34,000
" " revenue	6,970
	£218,320

The total cost of the Greymouth Harbour works is mixed up with the public-works expenditure, reclamations of land, construction of quay-walls, extension of breakwater previously carried out and now authorised, besides numerous other items of cost, so that I have not been able to make a comparison between the actual cost, and the original estimate of Sir John Coode's design, neither can I now ascertain the ratio of the cost of plant and roads to the total cost of the works they were used for This, however, is now of no use, the facts being that the work was done with fair economy The stone in the breakwaters cost, including interest on expenditure, from 4s. 9d. to 4s. 6d. per ton, that in the training-walls, from 3s. 10d. to 2s. 10d. per ton and the staging cost about £9 6s. per running foot. The breakwaters are in good condition, protected by heavy rock, and secure against damage by the sea. The staging on the north side has suffered to some extent by the attacks of sea-worms, but as the stone round these is very high the piles are in no danger of falling.

The above statement of cost applies exclusively to the harbour-works which were designed by Sir John Coode, and has no reference to the large sums spent by the Public Works Department in the Town of Greymouth, and on the railway to the coal-mines, all of which was connected with the development of the port as it now exists.

The Board is endowed with the revenues by "The Greymouth Harbour Board Act, 1884," which, during seven and a half years ending 30th June, 1892, has yielded £102,495, being an average yearly income of £13,666.

The total sums received from revenue have been spent as follows:—

	£
Interest and sinking fund	44,018
Paid as excess of revenue over expenses of works	30,232
Harbour expenses	8,033
Tug-steamer	9,792
Working-expenses of same	2,266
Sundries	1,946
	£96,287

The average revenue of the Board amounts to £13,666 a year, the expenditure, including interest and sinking fund, harbour expenses, and expenses of the Board, amounts to £10,000 a year, which leaves a yearly surplus of £3,666.

The Board is authorised to strike a special rate, under section 12 of "The Greymouth Harbour Board Act, 1884," upon all coal brought into port for shipment. This would increase the Board's revenue by about £1,850 a year, but the Board does not think it advisable to take advantage of this authority Of the Board's authorised loan, there is still the sum of £34,000 of debentures unsold.

The following is a list of the export of coal and coke since 1886:—

	Tons.
Nine months ending 31st December, 1886	98,938
Year 1887	165,551
Year 1888	176,351
Year 1889	142,010
Year 1890	121,819
Year 1891	152,332
Three months ending March, 1892	47,712

This table shows that the coal trade has expanded very little. Some of the mines have, however, been closed as not sufficiently profitable, but, on the other hand, steps are being taken to open up the Blackball Mine, which is one of the finest and most extensive deposits in this district.

Although the coal trade may be slack at present, coal of the quality found in the Grey coalfields is always valuable, and the great deposits in the various known coalfields will always insure a large amount of trade and shipping for the Port of Greymouth.

I have pleasure in acknowledging the kind assistance given me in the investigations submitted in this report by your Engineer, Mr T H. Rawson, and the Harbourmaster, Mr John Connor I am also indebted to your Secretary, Mr Thomas Allen, for assistance in investigating the expenditure and finances of the Harbour Board. I have, &c.,

The Chairman, Greymouth Harbour Board. C. Napier Bell, M.Inst.C.E.

THE WESTPORT HARBOUR WORKS.

No. 8.

The UNDER-SECRETARY for PUBLIC WORKS to the CHAIRMAN, Harbour Board, Westport.

(Telegram.) Wellington, 14th March, 1892.

RE training-walls Now ascertained no opinion was obtained from Sir John Coode prior to his death. Government proposes, therefore, to request Agent-General to return plans and papers sent him on subject. If engineering opinion still desired, matter can be referred to some engineer of standing in the colonies. H. J H. BLOW,

Chairman, Harbour Board, Westport. Under-Secretary for Public Works.

No. 9.

The CHAIRMAN, Harbour Board, Westport, to the UNDER-SECRETARY, Public Works.

(Telegram.) Westport, 16th March, 1892.

YOUR telegram *re* training-walls was considered at meeting held yesterday Unanimously resolved that the opinion of Mr Napier Bell on the subject be obtained. Copies of the plans sent to the late Sir John Coode can be supplied from this office to save delay Will you please obtain Minister's sanction to this course. JOHN J MOYNIHAN,

Chairman, Harbour Board, Westport.

The Under-Secretary, Public Works, Wellington.

No. 10.

Mr J A. MCARTHUR to the CHAIRMAN, Harbour Board, Westport.

(Telegram.) Wellington, 18th March, 1892.

IN reply *re* training-walls, Minister requests that you will kindly send copies of the plans referred to to this office in the meantime.

J A. MCARTHUR,

The Chairman, Harbour Board, Westport. For Under-Secretary, Public Works.

No 11.

The CHAIRMAN, Harbour Board, Westport, to the Hon. the MINISTER for PUBLIC WORKS.

Westport Harbour Board, Westport, 1st April, 1892.

SIR,— Re *Training-walls.*

In pursuance of your telegram dated the 18th March, 1892, I have now the honour to send to you in a separate parcel, by this mail, the following items, viz. (1.) Tracings of plan and sections of proposed alteration in alignment of training-wall (4 sheets). (2.) Copy of memorandum sent to Sir John Coode on the subject. (3.) Copy of report on harbour-works by Mr C. Napier Bell. (4.) Copy of Board's Engineer's letter dated the 31st March, 1892.

Trusting that your very early consideration will be given to this,

I have, &c.,

JOHN J MOYNIHAN, Chairman.

Enclosure 1 in No. 11.

Half-tide Training-walls, West Side of River.

Memorandum for Sir John Coode.

As it is now desired to construct the training-walls included in the scheme for the completion of the Westport Harbour works, and as the question has been raised whether it would be advisable to increase the width of the opening between the training-walls, or alter in any way the location of the walls on the west side of the river, I would beg leave to submit data, comprising—Drawing No. 1, general plan of the works, drawing No. 2, section showing improvement in tidal compartment, drawing No. 3, cross-sections of proposed channel, and the following statement:—

The reasons which have given rise to the suggestion are,—(1.) The alterations which have taken place in the conformation of the river-bed and banks since the date of the design in accordance with which the harbour-works are being carried out—viz., December, 1880. (2.) The increased width of entrance between the breakwaters which has been found advisable and provided accordingly, an increase which the harbour scheme specified should be made if necessary (3.) The susceptibility which the river-bottom in the neighbourhood of the wharves has shown to scouring-action.

Drawing No. 1 exhibits in plan, from late surveys executed for the purpose, the present bank of the river, and in conjunction therewith, in red, the bank of the river at the time the work was designed. I should explain, in case of its appearing as a discrepancy, that on the plan of the river sent Home in 1879, on which the works were laid down, an error in measurement of 80 links between the wharves and Disraeli Street existed, the distance appearing that much too short. This error has been eliminated in the present survey It will, on looking into the plan, be noticed that the outer ends of the training-walls as constructed and yet to be made do not lie quite symmetrically in the centre of the entrance between the breakwaters. The reason of this is the east training-wall was the first work done; next the west breakwater was commenced, and placed in the

position shown for it on the design, relatively to the work already finished, then the east breakwater was commenced, and carried out some distance, when it was finally decided to leave 700ft. in the width of entrance instead of 600ft. The increased width had then, perforce, to be left wholly on the east side, which threw the east training-wall rather far into the river On this plan will be seen the advance made by the shingle-bank, between Wakefield Street and Disraeli Street, towards the centre of the river, which bank has increased somewhat in height since the work was designed, likewise the erosion of the banks of the river which has taken place on the west side within the same period. I may say that, looking at the line of the training-wall on the ground, where it was staked temporarily, it appeared all that could be desired at its lower extremities, but, owing to the advance of the above-mentioned shingle-bank, and the receding of the opposite shore, it might be considered desirable to alter the line of the work, say, between Wakefield Street and the Buller Bridge more towards the west. This is independent of the question of whether or not it would be wise to widen the space between the training-walls now laid down as 500ft.

Drawing No. 2 is a section of the river which it is thought may assist in the consideration of these questions. It shows the improvement in depth to date which has taken place without the assistance of the training-banks. In connection with this, the average velocity of the current in the river at cross-section BB at low water has been calculated from the surface-velocities, which were carefully measured and found to be 1·4ft. per second, and the surface-velocity at the wharves was also measured during low-water spring-tides, after rain, which raised the river 2in or 3in., and found to be 6·09ft. per second. These velocities were measured with the idea that they would supply a guide to the nature of the current which shipping moving about at the berthages have to encounter At present at low-water spring-tides the current is found quite swift enough, and a very little rain renders it too swift to move large vessels about safely It is hoped also that this information may be of use in considering the effect of a possible alteration in the impingement of the current on the line of the wharves, due to an altered curve on the training-bank.

Drawing No. 3 consists of nine cross-sections of the river taken radially to the curves of the training-bank, with the form to which the future channel would have to be approximated as nearly as possible, shown thereon. Of these cross-sections AA and GG have been taken, so that they fall over cross-sections taken on the occasion of the first survey

In the proposed channel from the Buller Bridge downwards there remains about 1,000,000 cubic yards of material to be removed by scouring and dredging, and, though amending the line of the training-wall may not perhaps lessen this quantity much, it has been thought right to draw attention to this point, as it is feared extensive scouring and dredging operations may have a deleterious effect on the deep water at the entrance.

The range of tide has of late been carefully observed for a lengthened period, and found to be 9ft. 6in. at springs and 5ft. 6in. at neaps.

I trust the data comprehended in this memorandum and the drawings attached are sufficiently explicit to present the position in contradistinction to the state of affairs twelve years ago clearly

Will Sir John Coode kindly supply data for a short cable, saying whether walls should remain unaltered, or, if not, indicating what he recommends to such extent as would admit of preliminary works being commenced, pending the receipt of Sir John Coode's plan.

September, 1891. J. A. Wilson, Jun.,
Assoc. M.Inst.C.E., Engineer, Westport Harbour Works.

Enclosure 2 in No 11.

Report by Mr C. Napier Bell on the Progress and Condition of the Westport Harbour Works.

Sir,— 10th October, 1891.

In accordance with instructions received from you through your Secretary, I have the honour to report on the general progress and condition of the works as executed to date.

Accompanied by your Engineer, I inspected the breakwaters, the quarries, the railway, the plant and material, the Orawaiti overflow, and the relief-channel.

Condition of West Breakwater.—The western breakwater has now reached the length indicated on the original design of Sir John Coode. Here the normal depth of water is about 25ft. at low water, but the sea breaking against the stonework makes and maintains a pit or trench all round the end of the work, the depth of which is about 44ft. below low-water spring-tide. This phenomenon has accompanied the breakwater almost from the commencement, with the result that the foundations of the structure are placed at a great depth below the river-channel or the ordinary sea-bottom, and a great extra quantity of stone has been swallowed up in this pit. The breakwater was carried on for a length of about 2,700ft. as a tip bank, and was then carried on from staging to its present end.

Staging damaged in a Gale.—The staging had to be placed in the extra deep water mentioned above, consequently it was unusually high and slender, but, with the exception of being damaged on one occasion by a heavy gale, the construction has been very successfully carried out, and the breakwater stands now in good condition, without damage or deformation by the waves, the average slope of the stonework being about 2 to 1. The end is now being finished off with heavy stone of exceptionally hard and sound granite, and when finished the breakwater will stand any weather. Sir John Coode intended that concrete blocks should be placed on the end and for some 350ft. along the sides. Of course there is no necessity for this where stones of from five to twenty-five tons can be had for the same purpose, and your Engineer will see that stones of this size are placed to protect the ends and sides.

Maintenance.—From the evidence of your Engineer it appears that in places the slopes are liable to slip down, this is caused apparently by the waves excavating the sand on which the stones lie. This source of damage will not go very far, as the stones get too deep down to be further acted

on by the waves but the damage must be made up as fast as it occurs—probably for a year or two the breakwater must be watched and stones must be in readiness to be placed where damage occurs.

End to be strengthened.—It is impossible to know beforehand to what extent the waves may flatten down the slopes of the stone at the end, where they act with the greatest violence but even when the end is completed with the heaviest stone procurable it must be watched for some time, and subsidence of the stone made good. For the same reason it would not be advisable at present to erect a timber lighthouse on the end until the stone is thoroughly consolidated. The top of this breakwater is about 18ft. above high-water spring-tides.

East Breakwater.—The east breakwater has been carried out as far as intended by the original design, the first 2,500ft. as a tip bank and the remainder from staging. The stonework of this last part is intended to stand at half-tide level, with the object of letting floods from the river pass over it. This breakwater has not such heavy stone on it as the west one, still there is no appearance of any damage except that, at the end, the stone is liable in rough weather to be cast up in heaps. Heavy stone is now being placed round the end, and for some distance from the end on the sides. In one part the work is yet too low and it is intended to raise this to the right height with heavy stone. The east breakwater is not subject to such rough treatment by the waves as the west, and, the end being made secure, it is perfectly safe. It is liable, however, to have the sand below it on the river side scoured out, and keeps settling down on that side. This will need to be made up as it settles, and with this object, and to repair any possible damage, the staging must be maintained for a year or two at least.

Staging to be maintained.—The maintenance of this staging may cause some trouble and expense, but to what extent it is not possible to determine. The piles are not, as in the west breakwater buried up in stone, but stand in the water They are, therefore, pretty certain to be eaten by sea-worms, and it would be difficult to see how long they will remain safe under this damage. The piles are also liable to be knocked down by drift trees, brought down by floods, beating against them with the waves. It was supposed to be from this cause that a number of bays of the staging fell down during a gale in August, 1890.

Drift Trees.—It would appear that the end of the breakwater is the place where the piles are most liable to be knocked down by drift trees, and, if a tree knocked down one pile, the waves dashing the beams and rails about would soon demolish many bays of the staging.

End to be raised.—Your Engineer suggests that at the end the stonework be raised up so as to form a mound 8ft. or so above high water This would effectually protect the piles, while it would close very little of the waterway intended to flow over the low level of the breakwater, and I would recommend this elevated end to be carried out with heavy rock. At a distance of 2 or 3 chains from the end the waves do not strike the work with much violence, and your Engineer intends to cover this distance with heavy rock, which, with a strong end, will make the whole work safe. The west breakwater to this date contains 645,000 tons of stone, and the east 232,000 tons.

Quarries.—The total quantity of stone taken out of the quarries to date is 877,000 tons. Of this, 227,000 tons is from the limestone, and the remainder from the granite quarries.

Limestone.—The limestone quarry is now exhausted, and there is no further need of the permanent-way on the road, which may be lifted to be used at the training-wall in the river

Granite.—The granite quarry comprises the high level, at a height of about 120ft. above the sea-level, and the long range of low-level quarries extending for nearly a mile along the beach, to which the railway from the high level descends at a gradient of 1 in 40. The low-level quarries, which originally showed a grand face of rock, have proved most disappointing and unsatisfactory, from the great amount of soft disintegrated stone which had to be stripped and removed to get at the hard and sound patches. It is therefore fortunate that the breakwaters are just about completed when these quarries show signs of exhaustion. There is still some stone to be got from them, but the quantity and quality is now uncertain.

High Level.—It is therefore satisfactory to know that there is a considerable supply of fine stone, the finest, indeed, that has yet been quarried, on the high-level quarry, and your Engineer is fully alive to the importance of taking care that this stone is not wasted or broken up into small sizes.

Road to It.—The access to this high-level quarry has been laid out by a line from the main line, rising at a gradient of 1 in 20 to the base of the great blocks and ridges of stone. The position of this line is very suitable for the quarry, provided the hard stone does not extend down to any great depth below the level of the line, of which there is no evidence at present, as the base on which the hard stone rests appears to be soft granite. The road up to this quarry had cost about £1,150, and if, as is estimated, the quantity of stone amounts to from 50,000 to 80,000 tons, it is certainly worth the expense of getting but in fact, considering the state of the low-level quarries, it is indispensable that this high-level stone should be procured to finish off the work.

Quantity to finish.—Your Engineer estimates that about 60,000 tons of first-class stone is now required to complete the breakwaters, and there will be no difficulty in getting this quantity from the high-level quarry, with perhaps a small remainder from the low level. There is, of course, great abundance of smaller stone to be had for the purpose of forming the training-walls, for pitching the river-banks, and the slopes of the proposed ship-basin. In the process of quarrying for

large stone a quantity of such small stone has to be removed, and your Engineer is stacking it in a suitable position to be reloaded for the construction of the training-walls. This is advisable, and it will be economical to have this stone thus stacked rather than throw it away The price at which it is stacked—that is, 1s. per ton—seems high compared to the present contract price for quarrying and filling first-class stone—viz. 5d. to 8d. per ton—but the latter is so low a price that I doubt if the contract could be carried out unless assisted by the price obtained for the smaller stone which is removed and stacked when quarrying the larger

Stone for Repairs.—When the breakwaters are completed the question may arise of lifting the rails and sleepers of the low-level quarry to be used in constructing the training-walls in the river, for which about 2½ miles of permanent way will be required. Before doing so the further supply of heavy rock for repairs and maintenance of the breakwaters must be considered, and the road kept to such parts of the quarry as are likely to furnish such stone.

Permanent-way not to be lifted.—Mr Inspector Barrowman is of opinion that there is a quantity of good stone at the extreme south end of the bay, in the high granite cliffs which surround the shore at this place, and if the supply of stone wanted in the future for repairs has to come from this place the whole length of the quarry permanent-way must be kept in place.

Railway to Quarry.—The main line of railway to quarries, which is about 7¼ miles long from the west, and 10¼ miles from the east breakwater, is maintained in good order, and is very little the worse for wear The bridges also are in good order, and will last many years. Taking into consideration the heavy and rough character of the traffic which this line has had to carry it has been maintained in excellent condition at a cost of about 50 per cent. over the cost of maintenance of the railways carrying coal. The traffic of stone is exceptionally severe on the road, as trucks on a short-wheel base carry loads of stone from one and a half to three times the weight of ordinary coal-trucks, but the excellent rolling-stock of tip-trucks on springs have enabled five years of this traffic to be carried on without damage to the permanent-way

Stone Tip trucks.—There are 109 stone-trucks, of which ninety-seven are on springs. These trucks have been in use on an average about four years, and are still in good condition with the exception of the flooring, which is always subject to damage by the friction of the stones. A few have also been damaged by falling stones, or breaking axles, and a number of spiral springs which support the load on the trucks are now weakened by the great weights carried for over four years. The side-tip trucks on springs carry up to 35-ton stones, and the end-tip, up to 14-ton stones, and run with the speed and steadiness of an ordinary goods train.

Cranes.—There are in all fourteen cranes, which are in very good condition, and still fit for many years' work. There are three 25-ton, one 20-ton, five 10-ton, two 7-ton, and two 5-ton cranes. The 10- and 25-ton cranes have given great satisfaction. The 10-ton cranes often lift stones weighing 14 tons, and the 25-ton cranes stones weighing 30 tons, but on one or two occasions they have lifted 35-ton stones.

Locomotives.—There are four locomotives of Class F, and two of Class C. These have undergone many repairs, and are now in good order Two locomotives of Class F have been lent to the Railway Commissioners, who have had them in use for general coal traffic for over two years.

Buildings.—The buildings are in good condition, with the exception of roofs of engine-sheds, corroded by steam of the locomotives. There are twenty buildings situated at the quarries, the junction of the granite and limestone lines, or at Westport; these include engine-sheds, stores, smith-shops, weighbridge-houses, Inspectors' offices, weigh-clerk's cottage, 7th class railway-station, and magazine.

Dredges.—The Priestman dredge, mounted on its barge, is still in first-rate working condition, and is at present used to pull out snags and logs from the river-bed. It is not nearly so efficacious as the ladder-dredge for excavating gravel, but it is generally found useful for dredging in confined positions, where the ladder-dredge cannot work. No harbour of this description should be without one of this kind of dredge.

Ladder-dredge.—The ladder-dredge and two steam hopper barges, recently purchased by the Board, are a valuable acquisition to the plant of the port. Without some amount of dredging this port cannot be placed and maintained in the position which the deepening of the bar should enable it to hold as an accessible harbour for a large coal trade, and the result of dredging already done proves this dredging plant to be very suitable for the work required.

Cost of Dredging.—On a general average, taking delays and stoppages into account, the dredge lifts 30,000 tons a month, and the hoppers discharge the material two miles out at sea, the cost, including repairs and all charges, being 7½d. per ton, equal to 11¼d. per cubic yard, which compares favourably with dredging done in other places in similar material.

Effect of Works.—The works, so far as carried out to this date, have chiefly been directed to the improvement of the sea-bar, which, when these works were first commenced, was the principal obstacle to the development of the coal traffic.

Depth of Bar.—As soon as the west breakwater had reached a length of 2,800ft., and before the east breakwater had been commenced, the bar began to deepen, and the depth has steadily increased with the extension of the breakwaters until within the last two years, when it has apparently become stationary, averaging within a few feet according as the river is low or flooded. The following table, prepared by your Engineer from records kept by the Harbourmaster, shows very clearly the influence of the works upon the depth of water on the bar From this it appears that before the works began the usual depth of water on the bar was from 9ft. to 14ft., and since the completion of the works the usual depth is from 18ft. to 25ft. These depths are taken at high water, the rise of tide being from 6ft. to 10ft.

TABLE showing Variation of Depth in the Bar from 1883 to 1891.

Depths.	Before Works begun.			Since Works in Progress.					
	1883–84.	1884–85.	1885–86.	1886–87	1887–88.	1888–89.	1889–90.	1890–91.	1891.*
8ft. and under 10ft.	41	51	29	54	18				
10ft. „ 12ft.	164	219	218	246	169				
12ft. „ 14ft.	140	91	109	65	144				
14ft. „ 16ft.	20	4	9		25	14	8		
16ft. „ 18ft. ..	1				4	108	61		
18ft. „ 20ft.					4	151	98	55	59
20ft. „ 22ft.					2	88	105	117	82
22ft. „ 24ft.						4	70	126	36
24ft. „ 26ft.				.			22	50	6
26ft. „ 28ft.							1	11	
29ft. and over								6	
Total number of days	366	365	365	365	366	365	365	365	183

* For six months.

Low-water Line.—The line of low-water mark on the sand beach outside the west breakwater advanced seaward during the construction of the breakwater, until at the present time it is 33 chains seaward of the original low-water line. The low-water line outside the east breakwater advanced in a similar manner If the low-water mark is not now stationary it is advancing very slowly, and it is to be hoped that, as in the case of Greymouth, it may soon become stationary—that is to say, that the condition will be reached in which the currents carry round the end of the breakwater just as much sand as they bring up from the southward. As noticed above, the bar keeps its depth, although in very low states of the river the sand drifted round the end of the west breakwater forms a spit protruding towards the head of the east breakwater but the first flood scours this away, and restores the depth lost. The same thing is experienced in Greymouth, where the depth has been permanent for a long time.

Depth in River.—The sea-bar is not now the chief obstacle to navigation, which, however, occurs inside the river, the original depth of which has not been affected by the construction of the breakwaters.

Training-walls.—This difficulty Sir John Coode intended should be rectified by the construction of training-walls of stone, which by confining and directing the currents of both tides and floods, and being assisted by dredging, would deepen and maintain the depth of the river alongside the wharves, and out to the bar The training-wall on the original plan extends for 12,300ft., containing 120,000 tons of stone, and is estimated to cost £43,000, the cost was not included in the original estimate, being left for consideration as the trade of the port grew The trade has grown, and the wall is now required to maintain the deep channel in the position required by the traffic. In the upper part of the wall a difficulty occurs which has been referred to Sir John Coode. The difficulty is that the wall, as shown on plan, shuts out the deep channel of the river, and before the wall can be made a new channel must be cut for the river through a large shingle-spit, which is too hard and compact to be scoured by the current. The quantity to be removed from the shingle-spit to give the river the same amount of waterway shut out by the training-wall would be 200,000 cubic yards, and the cost would be about £10,000. But to dredge and scour the amount required to give the depth shown on Sir John Coode's longitudinal section would require the removal from this spit of about 500,000 cubic yards.

Buller Bridge Piers.—The deepening of the channel to this depth under the Buller Bridge would endanger the piers which, are on piles driven 20ft. into the shingle. They would therefore have to be protected by stone thrown in round them the combined mass of which would take up a large part of the waterway intended to be gained by the deepening. A spit of shingle in Greymouth occurs in a very similar position to this one, which does not seem to interfere with the scouring action of the river on the berthages along the wharves, and, subject to Sir John Coode's approval, I would suggest that the training-wall be carried no further up the river than the Buller Bridge, and be curved so as to include the deep-water channel, and take as little as possible off the shingle-spit. Your Engineer has, in a memorandum to Sir John Coode, pointed out this difficulty, and asked his advice as to altering the position of the upper part of the wall. It is therefore necessary to wait for his answer before taking any further steps.

Scour carried by Wall.—The material of the river-bottom along the face of the staiths and wharf is easily scoured by floods, and the construction of the training-wall will have a powerful effect in increasing the velocity of the current. It is therefore to be expected that deep water will be maintained by natural scour whenever the wall is built. At present, however, the navigable channel is in places neither deep enough nor wide enough, and therefore, while depending on the training-wall to maintain the depth, I would recommend that the only dredging to be carried out be that required to form a channel 250ft. wide at the bottom and 14ft. deep at low-water spring-tides, extending from the upper part of the Government wharf along the face of the wharves and staiths and out to the deep channel at the west breakwater A large part of this is already deep enough, and only requires to be widened, but from opposite the proposed floating-basin to the deep channel near the west breakwater the training-wall, as shown in plan, crosses the fairway of the

channel at present in use by steamers. If the floating-basin is to be carried out, this training-wall is necessary to keep the deep-water channel near the basin and divert it from its present position on the opposite side of the river

New Beacon Channel.—Consequently the new channel must be dredged before the training-wall is erected, so as not to interrupt the traffic by building the wall across the channel at present in use, which lies close alongside the west breakwater This new channel would have to be cut through a shallow shingle-bank on which the boulders and gravel are so packed that I doubt if the natural scour would have much effect until it was dredged.

Dredging to be carried on.—The dredging for this proposed channel of 250ft. wide, extending from the upper wharf to the west breakwater, should, I think, be commenced at once, and carried on simultaneously with the construction of the training-wall, for the reason that the channel is wanted now, and it is impossible to tell whether the training-wall will do the work by scour without the assistance of dredging. The construction of the training-wall will take about two years, and it would not do to wait until it is finished to see what effect it will have on the navigable channel.

Cost of Dredging.—Under this proposition the total amount of dredging to be done would apparently be about 314,000 cubic yards, and the cost would be about £14,500. It is found, however, that when the hard surface is removed the effect of floods is to scour away the sand and small gravel, so that a portion of the above estimated quantity will probably be removed by scour Your Engineer is at present dredging a channel along the berthage of staiths and wharf, which is to be 18ft. deep at low water for a width of 70ft. from the line of the wharves, and 10ft. deep for a width of 210ft. from the line of wharves. This will be a very serviceable channel for steamers to lie and turn in, and is much wanted at the present time. It would also form part of the total dredging-work suggested above.

Branch Line for Construction.—To build the training-wall it is necessary to make a branch line of railway from the main-quarry line to the training-wall. This branch was commenced by your late Engineer, Mr F W Martin. It leaves the main line 30 chains from the Buller Bridge, and, curving round, crosses the by-wash of the river above Martin's Island. The by-wash is crossed by twenty-eight spans of 13ft. each.

Blocked by Driftwood.—This is subject to the inconvenience of being blocked with driftwood brought down by floods.

Claims for Damage.—Mr. John Martin, who owns the island, has set up a claim for damages, on the alleged ground that the work has caused part of his land to be washed away I could not see any reason for this claim, as the head of his island has been washing away by every flood for many years, and the branch line across the by-wash should, when completed, rather have the effect of protecting the head of his island than of assisting to damage it. The blocking of the bridge over the by-wash by drift-timber is an inconvenience that must be endured. In any case it is a trifle that is easily remedied after every flood, and will be to some extent abated when the training-wall is carried past the opening, as it will arrest or divert down the main river most of the driftwood. It is now seen, however, that it would have been better to have laid out the branch line along the bank of the river above the by-wash, and not cross it at all, and so avoid the inconvenience caused by the floods and the plea for damage set up by Mr Martin.

Extension of Wharves.—On the subject of further extension of the merchandise wharf, I am informed that your Board can do nothing without the concurrence of the Railway Commissioners, to whose approval all plans are subject, and who, I understand, insist on making their own plans for all extensions. Under such circumstances it is to be hoped that your Board may always see its way to agreeing with the proposals of the Commissioners for works which the Board find the money for Your Engineer has prepared a plan for extending the merchandise wharf as far as the staiths. The necessity for this extension has long been felt, and the Board gave me instructions to prepare plans for its construction in 1886.

Cost of It.—The estimated cost of this extension is £5,100.

Loading Coal by 25-ton Crane.—Besides being of use for the traffic of merchandise, which requires more room than is afforded by the present wharf, it would be practical to load coal from it by the 25-ton cranes, the present goods-sheds being shifted to allow of the necessary siding. The loading of coal from this extension would offer no more inconvenience than is experienced at Greymouth, where all coal-trains traverse the passenger-wharves.

Capabilities of 25-ton Cranes.—Your Engineer has given me an estimate of the capabilities of the 25-ton cranes for loading coal, taken from its performance on stone, from which it appears that each crane can load into ships about 100 tons per hour, at a cost, including crane expenses, attendance, shunting, interest, and depreciation, of 2d. per ton of coal loaded.

Capabilities of Hydraulic Cranes.—According to Mr Rawson, the Engineer to the Board, the hydraulic cranes at Greymouth load coal at a cost, for working-expenses, with interest and depreciation, of 2½d. per ton. When, however, a number of cranes are worked at once this cost would be less—probably about 2d. per ton of coal. Under favourable circumstances the hydraulic cranes can load 100 tons per hour

Capabilities of Staiths.—The loading-capacity of the staiths is about 250 tons per hour at the upper shoots, when the rest of the staiths is occupied by a train of coal for these shoots only, but the average performance is a little over 100 tons per hour, varying, however with the size of the ship and the height of the tide. The cost, including handling, shunting, interest, and depreciation, is about 2¾d. per ton of coal for 100 tons per hour, but less per ton of coal if more than 100 tons per hour is loaded.

Steam-crane loads cheapest.—The above figures go to prove that the steam-crane is at least as economical as the staiths or the hydraulic cranes, which is possible, seeing how much cheaper it is than either of the other two.

Further Extensions.—Your Engineer has also prepared plans for 200ft. of extension of the wharf from the present end upwards towards Riley's wharf. Unless these extensions are used to load coal I should say that the first-mentioned extension from the present end of the wharf to the staiths would be found to be sufficient for the traffic of passengers and merchandise. If, however, coal is to be loaded from this wharf by cranes, then the whole of the extension, of which drawings have been prepared, would be necessary, the upper part being occupied for merchandise and the lower part for loading coal.

Commissioners most concerned.—But the question of using two sets of loading appliances, one by staiths and one by cranes, more immediately affects the railway authorities, whose opinions should be ascertained before steps are taken to provide these wharf extensions, with the view of loading coal from them.

Floating-basin.—I presume the construction of the floating-basin is not considered at present, and it is left over for the future. This would be a much safer and more commodious loading-place than the wharves and staiths on the river-bank, and, if it is made in the near future, it may be then found that the staiths and wharves on the river-bank will become disused, and the money spent on them lost. I think it would be advisable, when the extension of the staiths and wharf is completed, to wait and see whether the accommodation provided is not sufficient for the coal trade of the next few years. The fact of a permanent increase of coal-traffic would then be a sufficient justification for proceeding with the construction of the floating-basin, as shown on the plan recently sent out by Sir John Coode.

Gridiron.—I inspected the gridiron recently erected for the purpose of repairing the dredge and hoppers. I consider the site is very suitable, and, in fact, it is the only available site there is. The only other place that could be thought of is the lagoon on the opposite side of the river, but this is too inaccessible to the town, involving the passage across the river of men and materials, so that I do not consider it a suitable site at all. The gridiron is placed in a creek out of the way of most floods. It has water enough at present, and could easily be dredged to any depth required. It is also capable of being made into a patent slip, if ever such is required in this river

Relief-channel.—I visited the relief-channel, and noticed that the floods are gradually widening and deepening it. After the dredging was done on the bar at the head of the channel in 1887 the depth of water was 2ft. 6in., at present, in a similarly low state of the river, the depth is 4ft. 6in., and the depth of the main channel opposite is also 4ft. 6in., so that now the head of the relief-channel is as deep as the main river and I should say that in floods about half of the water passes down the relief-channel. I think that the floods will continue to deepen and widen this channel, until, in the course of years, the greatest body of water will flow down it. This is what is wanted, as the more that passes down the relief-channel the less overflows at the Orawaiti. Mr C. Y O'Connor was of opinion that dredging should be resumed at the head of the channel. I am of opinion it should be let alone, with the exception of keeping it always clear of snags and drift-timber, and in course of time nature will achieve the desired object.

Orawaiti Overflow.—The Orawaiti overflow is the skeleton in the cupboard to Westport. It is a danger that I think grows less every day and can be perfectly controlled, provided it is not neglected. The most immediate necessity is the protection of the river-bank from the wear-and-tear of floods, and there can be little doubt that, if the overflow had not been protected to the extent it has been, the Buller River would now be flowing out at the Orawaiti.

Cribwork.—In 1885 I erected 8 chains of cribwork, filled with boulders, which has stood the floods for six years, and is still as good as ever The banks below this have during the last six years been cut away to the depth of nearly a chain, and this bank must be protected without further delay

Deposits of Stone.—Your Engineer has discovered some deposits of stone in two or three creek-beds under the terrace on the Nine-mile Road. This will, I believe, give sufficient stone to protect the river-bank, which is being damaged by the river, and I do not think it is advisable at present to go to the great cost of making a road from the Buller Bridge to bring stone from the main quarries for this purpose, which can be done at any future time if found to be urgently necessary The length of road required to get the stone found in the above creek-beds is only 60 chains, and will not cost much, but the road from the Buller Bridge to the Orawaiti overflow would be about three miles, and would cost much more than at present seems justifiable.

Protection by Planting.—The foreshore of the overflow being made quite secure by stonework, all other damage by floods can be checked by placing fascines loaded with stones in the holes and gullies which the floods cut out of the soil, and by planting every part of the overflow with willows and blackberries. When the low ground is thus overgrown with bushes the sand and silt of floods will be arrested and again overgrown, and thus the land grows higher after each flood, instead of being cut away as it would be if neglected. At the same time the relief-channel is slowly cutting its bed deeper, and taking more of the flood-water every year Between these two influences the danger of the overflow will be entirely averted.

Time of Completion.—The harbour-works have now been six and a half years in operation. The first year was taken up in building the railway to the quarries, opening the quarries, constructing trucks, and procuring plant and machinery The breakwaters have been five and a half years under construction, and the general average rate of depositing stone has been 160,000 tons a year, but during 1888 and 1889, 470,000 tons were deposited, or at the rate of 235,000 tons a year, the daily rate varying from 800 to 1,000 tons.

Good Time.—The breakwaters, therefore, have been completed in a fairly expeditious manner, considering that the quarries are seven miles from the west and ten miles from the east break-waters, and taking also into consideration the very inferior and unsatisfactory nature of the quarries.

Cost of Works.—In considering the actual cost of the works as compared to the estimated cost given by Sir John Coode, it must be remembered that he reckoned to obtain the stone from the

Fairdown, where a quarry was then supposed to exist, which was proved to be useless. To the Fairdown a line of railway was already laid when Sir John John Coode was here, but when it was found that the stone must come from Cape Foulwind, it became necessary to construct a line to the cape, which was not provided for in his estimate. This was a somewhat costly line—seven miles long—and it had to be taken down to the level of the sea-beach on a gradient of 1 in 40, through deep cuttings and high embankments. In addition a branch line 60 chains long was constructed to reach the limestone quarry, which was on the top of the terrace at the back of the granite. These lines were laid in a substantial manner, having in view the heavy traffic intended to be carried, and a costly plant of locomotives, cranes, and rolling-stock was procured, also with the view of doing a large traffic and hastening the completion of the work. These anticipations have been justified, and the permanent-way and plant are now on hand in good condition.

Taking Sir John Coode's estimate as the basis of the value of the work done on the breakwaters, the actual cost as now ascertained must be considered as very economical. Sir John Coode estimated the cost of the breakwaters, including the Buller Bridge and all plant and appliances, but not including the railway to Cape Foulwind, at £438,776. The actual cost, taking the same basis as he did—that is to say, excluding the Cape Foulwind railway—is £297,037 But, as the stone had to come from Cape Foulwind, the railway had to be made to the cape, and the cost, including its construction, was £336,320 and there remains the plant and permanent-way on hand, which is worth, taking depreciation into account, about £23,500. The total expenditure to date has been £384,095 16s. 4d., which may be classified as follows:—

	£
Expenditure on breakwaters, with roads and plant up to date	326,320
Mokihinui Railway	12 500
Dredges, hoppers, and miscellaneous plant	18,285
Dredging in river ..	8,384
Extension of staiths, coal-bins, and wharves	9,651
Inner training-wall	1,237
Additional rolling-stock (coal traffic) .	3,595
Orawaiti overflow and relief-channel works	3 364
Sundries	309
Total	£384,095

There remain certain works to be done—namely, to complete the breakwaters, to make the training-wall, to dredge a navigable channel, and provide certain requisites to equip the harbour for an extended traffic—the total of which is estimated to cost £116,200, which may be classified as follows:—

Works not contemplated in Original Estimate.—List of works remaining to be done to complete the original design and to equip the port for the coal traffic:—

	£
Completing the ends of breakwaters	10,000
Extension of staiths	15,000
Extension of merchandise wharf	5,100
Face-piling at staiths to keep stones from rolling under ships' bottoms	3,000
Training-walls	42,500
Dredging as defined in report herewith	14,500
Orawaiti overflow protection, say	6,200
Addition to rolling-stock for coal traffic	4,000
Mokihinui Railway completion	12,500
Administration	3,400
Total	£116,200

These two sums added make a total of £500,295. This includes, however, various works not taken account of in the original estimate, but necessary for the development of the port, amounting on the whole to £139,890, of which the following is a statement either already executed or intended to be done:—

	£
Mokihinui Railway	25,000
Dredges, hopper-barges, and miscellaneous plant	18,285
Extension of staiths, wharf, and coal-bins	32,751
Training-walls	43,737
Additional rolling-stock for coal-traffic ..	7,595
Orawaiti overflow and relief-channel	9,564
Sundries ..	309
Administration	2,649
Total	£139,890

Works executed below Original Estimate.—Sir John Coode estimated the dredging at £50,000, but I have estimated what may be necessary at £23,334, which, being deducted, leaves the cost of works as less than the original estimate by the sum of £101,705. Apart from any comparison by the original estimate, I consider that the works have been carried out economically and quickly The cost of the stone, including interest and every other charge, has been 4s. 6½d. per ton, which is a moderate cost considering the circumstances under which it was obtained. The cost of the staging was £11 10s. for the west, and £9 14s. per running foot for the east breakwater

Ratio of Cost of Plant and Works.—The cost of the plant, taking its saleable value as one-half of what it cost, is 9½ per cent. of the value of the work done by it, which is also reasonable. The cost of the railways and branches is 13½ per cent. of the value of the work done, which is high, but of course was unavoidable.

Amount of Loan spent.—The amount spent out of the loan authorised by "The Westport Harbour Board Act, 1884," is £348,204 0s. 5d. The sum authorised to be raised was £500,000. There is therefore the sum of £151,895 19s. 7d. still available under the above Act. The trade of the port has steadily increased with the increase in depth of water on the bar, as is shown on the following table of yearly output:—

Year.	Coal exported from Westport.
1885 ..	78,094 tons.
1886	119,779 "
1887 ..	115,942 "
1888*	130,219 "
1889	163,915 "
1890† ..	160,214 "
1891‡	227,668 "

Excess of Revenue over Expenses.—The revenue of the Board has increased with the trade, and now amounts to about £30,000 a year, while the expenses are about £19,300. From excess of revenue over expenses the Board has placed £35,890 to assist the loan in carrying out the works. The cost of administration of the works has varied at different times, taking an average over the whole period of construction to date the cost has been 2·65 per cent. of the cost of the works, which is very moderate.

Cost of Administration.—The cost of administration is at present £1,350 yearly, which includes salaries, office-expenses, taxes, law-costs, and insurance. The Board also earns about £450 a year by the traffic over the Cape Foulwind Railway

Future of Coal Trade.—The Westport coal grows continually in favour in the colonial markets. There is no coal equal to it in these colonies, and the demand should continue to increase as the facilities of the port are improved. In view of the great coal trade that may be expected to arise if it is properly encouraged, I think that the staiths and wharves on the river-bank are to be considered as a temporary makeshift, and the only suitable accommodation for a coal trade such as is anticipated will be found in the shipping basin of which I submitted a plan and report to the Board on the 7th July 1885. This basin is approved of by Sir John Coode in his letter to the Agent-General of the 29th October, 1890. The Board has at present a revenue nearly sufficient to cover the interest on the cost of the works already constructed, together with the additional cost of this basin, and the export from the basin would greatly increase the Board's revenue. The financial position of the Board at present may be classed amongst the soundest and most prosperous in New Zealand, and there does not appear any reason why it should not continue in, and even greatly improve, its present prosperous position. I am glad to have this opportunity of expressing my thanks for the obliging kindness and assistance given me by your Secretary, Mr Charles N Greenland, the Engineer, Mr J A. Wilson, and the Inspector of Works, Mr J Barrowman, who have devoted much of their valuable time to furnishing me with all the information I required.

I attach a statement of income and expenditure from the commencement of the works to this date, prepared for me by your Secretary

I have, &c.,

The Chairman, Harbour Board, Westport.

C. Napier Bell, M.Inst.C.E.

Statement of Income and Expenditure from 15th December, 1884, to the 30th September, 1891

Revenue Account.

	£	s.	d.		£	s.	d.
Received from endowments under "The Westport Harbour Board Act, 1884"	110,728	8	9	Expended in interest	55,855	9	6
Interest on fixed deposits	7,230	0	0	Expended in sinking fund	9,779	13	10
Other sources	539	4	0	Harbour expenses	10,898	6	6
				Office-expenses	1,066	15	7
				Advanced to special fund accounts	35,890	15	11
				Balance	5,006	6	5
Total	£118,497	7	9	Total	£118,497	7	9

Loan Account.

	£	s.	d.		£	s.	d.
Received from loans, &c.	348,205	0	5	Breakwaters	326,314	1	9
Advanced from revenue accounts	35,890	15	11	Dredges and miscellaneous plant	18,285	0	0
				Dredging	8,834	1	4
				Extension wharf and staiths	9,752	1	0
				Inner training-wall	1,236	17	0
				Orawaiti overflow and relief-channel	3,364	4	8
				Sundries	214	9	8
				Westport–Ngakawau Railway—			
				Additions to rolling-stock	3,595	0	11
				Extension to Mokihinui	12,500	0	0
Total	£384,095	16	4	Total	£384,095	16	4

* Bar deepened. † Strike interfered with output, which would have been 200,000 tons. ‡ Last three months estimated.

Enclosure 3 in No. 11.

Westport, 31st March, 1892.

SIR,— *Plans for Training-walls West Side of River*

I now forward to you, for transmission to Wellington, in pursuance of a wire from the Under-Secretary for Public Works, dated the 18th March, 1892, copies of the plans and memorandum which were sent to Sir John Coode last year when asking him to reconsider the alignment of the training-walls on the west side of the river.

In addition to the information sent to Sir John Coode, the plans now exhibit the line on which it is considered the training-walls should be carried out.

It is not considered necessary or desirable (*vide* Mr Bell's report attached) to provide for carrying the training-walls above the Buller Bridge at present. The bridge has accordingly been made the starting-point on the plan now submitted.

The amount of waterway shut out by that portion of the proposed training-wall which subtends the heavy shingle-spit shown on plan and on cross-sections BB to DD will, if the amended plan is followed, be about 38 per cent. of the amount of waterway shut out by the training-wall as originally laid down, so that any partial removal of the shingle-spit which may be necessary, whether effected by scour only or assisted by dredging, should be lessened to the same extent.

Along its western shore, from the Buller Bridge to the head of Martin's Island, the river for some years past, has been inclined to encroach, causing its banks to assume here a rather too abruptly concave form. This the amended training-walls, as indicated in green, will work out in part, substituting an easy curve of 80 chains radius, which, by means of a reverse curve of 110 chains radius, is gradually joined in to Sir John Coode's line, nearly opposite the lower end of the coal-staiths.

From this point towards the bar, for the remainder of their course, Sir John Coode's line for the walls would be followed.

The amended line would increase the waterway opposite the merchandise wharf, on an average, about 66ft. This, however should not have an evil effect, but rather the reverse, for the reasons bracketed in memorandum to Sir John Coode attached.

I have, &c.,

The Chairman, Westport Harbour Board. J A. WILSON, Jun., Engineer

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No. 12.

The CHAIRMAN, Harbour Board, Westport, to the Hon. the MINISTER for PUBLIC WORKS.

(Telegram.) 8th April, 1892.

NOTICE given to quarrying contractors that work supplying stone for breakwater will cease on 8th May next. Will you kindly expedite matter reference to training-walls, as lot men be out of employment.

JNO. J. MOYNIHAN,
Chairman, Harbour Board, Westport.

Hon. Minister for Public Works, Wellington.

No. 13.

The UNDER SECRETARY, Public Works, to the CHAIRMAN, Harbour Board, Westport.

(Telegram.) Wellington 9th April, 1892.

IN reply *re* training-walls, Minister directs me to state that on return of plans from Mr Napier Bell matter will be duly dealt with.

Chairman, Harbour Board, Westport. H. J H. BLOW

No. 14.

The CHAIRMAN, Harbour Board, Westport, to the UNDER-SECRETARY, Public Works Department.

(Telegram.) 9th April, 1892.

KINDLY state if Government have sent plans train-wall to Mr Bell, or if it is assumed that Board have done so.

JOHN J MOYNIHAN,
Chairman, Harbour Board, Westport.

Under-Secretary, Public Works, Wellington.

No. 15.

The UNDER-SECRETARY, Public Works, to the CHAIRMAN, Harbour Board, Westport.

(Telegram.) Wellington, 12th April, 1892.

RE training-wall Plans not sent yet, as two points have to be settled before sending them—namely, can Mr Bell undertake to advise at all, and, if so, what will be his fee? On receipt of reply on these points matter will be dealt with further

H. J H. BLOW,
Chairman, Harbour Board, Westport. Under-Secretary, Public Works.

No. 16.

The Chairman, Harbour Board, Westport, to the Under-Secretary, Public Works.

(Telegram.) 12th April, 1892.

Have Government conferred with Mr. Bell *re* training-walls? If not, Board will do so to-day Please reply early.

Jno. J Moynihan,
Under-Secretary, Public Works, Wellington. Chairman, Harbour Board, Westport.

No. 17

The Under-Secretary for Public Works to C. Napier Bell, Esq., C.E., Hobart, Tasmania.

Public Works Department, Wellington, 12th April, 1892.

Sir,— Re *Westport Harbour Works.—Half-tide Training-walls*

I am directed by the Minister for Public Works to state that the Westport Harbour Board is desirous of obtaining an opinion from you with respect to the half-tide training-walls proposed to be constructed on the west side of the Buller River—viz., as to whether, in view of the alterations which have taken place in the conformation of the river-bed and banks since the original report and plans of Sir John Coode referring to the matter were prepared, it might not now be considered desirable to make some modification therein—and I am therefore to request that you will kindly state, for the information of the Government and the Board, at your early convenience, whether you would be willing to advise on the subject referred to, and, if so, what your fee for so doing would be?

Plans and all other requisite documents to enable an opinion to be given would, of course, be forwarded to you. I have, &c.,

H. J H. Blow,
C. Napier Bell, Esq., C.E., Hobart, Tasmania. Under-Secretary for Public Works.

No. 18.

The Under-Secretary, Public Works Department, to The Chairman, Harbour Board, Westport.

(Telegram.) Wellington, 12th April, 1892.

Re training-walls letter to Mr Bell posted to-day

H. J H. Blow,
The Chairman, Harbour Board, Westport. Under-Secretary, Public Works.

No. 19.

Mr C. Napier Bell to the Under-Secretary, Public Works.

Sir,— Hobart, 27th April, 1892.

In reply to your letter of 12th April previously to receiving it I had received from the Chairman of Westport Harbour Board a telegram asking if I would report on subject of training-walls at Westport when I could come to Westport, and what would be the amount of the fee I would charge. To this I replied by telegraph that I could come to Westport at once, and that I would charge £50 and actual expenses, but not the cost of passage from Hobart to Lyttelton. I received from the Chairman a telegram in reply, saying that my offer was accepted, and that I should come at once.

Upon this I arranged to leave for New Zealand to-morrow, but find unexpectedly that I shall be detained another week here, which I trust will not cause serious inconvenience to the Minister for Public Works nor to the Harbour Board, and I shall come to New Zealand with the least possible delay Chairman informs me that I shall find a letter of instructions waiting me at the Bluff, which I shall get, and attend to. I am, &c.,

The Under-Secretary for Public Works, Wellington. C. Napier Bell.

No. 20.

Report by Mr. C. Napier Bell on Extension of Breakwaters.

Sir,— 24th June, 1892.

In reply to your instructions to report to you as to whether I considered it advisable at the present time, and in view of the late shoaling of the water on the bar, to extend the breakwaters or only one of them, I proceeded to get lines of soundings taken from the ends of the breakwaters seaward, but, rough weather continuing, I was prevented from getting a number of lines of soundings such as would give evidence of any changes which may have taken place in the sea-bottom on either side of the works.

Plan and Soundings necessary.—An examination by means of soundings to make known periodical changes in the depths of water and the form of bank and shoals, round about the works, and on the coast for some distance east and west of the breakwaters, is of great importance as a guide for future operations, having in view the preservation of the navigable depth. Your Engineer has, in March last, reported on the necessity of having plans made on which should be recorded from time to time regular sets of soundings, to be taken out to the 8-fathom line and for some distance on either side of the breakwaters. From the data which exists, it is evident that some remarkable changes have taken place in the depths of water and form of beach-lines round about the mouth of the harbour, and I submit a plan and sections upon which these are shown. In 1879 the plan of the harbour-mouth was made and the lines of soundings taken on which Sir John Coode's design was laid down.

Observations in 1887.—In April, 1887, the west breakwater was built out a distance of 1,350ft., but the east one was not commenced At this time I had several lines of soundings taken. From these and the plan of low-water mark it is seen that great changes had taken place from the condition of things in 1879.

Changes in Beaches.—On the west beach the low-water mark had extended seaward, in a long point, to a position close to the line of the breakwater, and a little further out than the low-water line is at present. On the east beach low-water mark had extended seaward farther out than it is now, but in the form of a rounded point 1,500ft. away from the line of the east breakwater, and leaving a deep bay between the point and the end of the old training-wall. Between 1887 and 1892 the low-water line at the east and west beaches have become straightened, and even several chains inshore of the protrusions found in 1887, but on the east side of the east breakwater a narrow tongue of sand has crept out to the end of the wall.

Great Shoaling.—In 1887, in addition to the above changes in the low-water line, the sea-bottom outside had shoaled very remarkably all round the river-mouth compared with the depth in 1879, and the effect of the breakwaters has been in 1892 to deepen the shoaling of 1887 The following list of depths will show this:—

List of Depths in Feet at Low-water Spring-tides.

	East Wall.	Centre Line.	West Wall.
Depth 6 chains out from end of west wall—			
1879	23·0	25·0	25·6
1887	9·6	7·0	13·0
1892	16·0	19·0	15·0
Depth 14 chains out—			
1879	31·0	31·6	31·6
1887	14·0	14·0	15·0
1892	17·0	20·0	21·0
Depth 20 chains out—			
1879	36·0	36·0	36·0
1887	19·0	20·0	21·0
1892	21·0	23·6	26·0
Depth 24 chains out—			
1879	38·0	38·0	37·0
1887	23·0	22·0	26·0
1892	23·0	25·6	28·0

Supposed Origin of the Changes.—These changes, I believe, commenced after the river broke out a new mouth in 1872. The various surveys of low-water mark show that from 1875 to the present time incessant alterations in the west and east beach lines have been going on, but much more on the east beach. Before the breakwaters were built the tendency of the changes was evidently for the east beach to extend and encroach on the river-channel, so as gradually to assume the form of entrance that existed before the river broke out, but farther seaward of the old entrance. The completion of the breakwaters has apparently steadied the west beach; but the east beach, although it appears settled, has a great shoal-spit protruding seaward as appears from the line of breakers, which shows that on the west beach there is shallow water about 300ft. outside the end of the west wall, extending in a straight line towards Carter's house. At the east beach the shoal projects as a spit 600ft. or 800ft. beyond the end of the east wall, and 600ft. eastward of it, leaving a bay of deeper water between the end of the spit and the wall. There is also an island-shaped shoal with 12½ft. of water between the ends of the walls, rather nearer the east than the west wall, and there is a channel with 15ft. to 17ft. of water between the island and the end of each breakwater Shoals are thus seen to form on each side of the current out of the river, that on the east being much farther out, and more extensive, and they have a tendency to encroach on the channel between the walls, as shown by the island-shaped shoal in the channel.

Reason for Formation of Shoals.—This condition of things, I believe, is owing to the position of the east beach being under the shelters both of the walls and of the outflowing current of the river, and the fact of the west wall being 400ft. in advance of the east wall allows the shoals to encroach on the channel. The east side of the harbour-mouth must always have the greater amount of deposits forming shoals. The strong outflow of the river diverts the easterly set of the shore-currents, and slightly checks the violence of the waves: this allows the sand drifted from the west beach crossing the mouth of the harbour to deposit on the east side, and, in addition, all sand brought out of the river is deposited on the east side of the east breakwater

Observations by Floats.—As the sand which forms these shoals is carried by currents flowing near the bottom, I took a number of observations with floats sunk too near the bottom and others at the surface of the water On the 22nd June the river was low, and high water occurred at 7.50 a.m., with a west wind and westerly sea. A little after high water a ground-float dropped at west breakwater drifted out in a N.N W direction, and a ground-float dropped at the east breakwater drifted out towards N.N.E, but, as the tide fell, ground-floats from either wall drifted towards the N.E. Surface-floats did not vary much in direction to the ground-floats. On the 23rd June, with a brisk wind at N.N.E., and westerly sea at half-ebb, a ground-float drifted out in a N.E. direction, and a surface preceded it in the same direction.

Indication from Them.—These observations, so far as they go, show that the water flowing out from the walls spreads like a fan, but always tends towards the east.

Velocity of Currents.—The weather was too rough to take observations of the velocity of currents outside the heads, which would have been interesting and instructive. On the 22nd of June the river was low, but there was the last remains of a slight fresh, the tide was at half-neaps, and

the observations were taken at half-ebb, or three hours after high water The bottom-velocity in line of fairway at the upper end of old training-wall was 207ft. per minute at lower end of old training-wall, 207ft. per minute, at signal-station, 183ft. per minute, 26 chains from end of west breakwater, 198ft. per minute and at end of east breakwater, 210ft. per minute. On the 23rd June the river was low, and, without any flood-water, a ground-float showed the velocity at end of east breakwater to be 150ft. per minute. The above shows a good current to prevent accumulations of deposits, but it is rapidly diminished seaward. The above velocities are due to the emptying of the tidal area and the river-water, the tidal water being three and a half times as much as the discharge of the river

Tidal Area and Discharge.—The tidal area at low-water mark is 505 acres, and that between low water and high water 381 acres tidal area, 887 acres. The discharge of tidal water from a spring-tide is about 550,000 cubic feet per minute, to which is to be added the discharge of the river when it is low, which amounts to 157,000 cubic feet per minute. The total discharge is 708,000 cubic feet. A small flood of 4ft. high discharges 2,250,000 cubic feet, and a high flood like that of 2nd August, 1890, discharges about 11,000,000 cubic feet per minute, which would give a velocity between the ends of breakwaters of about 900ft. a minute, sufficient to produce a powerful scour a long way out to sea.

Depth at end of Wall.—When Sir John Coode made his design he anticipated placing the end of the west breakwater in 20ft. at low water, but in 1887, eight years afterwards, and long before the breakwater had reached this intended point, the depth had shoaled to 10ft. The west wall would have to be 840ft. longer to reach the 20ft. at present, but as the deposits of 1887 are deepened by the advance of the breakwater, as is shown by the sections herewith, probably at half that distance a depth of 20ft. would be attained. With the extension of the breakwaters seaward the line of low water, if it continues to advance, will do so at a diminishing rate, and the shoal-water in front of them will be steeper the farther seaward they are carried. For this reason I believe that the farther out the walls are carried the greater will be the permanent depth. As the inevitable shoaling in front of the breakwater gets steeper and steeper the farther they are carried out, so the deep water of the original bottom becomes closer to the ends of the walls, and the powerful scour of floods is more able to maintain a deep channel.

Injurious Effect of one Wall longer than the Other.—The east wall is at present 400ft. behind the end of the west wall, and, as the prevailing waves and currents are towards the east, the effective width is to be measured between the ends in a slanting direction to the flow of the river The effect of the outflow is therefore weakened by the water spreading like a fan as soon as it escapes from the end of the east wall. To concentrate and properly direct the outflow towards the nearest deep water the east wall should be carried out at least as far as the west one, and I believe that a still better effect would be secured by carrying the east wall a good distance beyond the west one. The river-current would in that case be kept up to its work in the desired direction by the pressure of the sea-current and the waves, which is most frequently exerted in an easterly direction. Although the east wall, being much longer than the west, would secure the best results in preserving a deep channel straight out to deep water in the sea, yet it might be dangerous for navigation having the longest breakwater on the lee side, and I should hesitate to recommend the work being carried out in this form, unless the Board were prepared, in case it were found to be bad for navigation, to extend the west wall also, so as to have the two ends opposite.

The Sulina Danube.—The experience gained at the Sulina mouth of the Danube supports my opinion that the east breakwater should be at least as long as the west one, especially as the condition of the shore and prevailing winds and currents at the Sulina are singularly like the state of things at Westport. At the Sulina the breakwaters were at first built with the one to leeward of the prevailing winds and sea-currents 670ft. shorter than the windward one, with the idea of sheltering vessels passing in and out. The effect of this was found to be that a shoal formed on the lee side of the shorter breakwater, which extended 200ft. inside the opening. The wall was then extended 457ft., but, this being found insufficient to cure the evil, it was extended 204ft. more, so that the ends were opposite. I quote from the report "So that now the full current is maintained to the end of the piers, any sediment deposited by the river beyond the ends of the piers is directly exposed to the combined action of the heavy seas produced by N to N.E gales and the littoral current from the north, and is swept away southward."

Evidence of Progressive Shoaling.—Having carefully considered all the circumstances of the case with somewhat deficient data, I come to the conclusion that there is not sufficient evidence to prove that the water on the bar has been steadily shoaling, and if that is the reason for extending the breakwaters it is not so conclusive as to give grounds for recommending the extension. On the other hand, the conditions of the depths of water round about the breakwater ends are totally different to those which existed when the works were designed, and the changed conditions are not the result of the construction of the breakwaters.

Suggestions.—I would therefore suggest that, as the preservation of the navigable depth is the first necessity which the Board should have in view means should be secured to undertake the extension of the breakwaters whenever further evidence is available to prove conclusively that the bar is permanently shoaling. But if the Board is desirous of obtaining a greater depth than was contemplated by Sir John Coode the breakwaters should be extended at once. In this case the west breakwater should be extended 600ft. at high-water level only, and the east breakwater 1,000ft. at half-tide level, and the walls should be converged to a width at their ends at mean-tide level of 600ft.

Ends to be Opposite.—This extension would place the ends of the breakwaters in about 14ft. of water with deep water outside close by, and the ends would be opposite each other so as to produce the best scouring effect. Whether this extension is carried out or not, I would recommend that the east breakwater be at once extended on the line of the extension proposed above, so that the end be opposite the end of the west breakwater.

The Width.—The question as to the proper width between the ends of the breakwaters is best determined by experience of the effects, as it is very easy to narrow the entrance by a groin, but it can never be widened again.

Average Depth.—It is found that the average depth opposite the present end of the west breakwater, the width being 700ft., is 12ft. 9in. at low water, and 22ft. 6in. at high water, being a little more at low water and a little less at high water than Sir John Coode anticipated. As it is objectionable for navigation to have the walls at the entrance parallel, on account of the roll of the waves which is kept up between them, it is just as well that the walls are at present 700ft. apart, as in the contemplated extension they can be converged to 600ft. and leave the entrance splayed, which is more roomy and better for navigation inside.

Supply of Stone.—For the extension here recommended I believe there is sufficient stone to be got at Cape Foulwind, but I would recommend that all the heavy rock now lying along the sides of both breakwaters where there is now no longer any danger from the sea, be lifted and placed in the extensions, and smaller stone be put in their places.

Shoaling of Bar.—In your instructions reference is made to the recent shoaling of the bar The sections and soundings I have taken show that there is over 22ft. at high-water spring-tide in the line of the end of the west breakwater, and the water deepens rapidly outside that line. On the line of the end of the east breakwater there is a general depth of 25ft., the deepest water being on the east side of the line. This shows that if the walls were opposite there would be deeper water in the line between the ends. It also shows that the current out of the river escapes more towards the east than straight out.

Want of Floods.—It has been noticed that for a long time there have been no floods of any consequence. Under these circumstances it is to be expected that shoaler water would be found on the bar, and I think it is satisfactory to find that, after nearly eighteen months without the necessary floods, there is still over 22ft. of water It is not to be expected that the depth can be maintained in the absence of floods, and it is only under the normal conditions of weather that a correct idea can be obtained as to the permanence or otherwise of the depth of water that the works are capable of maintaining. I am glad to have this opportunity of acknowledging the valuable assistance given me by Mr J A. Wilson, your Engineer, whose local knowledge and intelligent observation have been of great service to me in the investigations embodied in this report.

I have, &c.,

The Chairman, Harbour Board, Westport. C. Napier Bell, M.Inst.C.E.

[A plan and sections accompany this report showing changes in low-water mark and depth of water.]

No. 21.

Report on Training-walls, by Mr. C Napier Bell.

Sir,— 16th June, 1892.

Acting under your instructions, I have carefully considered the subject of the position of the training-walls proposed to be erected inside the river, and I beg to submit to you the following report, accompanied with a plan of the river, on which all proposed works are laid down.

In my report of October, 1891, I mentioned the objections which now exist to placing the walls on the lines originally laid down by Sir John Coode, the most serious of which was the great quantity of dredging and scouring which they would entail to restore the waterway cut off by them in the position intended, and this I did not consider necessary or advisable. Accordingly I have now shown the walls to commence at the left abutment of the Buller Bridge, from which it curves round so as to enclose as much as possible of the deep channel of the river, and not interfering with the great shingle-bank opposite Wakefield Street.

The curve will train the current so as to throw it against the lower part of Riley's wharf, and keep it on the right bank of the river, as far as the wharf and staiths extend. An opening in the wall is left opposite Martin's Island, which is required to give access to the island and the left bank of the river

This line excludes as little as possible of the existing waterway, and, terminating at the bridge, prevents any danger by contraction of the channel under it, it also trains the current to scour the navigable part of the river.

In dealing with the position for the training-wall below the lagoon I had to take into consideration the existing bank of shingle and sand which occupies the widest part between the breakwaters on the right side of the river This bank has grown since Sir John Coode's plan was made, and extensive dredging would be necessary to cut a channel through it in the original intended line. The chief objection to making the channel, and the training-walls to guide the current, on the original lines, is that the west training-wall would cross the present navigable fairway, and, if the training-wall were omitted until the channel were cut, it is feared it would silt up as fast as it was dredged.

On the other hand, I do not think it advisable to keep the present navigable fairway, which follows the track of an old, deep channel which existed in 1879, and leads the current in a round-about course to the signal-station, and from there in a direct line to the end of the east breakwater This skew direction of the current is not that which would have the best effect on the bar

After careful consideration I have adopted the plan of placing the west training-wall in such a position that it will leave open the present fairway, but at the same time it will divert the current so as to assist in scouring the new channel which is to be cut through the above-mentioned shingle-bank. The channel also is shifted more to the west, directing the current through the ends of the breakwaters more to the west than to the east side. This is an advantage, because the outflow of the river has always a tendency to run towards the east side of the entrance, which is caused by

the constant current at sea, which runs across the ends of the breakwaters with a velocity varying from one-half to about five miles an hour according to the weather and the direction of the waves also, if the breakwaters are ever lengthened, the new channel will be more in the centre of the breakwater ends than the original line would be.

The line of training-wall and channel shown on the plan herewith is very nearly in the same direction as intended by Sir J Coode, but shifted towards the west it therefore avoids a considerable portion of the dredging. The west wall is, however, in rather deeper water than on the original line, but this is unavoidable if the present fairway is to be kept open while the new channel is being cut.

Your Engineer has furnished me with the result of the dredging done in the river during the last fifteen months, from which it appears that there has been no silting-up of the deep parts which were dredged in front of the staiths. The part dredged along the merchandise wharf has silted to the extent of 5,500 tons, and the appearance of the sections taken across this space shows that this silting is caused by the rapid currents on the west side of the river, which here cross over and fall into the deepened part, leaving the sand they carry on the west slopes of the dredged trench. "Since this trench was dredged along the merchandise wharf and staiths, the river has set more directly towards the east side, and there is a perceptible fall in the surface of the water at the upper end of the berthages, where it drops from the original bed into the dredged basin"

The dredging done in the fairway from opposite the lagoon for 800ft. towards the signal-station was taken out 150ft. wide, and also, for some distance further down, at 50ft. wide. This has nearly all silted up to its original condition. I have had a complete set of contour-lines marked on the plan over the whole of the lower part of the river Contour-lines omitted from lithograph, lest on so small a scale they should prove confusing. And from this it is seen that the above-mentioned dredging, done in the fairway, lies along the eastern side of a deep natural channel. Now, the natural channel has maintained its depth of 24ft., but the dredged channel taken out on one side of it, and on the shallow ground, has silted up, showing that a new channel cannot be maintained while the old, deep, natural channel exists, and it is only by the assistance of the west training-wall that the proposed new channel can be maintained at a proper navigable depth.

With the object of gaining some idea of the state of the currents, and of their action on the bottom, Mr Wilson has had the velocities taken in various parts of the river at half-ebb tide when the river was low. These observations indicate that the velocity of the surface-current diminishes from 140ft. a minute at the bridge to 100ft. at the end of the staiths. The bottom velocities are extremely irregular, but they diminish with increasing depth of water and, in the deep dredged parts near the staiths, there is still water near the bottom. But a very slight fresh increases the current greatly, during one such the velocity of a float 7ft. deep was 350ft. per minute from bridge to Rintoul Street, 355ft. from Rintoul to Brougham Streets, 365ft. from Brougham to Lyndhurst, 190ft. from Lyndhurst to end of staiths, end of staiths to upper end of old half-tide wall, surface-velocity 297, bottom-velocity 207, upper end of wall to lower end of same (in line of fairway), surface-velocity 252, bottom-velocity 207ft. lower end of training-bank to below signal-station, surface-velocity 258, bottom-velocity 183ft.

Also, on the night of the 10th June, with a small flood, the velocity of the current at the staiths, 10ft. below the surface, was 546ft. a minute—a velocity which could not fail to scour any deposits in the deep water at the berthages.

These observations are only useful to show that the only scouring action occurs during floods, at the same time, it is only during floods that sand is carried by the currents.

From section across the river taken in 1888, before any dredging was done, the natural depth along the staiths was 16ft. to 19ft. below low-water spring-tides. In 1889 the berthages were dredged to 18ft., and, in place of subsequently silting, the dredged depths increased. In 1891 the berths at wharf and staiths were widened at 18ft. below low-water spring-tides, with the result that at present no silting has occurred, and in some places the depth is 23ft. The small amount of silting mentioned above is fine granite sand. So far no shingle has made its appearance as a deposit in the port. It is possible that in course of time the shingle will creep down from the higher parts of the river, but, until it arrives, one cannot tell whether it will form a deposit in the deep water at the wharves. When the design is completed by the construction of the training-walls there will be a considerable increase in the velocity of the currents along the wharf and staiths, and, seeing that there is little evidence of re-silting at present, I think one may confidently anticipate that the depths required for navigation will be maintained by the natural scour.

Height of Walls.—The training-walls are shown according to the height defined by Sir John Coode—that is, half-tide level, or 4ft. 9in. below high-water spring-tides.

Depth under a High Flood.—High water is practically level from the sea to the Buller Bridge, but, during the flood of the 2nd August, 1890, your Engineer has shown that the surface of the river was inclined over 4ft. from the signal-station to the Buller Bridge. Such a flood would stand 6ft. over the top of the training-walls at the lagoon bridge, and 10ft. over them at the Buller Bridge. Smaller floods have intermediate inclinations over this extreme, and in this feature there is a means of diverting more of a flood towards the wharves, if experience shows that it is desirable, for, by raising the walls at the upper end, this can be done, but no attempt of the kind should be made until the phenomena of a high flood have been studied.

Roads to Walls.—On the plan is shown the position of three lines of rails over which stone can be brought from the Cape Foulwind railway to the walls.

Ends not to join Shore.—Wherever it can be avoided the ends of the training-walls should not be joined solid to the shore, as in that case the enclosed space is sure to become silted up, which is not desirable, as all tidal waterway within the port is valuable.

Floating-basin.—On the plan accompanying this report it was necessary to determine the position of the proposed floating-basin, as this would influence the line of the training-wall on the

east side of the river I have placed the entrance to this basin much nearer to the town than is shown on Sir John Coode's plan. This is unavoidable, with the change in the line of the training-walls now adopted, but it has the additional advantages of placing the entrance in deep water, and in a convenient position to get to and from the fairway channel, without having to keep open a dredged channel from the fairway to the entrance and steamers will have no difficulty either entering or leaving the basin.

System of Loading.—The dock has a swinging-basin 450ft. wide. The body of the dock is 300ft. wide, and 1,200ft. long, suitable for eight of the largest steamers. I have adopted the system used in Newcastle, New South Wales, of having the vessels alongside, and not at projecting jetties, as the latter construction is very costly, and not so suitable for loading from cranes as the alongside construction.

Ample Loading-room.—With the present length of staiths, and 2,400ft. of berthage in the floating-basin, I think there will be ample loading facilities for any future extension of the coal traffic of this port. There would be room for eight cranes, which could load 800 tons an hour if all were working, and I believe this would be in excess of what the mines could supply

Alternative of a Groin in the River.—Mr J P Maxwell asked me, before deciding on the position for the training-walls, to consider his suggestion to construct a piled groin in the river, parallel to and 200ft. outside of the wharf and staiths. This suggestion was adopted by Mr C. Y O'Connor, but, on his referring it to Sir John Coode, he did not recommend it. It occurs to me that the principal reason Mr C. Y O'Connor had for recommending the groin was that by its means deep water could be preserved along the wharves, irrespective of the state of the river outside, and that vessels would be sheltered from the violence of floods. Mr Maxwell favoured it because it would obviate the necessity of having two loading-places.

Reasons against It.—Against its adoption there is evidence, so far, to show that the necessary depth will be maintained along the wharf and staiths by natural scour, and the violence of floods has not hitherto proved dangerous to vessels. It was not proposed to make the groin wide enough to be used as a wharf. Of course it could be made wide enough for that purpose, but it would be hardly possible to accommodate on such a structure all the lines of sidings which would be required to serve, say seven cranes and, if it were raised so as to make it into staiths, I believe it would prove very inconvenient, and would be blocked for room when the whole line of it was full of ships loading. If, therefore, it could not be used for loading ships, then, when the groin was built, there would be no more loading-room than the present extension of staiths affords, consequently if more loading-room is not wanted, neither the groin nor the floating-basin is required, but, if more room is wanted, the groin would not give it, and we are driven to adopt the floating-basin. Lastly, the groin is a precarious structure of wood, liable to decay and destruction by worms it is, besides, an objectionable feature in the river, and in very heavy floods might tend to cause injurious changes in its channel. The floating-basin is open to none of these objections, it is capable of being made small for present, and extended for future, requirements. The estimated cost of it, for 1,200ft. long, is about £100,000.

Estimated Cost of Walls.—The estimated quantity of stone in the training-walls is 110,000 tons, which, at 5s. per ton, amounts to £27,500, exclusive of the cost of approach-roads from the main line to the walls.

Estimated Cost of Dredging.—The amount of dredging is about 230,000 tons, which, at 8d., amounts to £7,680.

I have, &c.,

The Chairman, Harbour Board, Westport. C. Napier Bell, M.Inst.C.E.

No. 22.

Report by Mr L. H. Reynolds on the Half-tide Training-walls and Railway-approaches.

Sir,— Westport, 13th June, 1892.

In accordance with your instructions, I have duly considered the location of the training-walls for the improvement of the river-channel, and railway-approaches thereto, and have now the honour to forward you my report, accompanied by a tracing compiled from plans and data furnished by the Board's Engineer, showing the direction and extent of the training-walls which I have to recommend.

Tidal Compartment and River Discharge.—The quantity of tidal water, together with the normal discharge of the Buller River which flows out between the breakwaters in an ebb-tide during springs, is about 230,000,000 cubic feet, which is, approximately, at the rate of 640,000 cubic feet per minute. The normal discharge of the river, apart from tidal water, is about 170,000 cubic feet per minute, whereas during a fresh of 2ft. the river-discharge amounts to nearly 800,000 cubic feet per minute. A fresh of 4ft. would discharge over two and a quarter millions of cubic feet per minute. It will be seen from these figures that the scour during freshes, apart from tidal water, is considerably greater than that due to normal scour during ebbing tides, especially in the upper reaches of the river Were the present waterway confined by training-walls the velocity of the current and the depth between the walls maintained by scour would be greatly increased. The position of the training-walls therefore requires careful consideration, more especially in the upper portions of the channel.

Line of Training-walls proposed by Sir John Coode.—Sir John Coode in his report recommended that the west training-wall should commence at a point about 3,700ft. above the Buller Bridge, and sweep towards the east bank by gentle curves, until the proposed channel would be confined to a breadth of 500ft. abreast of the wharves. From this seaward the wall would run parallel to the wharves and staiths, and at a distance of 500ft. out from them. In recommending this line above the wharves, Sir John Coode had in view the desirability of forming the river-bed between the walls to gradients and levels as would admit of the tidal level at low water extending

further up the river and diminishing the current-velocity for some distance above the wharves, in order that the rush of water in the channel, due to the confined waterway and fall of the river above the town, would not be so increased as to interfere with the shipping. With regard to the levels and gradients, Sir John Coode in his report remarks, "There cannot be a doubt that the execution of the external and internal works previously described will have the effect, by scour alone, of materially improving the depth in the channel opposite the town and seaward thereof. It is more than probable that this scour would have to be supplemented by dredging. In any case it is advisable that the permanent bed of the channel should be formed at the level and to the gradients shown on the longitudinal section, drawing No. 1." From the wharves seaward Sir John Coode shows the west wall to run in a straight line, terminating about 1,100ft. below the existing half-tide wall on the east side, leaving a break for the influx and reflux of the lagoon waters, the width between the walls being 500ft., as at the wharves. By carrying the west wall straight out advantage would be taken of the existing half-tide wall on the east side for its entire length.

Proposed Amended Line of Training-walls.—I have shown upon the accompanying tracing the direction and extent of the training-walls which I have to recommend, to be executed on amended lines to those laid down by Sir John Coode. I propose that the wall should be commenced on the west bank of the river, at a point 1,000ft. above the Buller Bridge, and trend towards the east bank by easy curves as far as the section marked FF on the plan, where it would join with the line of wall as proposed by Sir John Coode. From section GG, for a length of 2,000ft. seaward, it would continue in a straight line thence, as shown, curve gently toward the west breakwater, thus including a great portion of the deep-water channel in the fairway. The line shown in green colour would pass under the Buller Bridge east of the first pier, and, as will be seen from the plan, would for a considerable length run practically parallel to the line of wall recommended by Sir John Coode.

I may here remark that Mr Wilson (the Board's Engineer) had staked out the wall above the town upon somewhat similar lines to those which I have adopted. Mr Wilson contemplated commencing immediately below the bridge, thus giving a sharper run to the bank than I have shown.

By keeping the training-wall further to the west than Sir John Coode advises, without having recourse to sharp bends, such as to cause the upper currents during the early stages of ebb-tide to overtop the wall, the channel would include a much greater area of the present waterway, and during freshes the river would not be so liable to scour away the top of the shingle-spit which now protects the gridiron. The line of wall indicated by green colour is as far to the westward as I would care to recommend with a view to obtaining the best results from the wall. This line will necessitate the removal of about 500,000 cubic yards of material, to bring the river to suitable gradients and levels after confining the channel. It is impossible to estimate with any degree of accuracy what portion of this amount would be carried off by scour—probably, one-half. This would leave, say, 250,000 cubic yards to be dredged, and the cost would be about £12,500.

If the Board is not prepared to undertake this amount of dredging above the wharves I would recommend that the wall be commenced on the west bank of the river, between the sections marked CC and DD on the plan, as shown by red line. This would not seriously interfere with modifications of the line of wall should it be found advisable in the future to alter it. For instance, should the wall be constructed, commencing between the sections CC and DD, as indicated on the plan, and it were afterwards decided to carry out the wall commencing above the bridge, it might be brought down the river on the line shown by green colour and stopped at a point a little below section DD, thus forming an overlap. The break between the walls would not, I consider, materially affect the general flow or sweep of the current, and would admit of logs getting clear should they overtop the wall higher up the stream.

With regard to the training-walls opposite the proposed floating-basin, it will be seen that I recommend, instead of their being run out straight, they should be curved to the westward. In recommending curved in preference to straight walls, I have been guided not so much by the saving in dredging by including a large portion of the deep water on the line of fairway as by the natural trend of the currents, rebounding from the east bank of the river near the staiths.

If the wall above the wharves were constructed as proposed to the west of the line suggested by Sir John Coode, thus giving a sharper inset to the current toward the east side of the river, it is extremely probable that it would impinge against the staiths, and make over toward the west with more force than at present. Were the walls run out straight the surface-currents during the first stages of ebb-tide would tend to overtop them, and proceed onward toward the west breakwater

I have duly considered this point, and have decided to recommend that the walls be curved, so that the whole of the filaments of the current would be brought into a series of gentle curves harmonizing with the general direction of the walls, and, instead of being stopped and thrown off, thus impairing the combined effect, they would glide gently by with the least interruption possible. By curving the walls abreast of the lagoon a very much less quantity of material will require removing by scour and dredging from the channel and shingle-spit. I am informed by the Harbour-master, Captain Leech, that, as a rule, the seas entering between the breakwaters hug the east mole, in which case it would be an advantage to keep the channel to the west.

I have shown the knuckle or bend of the detached wall on the west side extending to the shore in order that the discharge from the lagoon might be brought into the main channel.

I would suggest that the training-wall on the west side, above the lagoon, be constructed and maintained at the level of 4ft. above low-water spring-tides, and, below the lagoon, at full half-tide. The walls complete, from 1,000ft. above the Buller Bridge to the seaward end shown on the plan, would contain, apparently, about 160,000 cubic yards of rubble. The alternate line, shown in red, commencing between sections CC and DD together with the east wall, will contain about 135,000 cubic yards. The cost of each respectively, apart from railway approaches, may be taken at, approximately, £48,000 and £40,000.

The quantity of material to be removed by scour and dredging, for a channel with a bottom width of 300ft., and a depth of 14ft., at low-water spring-tides, from the staiths out to deep water, between the breakwaters, would be about 270,000 cubic yards, which would cost, allowing one-half for scour, £6,800. I have shown both the east and the west walls to extend further seaward than proposed by Sir John Coode. It may be found advisable in the first instance not to extend them to the full length shown, in which case I would suggest that they be stopped at the points marked MM on the plan.

Fretting of the River-banks.—The river-banks on the west side, for some distance above and below the Buller Bridge, and at the island, are fretting away through the action of the river during floods. As the half-tide wall will form little, if any, protection to the banks during floods, it will be found necessary to protect them. I would advise that this be accomplished by quarry refuse and small rubble of blocks, weighing from 1cwt. to 2cwt. Fascine work may be used with advantage where suitable, provided material fit for fascines can be procured within easy distance.

River Training-walls and the Bar.—I may mention that I do not anticipate any material improvement to the bar will be derived from the river training-walls. It is very probable that the scour, while dredging upstream, will deposit detritus on the bar, which will require to be removed by dredging or harrowing.

Entrance to the Proposed Floating-basin.—By curving the walls to the westward, the proposed entrance to the floating-basin would be effected, but I see no reason why the site of the basin should not be kept a little further upstream, with the entrance, approximately, as indicated by green colour I have shown, roughly, on the plan two positions for the floating-basin. That shown by green colour would not admit of much future extension without running dangerously near the high-water mark outside, while by keeping the line of dock more east and west, as indicated by blue, it might be considerably enlarged. The greatest drawback against curving the walls, probably, is that by so doing a portion of the existing half-tide wall on the east side would be rendered useless.

Railway Approaches.—I have shown on the plan the approximate positions of railway approaches. Should the wall be constructed by end-tipping, without staging, as proposed by the Board's Engineer, it will be necessary that the trucks be before the engine while tipping the rubble. This arrangement would also suit better in the event of tipping the wall from staging. I have therefore allowed for back-shunting to all the approaches. Where the work commences upstream of the tangent point on the wall I would propose that this portion, which in no case is of any great extent, be left until a sufficient portion of the wall below is built to allow of backing up the line. The steepest gradient would occur on the approach to the wall, above the Buller Bridge, amounting to about 1 in 37½. This, I consider, will be within the limit of a difficult grade for the purpose required. It will be seen from the plan that I advise the first 500ft. of the wall to be constructed at the level of full tide. This arrangement gives an easier gradient to the approach, and will afford more advantages to standing-room than if kept to half-tide level. Although the approach to the wall at Martin's Island would be liable to be blocked by logs brought down the river during floods, I think it should be completed, as this approach would be much needed with a view to expeditiously carrying out the work, and as a considerable portion—fully one-half—is already constructed. The approach to the detached wall upon the west side of the river, although necessitating the construction of nearly half a mile of line from the junction near the root of the west breakwater to the wall, will, I think, be found comparatively easy

Conclusion.—In conclusion, I must express my pleasure in acknowledging the attention I have received from Mr J J Moynihan, Chairman of the Board, Mr J A. Wilson, the Engineer, and Mr. Charles N Greenland, the Secretary, each and all of whom have rendered me every assistance during my inspection of the river, and the data in connection therewith.

I have, &c.,

The Chairman, Harbour Board, Westport. LESLIE H. REYNOLDS, C.E.

No. 23.

Notes by Mr J A Wilson, Jun., on the Reports on the Training-walls.

SIR,— Harbour Board Office, Westport, 28th June, 1892.

In pursuance of a resolution of the Board dated the 21st instant, I have given careful thought to the reports on the lines the training-walls should follow, prepared by Messrs. Bell and Reynolds, C.E.'s, and would submit the following notes thereon :—

Division of Walls into Sections.—For the purpose of considering the reports, the training-walls may be divided into three sections—namely, the upper section, along which the lines advised to be followed in both cases depart from the line as it appears on Sir John Coode's original design, and which may be said to embrace that part of the training-wall upstream from cross-section FF, the middle section, extending from cross-section FF to the mouth of the lagoon, throughout which length the proposals of both gentlemen follow, either on or very close to the original line, and the lower section, extending seaward from the mouth of the lagoon, where they again propose to diverge from the line as originally designed.

Consideration of Upper Section.—Taking the upstream section, and considering that first, Mr Reynolds has shown in green colour a line which he approves of, commencing 1,000ft. above the Buller Bridge, and trending downstream by easy curves till it joins Sir John Coode's line at cross-section FF This is the line Mr Reynolds would favour as likely to give the best results, in conjunction with dredging, defined on his plan, and estimated to cost £12,500. This line from the Buller Bridge downwards, is located a little to the eastward of the line proposed by myself, in connection with which it was not anticipated that heavy dredging would be entailed, as there was no idea of reducing the level of the river-bottom to Sir John Coode's grade-line by that means,

though it seemed possible that the shingle-spit on the east side would have to be assisted to scour by dredging, with the view of widening the channel so as to make up for the waterway cut off.

Mr Reynolds's reason for advising the dredging here is that he considers, unless the grade-lines specified by Sir John Coode are approximated to, the berthages for shipping at the wharves, &c., will be rendered less safe owing to an increased velocity attained by the current, due to the upper training-wall (*vide* his report)

Having these considerations in view, Mr Reynolds shows an alternative line for the training-wall, which he would recommend if the Board desired to do without dredging, pointing out at the same time that the alternative can be made so as to work into his first proposal if at any time dredging is decided on, and it is desired to build the walls from above the Buller Bridge. This alternative commences 700ft. above Martin's Island, and runs into Sir John Coode's line at cross-section FF

From the Buller Bridge, downstream, to the proposed commencement of this wall the river-bank would be protected with hand-packed rubble. Bank-protection of the same class is shown for 2,000ft. above the Buller Bridge, and the head of Martin's Island is also to be protected.

Turning now to Mr Bell s proposal This commences at the Buller Bridge, and leads downstream near the west bank of the river When it reaches about 500ft. above Martin's Island its course falls very close to Mr Reynolds's alternative line, and the two locations from this onward are practically identical until they reach cross-section FF where they merge into Sir John Coode's line. Mr. Bell s shows a small amount of dredging along the edge of the heavy shingle-spit on the east side of the river sufficient to widen the waterway to 500ft. Viewing these two schemes, the question of dredging above the wharves towards the Buller Bridge, to secure a grade-line previously referred to, which is an important factor in one of the schemes, requires to be first considered. I would advise that this, in common with all dredging undertaken inside the tidal compartment, will have a temporary tendency to shoal the bar, as there is a certain amount of detritus disturbed by the dredge, but not actually lifted, which the current during freshes acts on, and carries gradually out of the river While this is passing over the bar it must be detrimental to a regular continuance of deep water thereon. Add to this the estimated cost of such work, as already noted, and these points, I think, virtually place on one side any plan including heavy dredging operations, leaving Mr Reynolds's alternative line and Mr Bell's under consideration. As already mentioned, from cross-section FF to 500ft. above Martin's Island there is no choice, both lines preserving the same course. Above this Mr Reynolds's line merges into bank-protection, while Mr Bell's shows a training-bank in shallow water There is very little between the courses, but of the two I prefer Mr Bell's, as commencing to train the river sooner, and inducing its currents into one particular channel for a longer distance upstream. I shall, however be quite prepared to find that some of the bank-protection proposed by Mr Reynolds may eventually prove necessary and, if so, it will have to be executed, but need not be undertaken at present. Mr Reynolds's recommendation that the walls in the upper reaches of the river should be kept a little low I will keep carefully before me, and act on, should it seem desirable so to do.

Consideration of Middle Section.—Considering the middle section from cross-section FF to the mouth of the lagoon, a distance of 3,700ft., it will be found that both reports agree—that the lines are one and the same, and vary very little from that laid down by Sir John Coode, except that Mr Bell s plan exhibits an entrance to Martin's Island to allow of access by water, which it would be advisable to leave when constructing the wall. At the lower end of this length of training-wall, where an opening is left to provide for drainage of the lagoon on both plans, the works are curved slightly to the west, with the view of lessening the amount of dredging required by making the future channel more to the west than Sir John Coode intended—that is, more in the present deep water Also, as is very lucidly explained by Mr Reynolds, the curved course will more effectually train the river-currents, bringing the currents during the early part of the ebb into play, as well as those approaching half-tide.

Consideration of Lower Section.—The lines suggested in connection with the outer training-walls on the west side, though not precisely similar, do not greatly diverge from one another, and the ends of the walls on the two plans coincide exactly as to length, if the shorter section provided by Mr Reynolds is alone considered, and the outer extension, for which he made provision if considered necessary in the future, is eliminated. Mr Bell specifies that the wall on the portion of his line which crosses the present fairway should not be constructed until the new channel is dredged. On the east side of the river both show a training-wall, starting from the existing training-wall and trending seawards and towards the west. On this point both are agreed as to position and length, the walls being counterparts of each other As in the case of the west training-wall, however, Mr Reynolds shows beyond this a future extension.

With regard to the west training-wall below the lagoon, in the position this is placed by Mr Bell, it conducts the centre-line of the channel sought to be established seawards, in a line parallel with the outer ends of the breakwaters but, instead of being in the centre of the channel, it is nearer the west breakwater A tendency of the line of fairway towards the east breakwater, he explains, would be likely to be objectionable, as the prevailing ocean-currents, which here travel in a south-easterly direction, meeting at an angle the currents going north, cause the resultant direction on the bar, and outside it, to lie between the two, in a direction which varies as their respective forces vary, but which is always inclined to fan out towards the east, being the most sheltered side of the harbour, thus preventing a straight run out over the bar, and nullifying a large amount of scouring-power The possible advisability of extending the breakwaters now being seriously discussed is another reason for keeping the fairway from trending to the east, as in the event of an extension the position would be aggravated, and the deepest water would be found near the east breakwater, which in the heaviest weather experienced here—namely N.N W to

N W.—is the lee wall, making the entrance dangerous. Looking at the matter in this light, anything that is calculated to direct the current more towards the west breakwater we should avail ourselves, of and this, I think, the form Mr Bell proposes for the west training-wall below the lagoon would be likely to effect, so that I think it should be followed. *Re* the east training-bank, shown in both plans, I understood from Mr Bell and from Mr Reynolds that they did not consider this an urgent matter I would accordingly advise that no steps be taken at present with regard to it.

Cost of Walls.—Looking into the cost of the works proposed, I have deducted the cost of the extension he proposes from Mr Reynolds's estimate for purposes of comparison, and find that, taking his alternative line below the Buller Bridge, which differs only slightly from Mr Bell's, the respective costs of the works, according to each gentleman s estimate, stand as follows Mr Bell s scheme, £27,500, Mr Reynolds's scheme, £30,000. I think Mr Reynolds provided for a wall 10ft. wide on top, while, I believe, Mr Bell reckoned on a 9ft. wall as being sufficient to carry the roadway, which will probably account for some of the difference.

Approaches.—Examining the several approaches suggested, there is practically no difference of opinion with regard to them. The approaches to the upper walls are recommended to be a right-hand curve, from the west end of the Buller Bridge to the river, at the upstream side of the bridge, where a back-shunt would be put in with siding-room for trucks, and by the approach at the head of Martin s Island, which is to take the form of staging when it arrives at high-water spring-tide mark. The approach considered advisable to the west training-wall, below the lagoon, curves off the Cape Foulwind railway about 10 chains before reaching the west breakwater, and runs over the sandhills, curving round by the signal-station on to the wall. Here Mr Reynolds prefers a solid approach, with the view of preventing the lagoon finding its way out on the west side of the training-wall, while Mr Bell adopts an open staging, trusting to deepening the mouth of the lagoon by dredging to take its drainage through the proper channel. Mr Reynolds also shows the approach he would recommend to the east training-wall, but Mr Bell does not mention this point.

Dredging.—The estimates for dredging approach each other in their total cost, though arrived at in different ways. Mr Bell s dredging estimate is based on a cut to be made 150ft. wide, allowing nothing for scour, but considering the whole as solid dredging while Mr Reynolds has estimated for a cut 300ft. wide, about one-half of which he allows might be effected by scour The width of the channel we are dredging at present, at the upper end of the fairway, is 150ft. I should be inclined not to widen it beyond this, unless hereafter found necessary

Floating-basin.—I would advise that no proposal for amending the position of the floating-basin be definitely decided on, as there is no necessity to be precipitate in that matter Both are valuable, and should be carefully studied, so that when the time comes to act the Board may be prepared to do so, secure that they are working on the best lines.

Miscellaneous.—Mr Reynolds having noticed that our dredging operations here would lend themselves well to a system of harrowing the bar, as the hopper-barges are continually crossing it, makes a valuable suggestion on that point, and I would recommend that a trial be given to his proposal. Mr Reynolds also thinks that the river-bank above the half-tide wall, on the east side of the river, should be advanced to the front line of Sir John Coode's works. This, in my opinion, should be done, but, if wharves are in the future to be erected there, it could be effected conveniently then.

Summary of the Foregoing Suggestions.—First, the training-walls and approaches on west side of river should be constructed where there is any difference between the two proposals on lines laid down by Mr Bell. Second, the bank-protection advocated by Mr Reynolds should be kept in view, and undertaken if it at any time becomes necessary Third, Mr Reynolds's proposal *re* harrowing the bar should be tested in connection with the dredging operations.

In conclusion, I may say that both reports herein treated on are of considerable value, as the investigations therein have been patiently pursued on sound engineering principles, and an examination of them will show that, though independently framed, very much the same conclusions have been deduced, and that there is nothing antagonistic in the reports, differences being on minor points only

I have, &c.,

J A. Wilson, Jun.,
Engineer Westport Harbour Board.

The Chairman, Harbour Board, Westport.

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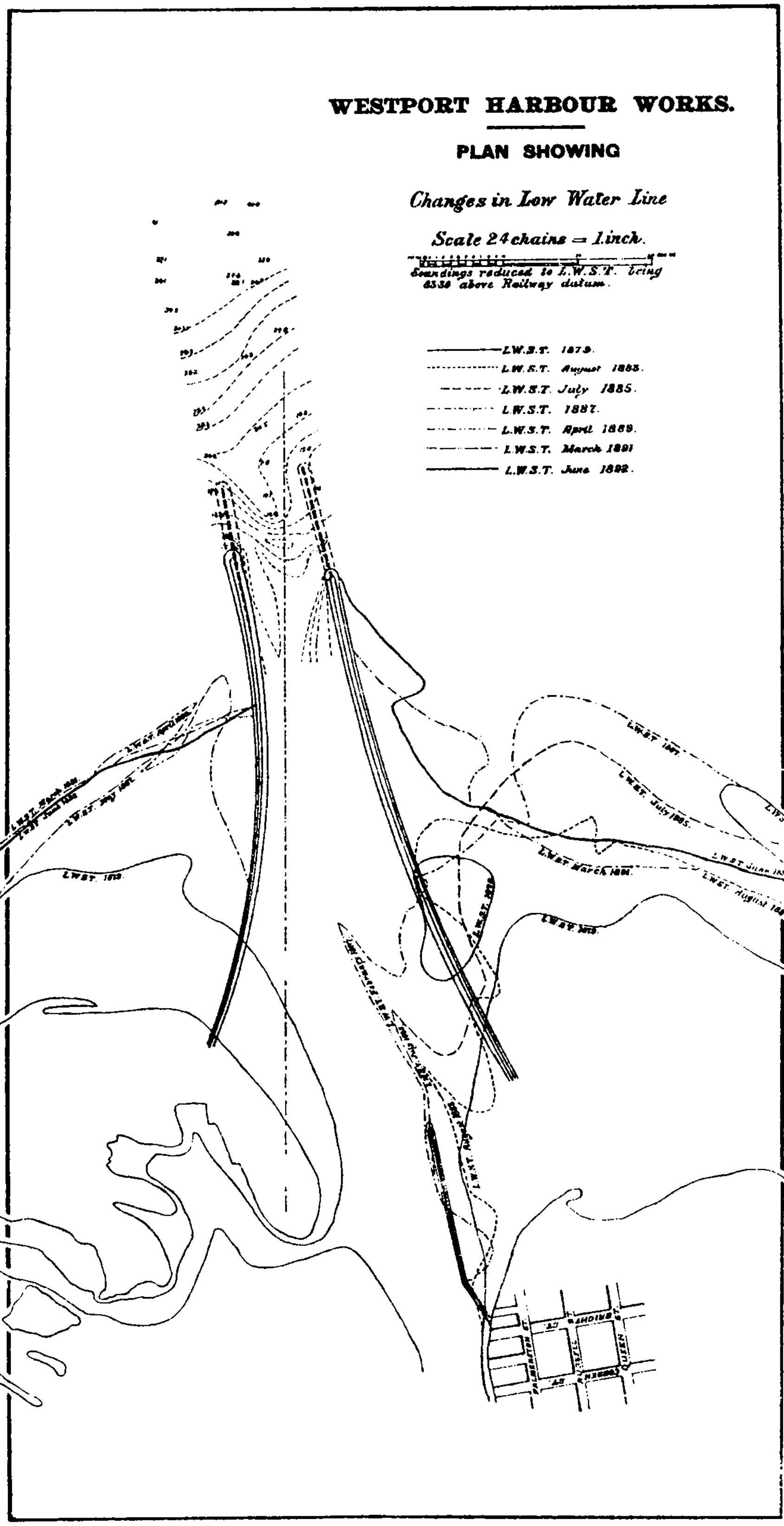
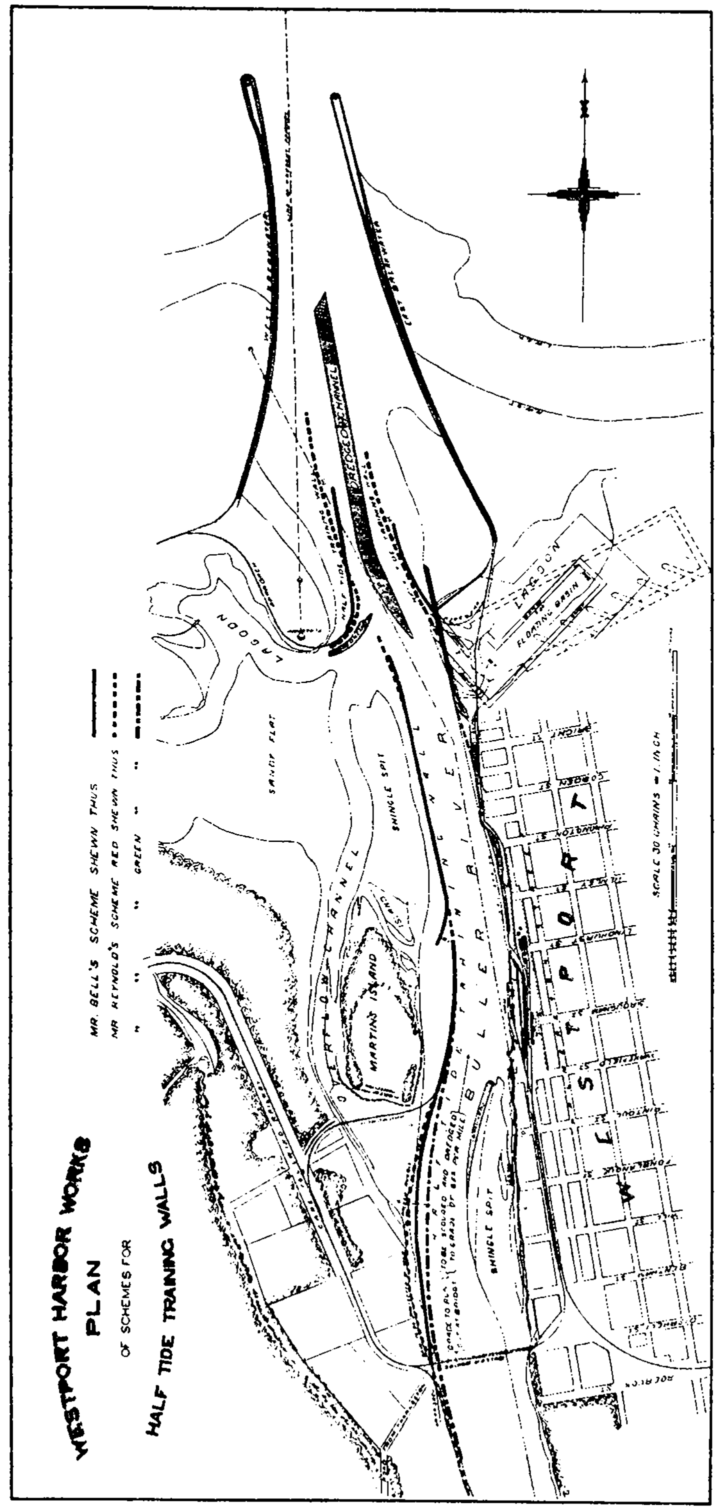
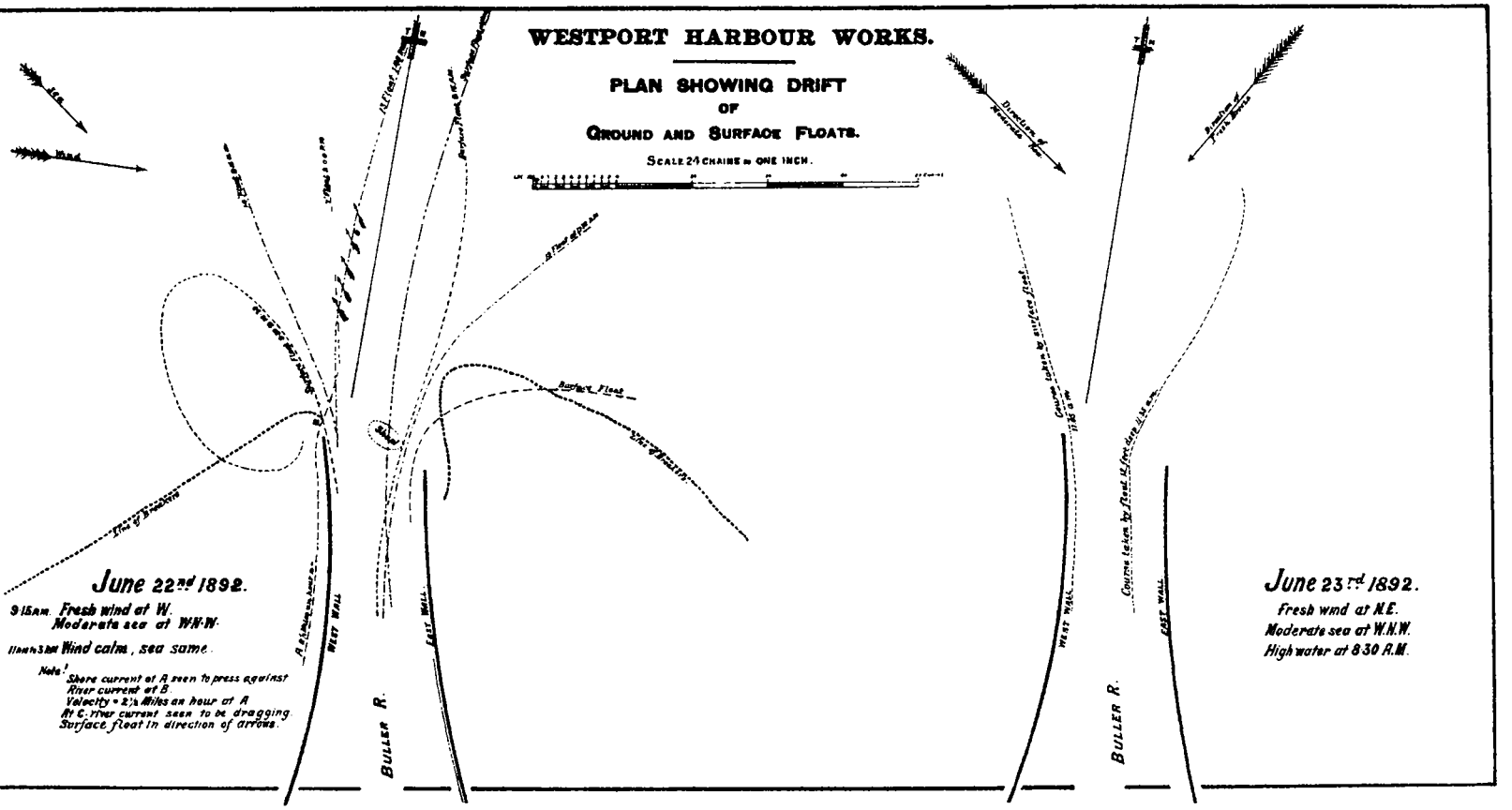

WESTPORT HARBOUR WORKS.
PLAN SHOWING
Changes in Low Water Line
Scale 24 chains = 1 inch.
Soundings reduced to L.W.S.T. being 6536 above Railway datum.
L.W.S.T. 1879.
L.W.S.T. August 1883.
L.W.S.T. July 1885.
L.W.S.T. 1887.
L.W.S.T. April 1889.
L.W.S.T. March 1891
L.W.S.T. June 1892.


WESTPORT HARBOR WORKS
PLAN
OF SCHEMES FOR
HALF TIDE TRAINING WALLS
MR. BELL'S SCHEME SHEWN THUS
LAGOON
SANDY FLAT
SHINGLE SPIT
MARTINS ISLAND
BULLER RIVER
WESTPORT
SCALE 30 CHAINS = 1 INCH

WESTPORT HARBOUR WORKS.

PLAN SHOWING DRIFT OF GROUND AND SURFACE FLOATS.

SCALE 24 CHAINS = ONE INCH.



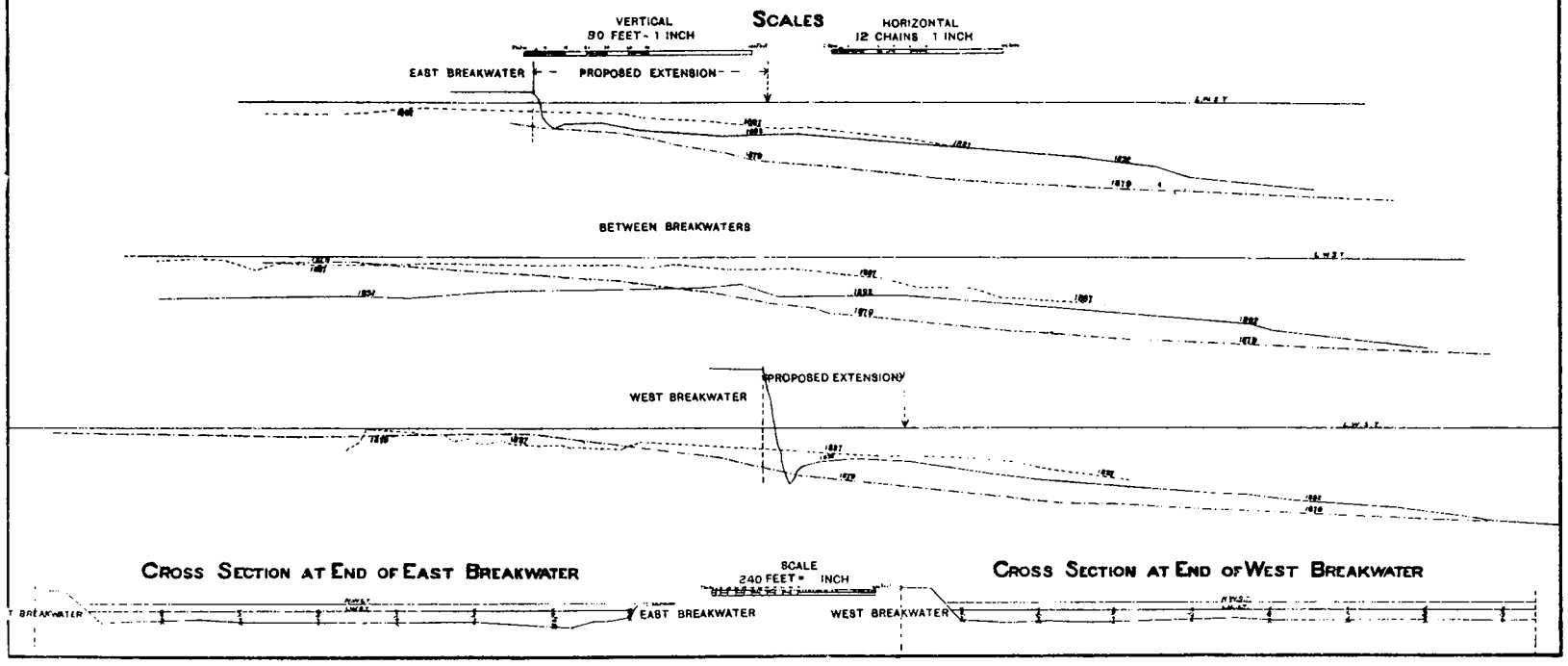
WESTPORT HARBOUR WORKS

SOUNDINGS SHEWING SHOALING IN FRONT OF BREAKWATERS

SCALES

VERTICAL 30 FEET = 1 INCH

HORIZONTAL 12 CHAINS = 1 INCH

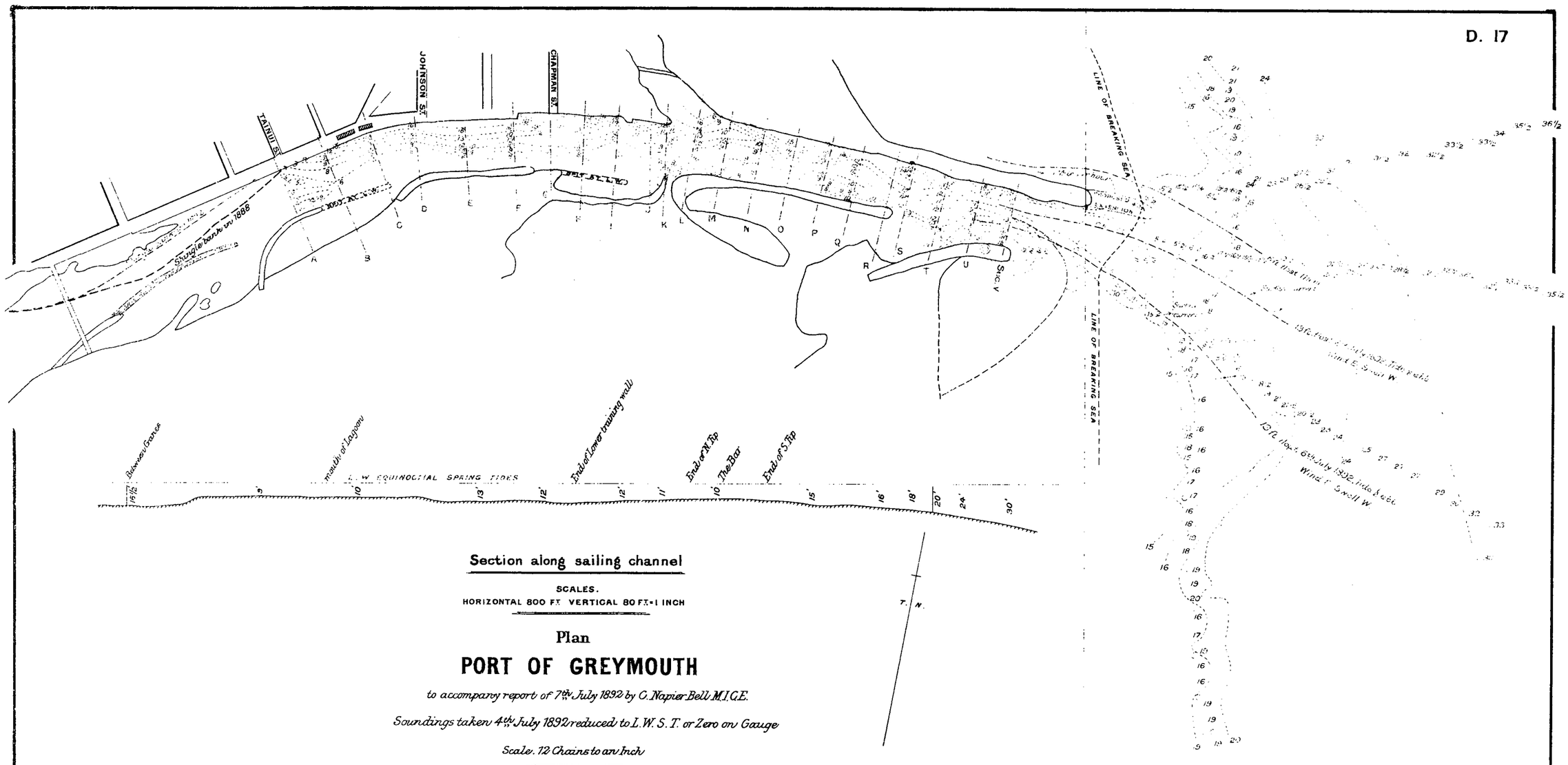


CROSS SECTION AT END OF EAST BREAKWATER

SCALE 240 FEET = INCH

CROSS SECTION AT END OF WEST BREAKWATER

D. 17



Section along sailing channel

SCALES.
HORIZONTAL 800 FT. VERTICAL 80 FT = 1 INCH

Plan

PORT OF GREYMOUTH

to accompany report of 7th July 1892 by C. Napier Bell M.I.C.E.

Soundings taken 4th July 1892 reduced to L.W.S.T. or Zero on Gauge

Scale. 12 Chains to an Inch

Photolithographed at the Head Office, Department of Lands and Survey Wellington, N.Z. October 1892.